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Preface

This volume of the World Weather Open Science Conference 2014 edition contains all available WWOSC 2014 submitted abstracts for:

- Plenary Sessions
- Panel Sessions
- Parallel Session presentations
- Poster Session presentations

The content of this book is available in electronic format only via the internet.
Foreword

The organizers of WWOSC 2014 are proud to present this collection of abstracts during the World Weather Open Science Conference, held the vibrant city of Montréal (Québec, Canada) from August 16 to August 21, 2014.

This electronic collection of abstracts contains all valid submissions to be presented as oral or poster presentations at WWOSC 2014. Abstracts noted as WITHDRAWN represent abstracts to be included, however; the authors or presenters were not on-site participants.

Abstracts are presented as they were submitted. The organizers take no responsibility for the content or grammatical mistakes or errors in the texts.

Abstracts presenters in the Oral program may have consented to include their PowerPoint content to interested conference participants. This content will be made available on the WMO website.

Sarah Jones & Gilbert Brunet
Co-Chairs, Science Program

Brian Mills & David Rogers
Co-Chairs, User, Application and Social Sciences (UAS) Program

Montreal, Canada
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Joint Plenary Session

WW-JPL01.01 - A Vision of Earth-system Research, Prediction and Services in the 21st Century

Mel Shapiro

1 NCAR/NOAA, Boulder, CO, USA

We stand at the threshold of accelerating advances in the prediction of high-impact weather and the complex interaction between the physical-biological-chemical Earth-system and global societies. As the way forward, the WMO World Weather Research Program seized upon the timely opportunity to convene the inaugural World Weather Open Science Conference that "brings together the entire weather science and user communities to review the state-of-the-art and map out the scientific frontiers for the next decade and more". This plenary lecture, during the Opening Ceremony of the Conference, will: i) highlight selected accomplishments at the forefront of the current state-of-the science, and its socioeconomic and environmental applications and assessment; ii) identify the foremost challenges to continued advancement; iii) present a vision of future advances in our science of the atmosphere and anticipated deliverables and benefits to society. This perspective draws upon input from colleagues at the forefront of the key elements of the science and its derived services. It spans observations, data-assimilation, dynamical prediction, socioeconomic applications and assessment, emerging supercomputer capacity and visualization integration of geophysical and societal information. We begin with a synopsis of the foresight of Vilhelm Bjerknes, Jule Charney and Edward Lorenz, who, among others, charted the course of our journey to our current knowledge and prediction of the Earth system. The subsequent accomplishments represent one of the most significant scientific, technological and societal achievements of the 20th century. We follow with notable examples of the current state of our weather enterprise and foremost challenges before it, guided by the Conference Session Themes. We conclude with our vision of Earth-system research, prediction and services in the year 2020 and beyond.

Keywords: Earth-System, Prediction
Joint Plenary Session

WW-JPL02.01 - Why should we be concerned about meteorological impacts on our energy systems?

Alberto Troccoli\textsuperscript{1}, Laurent Dubus\textsuperscript{2}

\textsuperscript{1}CSIRO, Canberra, Australia, \textsuperscript{2}EDF, Chatou, France

Energy systems are the engine of economic and social development. Their investments represent a sizeable portion of a country’s GDP. Energy planning and operations are markedly affected by meteorological events. For instance, 4.3% (equivalent to many hundreds of M€) of the total Electricité De France (EDF)’s 2013 income was attributed to favourable weather and climate conditions in France. With an ever-growing global energy demand – currently about 13 billion tonnes of oil equivalent, an increase of nearly 30% in ten years – energy systems are increasingly exposed to the vagaries of weather and climate. But how does meteorology actually impact the energy industry? And how large a meteorological event needs to be for it to cause unpropitious or indeed advantageous effects on energy systems? These are the underlying questions explored in this talk. In particular, we note that not only is the energy sector at risk from future climate changes, it is also at risk from current hydro-meteorological climate variability and change. It is important therefore to gain an in-depth understanding of the historical impacts of weather and climate on energy systems in order to make these more resilient to future events. By examining a selection of meteorological variables, this talk exposes how historical climate variability and abnormal weather events can, and do, impact all aspects of energy systems, from their planning to their operations. The extent to which such impacts could be modified in future energy systems, also considering the climate change driver, is also discussed.

\textbf{Keywords:} Energy systems, Weather and climate impacts, Climate variability and change, Renewable energy
Joint Plenary Session

WW-JPL02.02 - Advances and prospects in assimilation of weather and climate observations

Jean-Noel Thepaut¹
¹ECMWF, Reading, UK

The skill of Numerical Weather Forecasts has continually improved over the past decades, leading commonly nowadays to accurate forecasts a week ahead. This remarkable progress has been achieved through major advances in the development of numerical weather prediction models, a much better designed observing system composed of in-situ and satellite instruments, improved data assimilation techniques and last but not least, increased computer power capacities which have allowed combining these components together in an optimal and efficient way. Data assimilation is being used for a wide range of initialisation applications, including ocean, land and ice surface, and atmospheric composition, and in the context of reanalyses which become essential for climate monitoring applications. These developments will benefit from increasingly accurate information provided by future observations, in particular from the forthcoming satellite programmes in Europe and worldwide. As Earth-system modelling is now being more integrated, data assimilation techniques are evolving to treat the initial condition estimation as a coupled problem. The scales spanned by data assimilation systems are also expanding and specific methods are being designed to address very fine scales and associated non-linearities and exploit dedicated observation networks. Finally, data assimilation is not only providing the initial state of a numerical forecast but is one component of a seamless estimation of a probability density function evolution. Ensemble approaches for data assimilation are therefore developing rapidly, as they also offer the potential of being more scalable on future High Performance Computer architectures.

Keywords: Data, assimilation, observations
SCI-PS101.01 - Water cycle prediction at the regional scale: on the importance of being consistent

Vincent Fortin\textsuperscript{1}, Al Pietroniro\textsuperscript{2}, Pierre Pellerin\textsuperscript{1}
\textsuperscript{1}Meteorological Research Division, Environment Canada, Dorval, Canada,
\textsuperscript{2}Water and Climate Services, Environment Canada, Saskatoon, Canada

Improving watershed management practices over a large watershed is challenging, as there are generally multiple stakeholders with conflicting objectives, as well as incomplete knowledge of the impacts of different management strategies on the ecosystem. Especially when vulnerabilities related to water levels are significant, it becomes critical to be able to understand and predict the water and energy cycle at temporal and spatial scales of interest for decision making. For large watersheds, this is typically not possible without heavily relying on models. Fortunately, sophisticated numerical models of the atmosphere, the land surface, rivers and lakes are now available. However, installing and coupling these models remains a challenge. When difficult choices need to be made in order to deliver a useful modelling system from a user perspective, we argue that ensuring consistency is often more important than increasing model complexity. Consistency can be improved by (1) ensuring consistent definition of parameters and variables across all components of the modelling system, and especially for variables which are exchanged between components, (2) ensuring that state variables are continuously updated, through a data-assimilation system, in order to reflect the current state of the system, (3) ensuring that model predictions are compared to observations which are made at spatial and temporal scales which are compatible with the model, and (4) paying attention to model biases, which can help identify and reduce model deficiencies. These four points are illustrated, using examples taken from an environmental system developed for the Great Lakes and St. Lawrence River system.

Keywords: Hydrometeorology, Modelling, Prediction, Coupling
Parallel Session

SCI-PS101.02 - Land-atmosphere feedbacks over North America: How well do weather and climate models represent reality?

Paul Dirmeyer¹, Ahmed Tawfik²

¹George Mason University, Fairfax, USA, ²Center for Ocean-Land-Atmosphere Studies, USA

Recent advances in the understanding of processes of land-atmosphere coupling on weather and climate time scales has led to the development of metrics of land-atmosphere feedback based on the statistics of measurable quantities. These metrics are proving invaluable both for understanding nature and for the diagnosis, development and calibration of numerical models. Indices calculated from environmental states and fluxes from FLUXNET sites over North America are compared to calculations from several different weather and climate models. Comparisons reveal various problems and virtues in components of the land and atmospheric models, providing new opportunities for improvement and potentially enhancing the harvest of predictability as forecast skill.

Keywords: land-atmosphere coupling, predictability, FLUXNET, modeling
Parallel Session

SCI-PS101.03 - Using temporal changes in drought indices to provide drought early warning over sub-seasonal time scales

Jason Otkin\textsuperscript{1}, Martha Anderson\textsuperscript{2}, Chris Hain\textsuperscript{3}, Mark Svoboda\textsuperscript{4}
\textsuperscript{1}University of Wisconsin, Madison, USA, \textsuperscript{2}U.S. Department of Agriculture, Beltsville, USA, \textsuperscript{3}University of Maryland, College Park, USA, \textsuperscript{4}University of Nebraska, Lincoln, USA

In this study, the potential utility of using rapid temporal changes in drought indices to provide early warning of an elevated risk for drought development over sub-seasonal time scales is assessed. Standardized change anomalies were computed each week during the 2000-2012 growing seasons for drought indices depicting anomalies in evapotranspiration, precipitation, and soil moisture derived from satellite remote sensing observations and land surface model output. A new metric, known as the Rapid Change Index (RCI), was created to encapsulate the accumulated magnitude of rapid changes in the weekly anomalies for each dataset, and is designed to highlight areas undergoing either rapid increases or rapid decreases in moisture stress. Case study analyses revealed that the initial appearance of negative RCI values indicative of rapid increases in moisture stress often occur several weeks prior to the introduction of severe drought conditions in the United States Drought Monitor. Statistical analyses showed that drought intensification probabilities derived from the RCI datasets have reasonable reliability and forecast skill, especially over the central and eastern United States in regions most susceptible to rapid drought development. Taken together, the results suggest that tools used to identify areas experiencing rapid changes in drought indices may be useful components of future drought early warning systems.

\textbf{Keywords:} Drought monitoring, Drought early warning, Sub-seasonal prediction
Parallel Session

SCI-PS101.04 - Daily local coupling and predicting convective initiation

Ahmed Tawfik¹, Paul Dirmeyer¹
¹George Mason University, Fairfax, USA

Using a new framework, the Heated Condensation Framework (HCF; Tawfik and Dirmeyer 2014), local land-atmosphere coupling can be examined by separating the atmospheric background state from the land surface state in terms of convective initiation. In particular the HCF returns variables that are analogous to traditional convective metrics such as the lifted condensation level (LCL) and convective inhibition (CIN), but have the advantage of being conserved throughout the diurnal cycle. This enables the possibility of predicting 1) the onset of convection, 2) the strength of convection, and 2) the impact of the local surface forcing. This land-convective relationship is explored in observations, reanalysis, and models with emphasis on where and when models differ and how they may be improved.


Keywords: Local coupling, convective triggering, predictability, model deficiencies
Joint Plenary Session

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Mel Shapiro1
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Jean-Noel Thepaut

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Vincent Fortin\textsuperscript{1}, Al Pietroniro\textsuperscript{2}, Pierre Pellerin\textsuperscript{1}

\textsuperscript{1}Meteorological Research Division, Environment Canada, Dorval, Canada,
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Parallel Session

SCI-PS101.02 - Land-atmosphere feedbacks over North America: How well do weather and climate models represent reality?

Paul Dirmeyer\(^1\), Ahmed Tawfik\(^2\)

\(^1\)George Mason University, Fairfax, USA, \(^2\)Center for Ocean-Land-Atmosphere Studies, USA

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**Keywords:** land-atmosphere coupling, predictability, FLUXNET, modeling
Using temporal changes in drought indices to provide drought early warning over sub-seasonal time scales

Jason Otkin\textsuperscript{1}, Martha Anderson\textsuperscript{2}, Chris Hain\textsuperscript{3}, Mark Svoboda\textsuperscript{4}
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Parallel Session

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Ahmed Tawfik¹, Paul Dirmeyer¹
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Keywords: Local coupling, convective triggering, predictability, model deficiencies
Parallel Session

SCI-PS102.01 - User-focused approaches for forecast evaluation

Barbara Brown\textsuperscript{1}, Jeff Lazo\textsuperscript{1}, Elizabeth Ebert\textsuperscript{2}
\textsuperscript{1}NCAR, Boulder, USA, \textsuperscript{2}CAWCR, Melbourne, Australia

Forecast evaluation is an important component of any forecast development effort, and is a critical aspect of the forecast value chain. While traditional approaches for forecast verification have focused on basic mathematical techniques developed decades ago, more recently the importance of structuring forecast evaluation methods to provide meaningful information to users (e.g., power traders, forecasters, water managers) has become evident. Fundamental to this idea is the fact that verification approaches used in development of a forecasting system have a critical impact on the capabilities of the resulting system. For example, models that are intended to predict flood events should be evaluated based on their ability to provide meaningful information about precipitation and other relevant variables. Beyond the forecast development imperative for user-focused verification information, forecast evaluations also provide important information to users for decision making. Specifically, verification information can inform users regarding forecast uncertainties associated with specific situations with economic or other importance to society. For example, evaluations of model predictions of energy ramps require particular kinds of verification information that cannot be extracted using traditional approaches. Sometimes called “diagnostic” verification, user-focused approaches can include new spatial methods as well as event-based time series approaches. Specific user needs for particular kinds of verification information can be elicited using a focused survey methodology. This talk will consider approaches for identifying users’ needs and developing user-relevant verification approaches, along with several examples of applications, and will include a discussion of how these approaches might evolve in the future.

Keywords: Verification, Evaluation, User
Parallel Session

SCI-PS102.02 - Object-based spatial verification for multiple purposes

Beth Ebert¹, Lawrence Rikus¹, Aurel Moise¹, Ying Jun Chen², Raghavendra Ashrit³
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Recent years have seen the development of methods for verifying spatially coherent weather "objects" such as rainfall or cloud systems. A strong motivation has been to better assess the performance of high resolution NWP using intuitive approaches that somehow mimic a human's evaluation, and where traditional grid scale verification metrics may sometimes give misleading results. Two of the earliest object-based techniques to be developed were the Contiguous Rain Area method (CRA) and the Method for Object-based Diagnostic Evaluation (MODE). Given a pair of matched forecast and observation grids, these schemes search for contiguous areas of a variable exceeding a threshold (for example, rain greater than 5 mm d⁻¹), perform a matching step to associate forecast objects with observed objects, and then compare several attributes of the objects including location, size, intensity, and orientation. This approach quantifies how well a forecast "looks like" the observations and provides hints as to the causes of error. When applied over many cases, object-based verification methods are useful for diagnosing systematic errors. Both the CRA and MODE techniques are now fairly mature and are being applied for a variety of applications. This talk will describe the object-based verification approach, focusing on the CRA method, and demonstrate its use in verifying mid-latitude rain systems, tropical cyclone rainfall, sub-tropical jets, and climate features such as the South Pacific Convergence Zone. Results from these studies are being used both to guide improvements to models, and interpretation of model forecasts and climate projections by users.

Keywords: Spatial verification, Object-based verification, Diagnostic verification
Parallel Session

SCI-PS102.03 - Verifying deterministic and probabilistic forecasts of objectively clustered weather regimes.

Ric Crocker¹, Robert Neal¹, David Fereday¹

¹Met Office, Exeter, UK

The Met Office in the UK has developed an updated weather regime forecast system. The system uses k-means clustering to objectively categorise the pressure anomalies over a selected area of the world to create a pre-specified number of most-likely weather regimes. Both deterministic and individual ensemble member forecasts can be categorised into one of these weather regimes giving guidance as to the most-likely regimes over both short and longer timescales. Here we take a brief look at the weather regime system and look particularly at how this system can be used to verify the skill of the underlying forecast models at both short and long forecast periods.

Keywords: verification, weather regimes, probabilistic
Over the past 40 years, there has been remarkable research progress in understanding meteorological science and integrating results into research models and applications. However, improving the process of transitioning these results into successful operational use has remained a limiting factor in producing desired socio-economic impacts. The delayed implementation of cutting edge research diminishes the impact of the science, and decreases the benefit to the operational users – and, in turn, to society. This paper demonstrates the success of an IT architecture that is designed to facilitate the R2O process through iterative O2R impact analysis. It consists of an architecture that more effectively and efficiently tests and exercises research algorithms under continuous quasi-operational conditions presented in side-by-side comparison with operational products. It exploits a process that preserves not only the output of both sets of algorithms but also the ancillary data used. And, it allows detailed evaluation of the results through automated change detection techniques, to lessen the tediousness and improve the thoroughness of the testing process. Finally, it exploits a process that allows for iteration to occur in a timely manner and research to be transitioned into sustained operations more effectively.

**Keywords:** facilitate R2O and O2R, exercises research algorithms, continuous, quasi-operational conditions, automated change detection techniques
Four-dimensional variational assimilation (4DVar) has been the method of choice for most leading global Numerical Weather Prediction (NWP) centres for the last decade - I briefly discuss why. However it has both scientific and technical weaknesses - the use of climatological covariances and the repeated running of an adjoint forecast model. We can address the first problem by using a hybrid covariance, combining climatology with an estimate from a current ensemble of forecasts. Four-dimensional ensemble variational assimilation (4DEnVar) does this, and addresses the second problem by using instead a time-history of each forecast from the ensemble - this makes 4DEnVar much easier to implement on massively parallel computers. But 4DEnVar too has its weaknesses. In particular, because it avoids the use of models within the algorithm, its use of climatological covariances is like 3DVar rather than 4DVar. Because of this, hybrid-4DEnVar currently performs less well than the hybrid-4DVar which is used in the operational global NWP at the Met Office, both in idealised experiments and realistic trials. To improve hybrid-4DEnVar we need to place less weight on the climatological covariances; this requires a large, reliable ensemble and improved localisation methods. Met Office research on these lines will be described.

**Keywords:** 4DEnVar, 4DVar, data assimilation, NWP
Parallel Session

SCI-PS103.02 - Convection-permitting forecasts initialized with limited-area 3DVAR, ensemble Kalman filter, and “hybrid” variational-ensemble data assimilation systems

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Analyses with 20-km horizontal grid spacing were produced from parallel continuously cycling three-dimensional variational (3DVAR), ensemble square root Kalman filter (EnSRF), and “hybrid” variational-ensemble data assimilation (DA) systems between 0000 UTC 6 May and 0000 UTC 21 June 2011 over a domain spanning the continental United States. Beginning 9 May, the 0000 UTC analyses initialized 36-hr Weather Research and Forecasting (WRF) model forecasts containing a large convection-permitting 4-km nest. These 4-km 3DVAR-, EnSRF-, and hybrid-initialized forecasts were compared to benchmark WRF forecasts initialized by interpolating 0000 UTC Global Forecast System (GFS) analyses onto the computational domain. While important differences regarding mean state characteristics of the 20-km DA systems were noted, verification efforts focused on the 4-km precipitation forecasts. The 3DVAR-, hybrid-, and EnSRF-initialized 4-km precipitation forecasts performed similarly regarding general precipitation characteristics, such as timing of the diurnal cycle, and all three forecast sets had high precipitation biases at higher rainfall rates. However, meaningful differences emerged regarding precipitation placement as quantified by the fractions skill score. For most forecast hours, the hybrid-initialized 4-km precipitation forecasts were better than the EnSRF-, 3DVAR-, and GFS-initialized forecasts, and the improvement was often statistically significant at the 95th percentile. These results demonstrate the potential of limited-area continuously cycling hybrid DA configurations for prediction of high-impact, convective weather.

Keywords: Hybrid variational-ensemble data assimilation, High-resolution forecasts, Continuously cycling limited-area analysis/forecasts systems
Parallel Session

SCI-PS103.03 - Implementation of 4D ensemble-variational data assimilation for global deterministic NWP

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It is planned to soon change the Canadian operational global deterministic data assimilation system for numerical weather prediction (NWP) from 4D-Var to the 4D ensemble-variational (EnVar) approach. 4D-EnVar has been extensively tested and compared with the operational 4D-Var with the result that the forecast accuracy is significantly improved or neutral depending on the region and season, together with a significant reduction in the required computational resources. 4D-EnVar has been combined with numerous other improvements to the data assimilation system. Also, the currently operational non-incremental digital filter initialization scheme has been replaced by a 4D incremental analysis update (4D-IAU) approach that uses the 4D analysis increments produced by 4D-EnVar. Results from data assimilation experiments comparing 4D-EnVar and 4D-IAU with 4D-Var and digital filter initialization will be presented and plans for future development outlined.

Keywords: EnVar, 4D-Var, IAU
Parallel Session

SCI-PS103.04 - An EnVar-based data assimilation scheme for the Canadian Regional Deterministic Prediction System

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A new data assimilation scheme has been developed for the regional deterministic prediction system (RDPS; limited-area domain with a 10-km grid spacing covering North America) and is currently being evaluated for an operational transfer at the Canadian Meteorological Centre (CMC). The main changes is the replacement of the limited-area 4D-Var data assimilation algorithm by a computationally cheaper variational algorithm (4D-EnVar) where background error covariances are represented by a blend of climatological covariances and 4D flow-dependent covariances derived from an EnKF-based global ensemble prediction system. It will be shown that a global-based 4D-EnVar scheme can provide RDPS forecasts slightly improved compared to the limited-area 4D-Var scheme, particularly during the first 24-h of the forecasts and in summertime convective regime where the lack of moist physical processes representation in our TL/Ad model impedes the performances of our 4D-Var scheme. Further forecast improvements were also made possible by adopting a new bias correction method, assimilating ground-based GPS data and improving the treatment of radiosonde and aircraft observations. Finally, an overview of the data assimilation strategy planned for the next-generation of the RDPS, using a convection-permitting model configuration, will also be presented.

Keywords: Data Assimilation, Ensemble-Variational, Limited-Area, Forecasting
Parallel Session

SCI-PS104.01 - The THORPEX Pacific Asian Regional Campaign (T-PARC) and affiliated programs: objectives, results, and implications

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The THORPEX Pacific Asian Regional Campaign (T-PARC) was a multi-national field campaign that addressed the shorter-range dynamics and forecast skill of high-impact weather events in one region (Eastern Asian and the western North Pacific) and the downstream impact on the medium-range dynamics and forecast skill of another region (in particular, the eastern North Pacific and North America). Although many significant weather events occur over eastern Asia and the western North Pacific, the focus of T-PARC was on various aspects of typhoon activity, which included formation, intensification, structure change, motion, and extratropical transition. Because of the significant impact of typhoon activity on the region of eastern Asia and the western North Pacific, T-PARC was comprised of several affiliated programs. The experimental design for T-PARC addressed three primary components: (1) A tropical measurement strategy to examine circulations of the tropical western North Pacific monsoon environment as they related to tropical cyclone formation, tropical cyclone intensification, and tropical cyclone structure change. (2) Extratropical transition (ET) and downstream impacts was based on the poleward movement of a decaying tropical cyclone and the resulting intense cyclogenesis that results from its interaction with the midlatitude circulation. (3) Identification of regions in which extra observations may reduce numerical forecast error growth associated with forecasts of tropical cyclone track over the western North Pacific. Results addressed multi-scale factors in tropical cyclone formation, impacts of tropical cyclones on midlatitude flow characteristics, and the role of in situ observations in improving tropical cyclone track forecasts.

Keywords: THORPEX, Field Programs, Tropical Cyclones, Predictability
Parallel Session

SCI-PS104.02 - Reviewing the Greenland flow distortion experiment: Forecast sensitivity to observational error and steep orography

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The Greenland Flow Distortion Experiment focused on orographic flows around Greenland and Iceland, in particular barrier flows, tip jets and polar lows, and their associated air-sea interaction. As part of the IPY-THORPEX cluster of projects an aircraft-based field campaign in 2007 made the first in situ observations of some of these features, and also carried out a programme of targeted observations and forecast sensitivity experiments. Here we will briefly review results from GFDex from forecast model improvement perspective. There will be a focus on forecast sensitivity to observational error covariances and the role that high steep orography plays in corrupting appropriate data assimilation. Experiments were conducted using the Met Office Unified Model with a four-dimensional variational data assimilation scheme. Reducing the operational dropsonde observation errors by one-half increases the maximum forecast improvement from 5% to 7\textendash;10%, measured in terms of total energy. However, the largest impact is seen by replacing two dropsondes on the Greenland coast with two farther from the steep orography; this increases the maximum forecast improvement from 5% to 18%. Forecast degradation caused by two dropsonde observations on the Greenland coast is shown to arise from spreading of data by the background errors up the steep slope of Greenland. Although only from one case study, these results suggest that observations positioned within a correlation length scale of steep orography may degrade the forecast through the anomalous upslope spreading of analysis increments along terrain-following model levels.


Keywords: Orography, Data Assimilation
Sunday, 17 August 2014

Parallel Session

SCI-PS104.03 - Distinguishing the cold conveyor belt and sting jet air streams in an intense extratropical cyclone

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Strong winds equatorwards and rearwards of a cyclone core have often been associated with two phenomena, the cold conveyor belt (CCB) jet and sting jets. Here, detailed observations of the mesoscale structure in this region of an intense cyclone are analysed. The in-situ and dropsonde observations were obtained during two research flights through the cyclone during the DIAMET (DIAbatic influences on Mesoscale structures in ExTratropical storms) field campaign. A numerical weather prediction model is used to link the strong wind regions with three types of “air streams”, or coherent ensembles of trajectories: two types are identified with the CCB, hooking around the cyclone center, while the third is identified with a sting jet, descending from cloud head to the west of the cyclone. Chemical tracer observations show for the first time that the CCB and sting jet air streams are distinct air masses even when the associated low-level wind maxima are not spatially distinct. In the model, the CCB experiences slow latent heating through weak resolved ascent and convection, while the sting jet experiences weak cooling associated with microphysics during its subsaturated descent. Diagnosis of mesoscale instabilities in the model shows that the CCB passes through largely stable regions, while the sting jet spends relatively long periods in locations characterized by conditional symmetric instability (CSI). The relation of CSI to the observed mesoscale structure of the bent-back front and its possible role in cloud banding is discussed.

Keywords: Extratropical cyclone, Field campaign, Mesoscale dynamics
Parallel Session

SCI-PS104.04 - First results from the HyMeX-SOP1 field campaign dedicated to Mediterranean heavy precipitation and flash-floods

Véronique Ducrocq¹, François Bouttier¹, Julien Delanoe², Fanny Duffourg¹, Cyrille Flamant², Evelyn Freney³, Olivier Nuissier¹, Jean-Pierre Pinty⁴, Benoit Vie¹, Béatrice Vincendon¹

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The Mediterranean region is frequently affected by heavy precipitation events (HPE) associated with flash-floods (FF), landslides and mudslides each year that cost several thousands millions of euros in damage and causing too often casualties. Within the framework of the 10-year international HyMeX program dedicated to the hydrological cycle and related processes in the Mediterranean, a major field campaign has been dedicated to heavy precipitation and flash-floods from September to November 2012. The 2-month field campaign took place over the Northwestern Mediterranean Sea and its surrounding coastal regions in France, Italy and Spain. The observation strategy aimed at documenting four key components leading to heavy precipitation and flash-flooding in that region: (i) the marine atmospheric flows that transport moist and conditionally unstable air towards the coasts; (ii) the Mediterranean Sea as a moisture and energy source; (iii) the dynamics and microphysics of the convective systems; (iv) the hydrological processes during flash-floods. The presentation will briefly provide the rationale for developing this field campaign and an overview of the design and execution of the field campaign (Ducrocq et al, 2013). Highlights on specific Intense Observations Periods (IOPs) will illustrate some first results using aircraft and ground-based observations and associated modeling studies in terms of (i) atmospheric process understanding, (ii) HPE and FF predictability studies and (iii) NWP validation and improvement. HyMeX is endorsed by WWRP-THORPEX and WWRP JSC.

Keywords: Mediterranean, precipitation, flash-flood, field campaign
Parallel Session

SCI-PS105.01 - Achievements and challenges for atmospheric observations from micro- to meso-scales

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Technology for in-situ and surface-based atmospheric remote sensing instrumentation has made quite substantial progress over the last decade(s). As usual, with improving capabilities new wishes emerge, which in turn lead to new challenges. While it is not possible to comprehensively cover all atmospheric variables and all scales in a short overview, an attempt will be made to point out the major achievements (‘what did we not have twenty years ago?’), the quality of the resulting observations and the potential for improvement. New desires in general emerge from the overall tendency in atmospheric sciences to address smaller and smaller scales, which in turn is triggered mainly by communication and information technology: high-resolution numerical models – enabled through ever faster running computers - require input (assimilation) and validation data at high spatial resolution. Today’s communication protocols, in turn, do allow for measuring (and transmitting in ‘real time’) high-frequency and/or high-resolution data. While technically the limits are constantly ‘being pushed’ (i.e., more and more is technically possible), there are a number of quality issues that need to be addressed so that the observations made are able to fulfill their requirements. Finally, some outstanding issues such as a true reference turbulence observation ‘away from the surface’ will briefly be addressed.

Keywords: spatial inhomogeneity, high resolution, in-situ, remote sensing
Parallel Session

SCI-PS105.02 - Nineteen-Year (1996-2014), high-quality, high vertical resolution GPS dropsonde observations for weather research

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The GPS dropsonde was developed in 1995 by NCAR to provide atmospheric researchers and operational forecasters with targeted atmospheric profile measurements. The NCAR dropsonde system provides high-quality, high vertical resolution (5-20m) profiles of atmospheric pressure, temperature, humidity, and winds from the flight level to the surface. Over the years it has been upgraded with newer technology and capabilities, including miniaturized dropsondes for deployment from high altitude, long duration balloons and UAVs. Future developments include new sensors to measure other atmospheric parameters. Dropsondes are deployed during many hurricane and typhoon flights each year, and for scientific field experiments around the globe to study both fair and high-impact weather. Since 1996, NOAA and the US Air Force have dropped over 22,000 dropsondes into 125 tropical storms. Use of dropsondes has greatly advanced our understanding and forecasting of weather. Dropsonde data have been shown to improve hurricane track forecasts by up to 25% within the critical first two days. Dropsondes are also regularly deployed for research to study the winter storms, tropical cyclones, typhoons, strong convective systems and other severe weather events, and to ultimately improve their forecasting. We have created a long-term, high-quality, high-vertical resolution dropsonde dataset for the community. The current version includes all dropsonde soundings from NOAA hurricane flights in 1996-2012. They have been consistently and carefully quality-controlled using state-of-art QC tools, and converted to a common format. Some value-added products are generated and added to the dataset. This dataset will be described and some scientific applications will be highlighted.

Keywords: Dropsonde, Hurricane, Weather
Parallel Session

SCI-PS105.03 - GlobalSense: Next Generation, In situ observing system based on large ensembles of airborne probes

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This paper describes efforts to develop and test a system known as “GlobalSense”, which features an ensemble of disposable probes, mechanisms to deploy probes, and receiver platforms to gather data from probes. The GlobalSense probes will make measurements as they drift passively through the air with no active propulsion or flight. The initial GlobalSense application is improved weather analysis and forecasting at a broad range of scales that will be achieved by greatly expanding the time and space density of measurements throughout as much of the relevant atmospheric volume as possible. The system could have much broader impacts by measuring other parameters of interest for surveillance, reconnaissance, and related applications. GlobalSense probe design will exploit miniaturization as well as integration of micro- and nanotechnology-based components. The mass (size) of GlobalSense probes will be about 1 gram (tens of centimeters) with an aerodynamic shape based on bio-inspired designs (e.g. dandelion seeds). This probe design represents a paradigm shift in simply miniaturizing rawinsondes or dropsondes to leverage flexible and biodegradable electronic components currently being used for biomedical applications. Probes could be deployed from aircraft or as payloads on weather balloons that leverages existing infrastructure. Communication will feature ultra-low power transmission (-20 dB) directly from probes in discrete data packets. Fixed or mobile low-cost receiver platforms will decode data from multiple probes within range and store or retransmit the information to other locations. The conference presentation will highlight GlobalSense specifications, component design, and plans to test a prototype system featuring hundreds of probes.

Keywords: meteorology, microsensors, nanotechnology, observations
Parallel Session

SCI-PS105.04 - The Quebec climate monitoring program

Onil Bergeron

Ministère du Développement durable, de l’Environnement, de la Faune et des Parcs, Québec, Canada

The ministère du Développement durable, de l’Environnement et de la Lutte contre les changements climatiques sustains its own climate, air quality and precipitation quality monitoring programs. The climate monitoring network comprises over 350 stations, either fully automated or operated by an observer. Under the 2006-2012 provincial climate change action plans, the climate monitoring program has been consolidated by modernizing most stations, by extending the spatial extent of the network to northern regions and urban environments, by archiving historical data and by publishing new climate products such as normals and extremes for the 1870-2010 and 1960-2010 temperature trends. The fifth priority of the current (2013-2020) climate change action plan provides provisions to further the dissemination of high quality climate products to clients, partners and the general public. Among planned activities, new climate stations will be installed through partnerships in areas where coverage is lacking, including northern Quebec and urban environments. Also, further historical data will be archived, quality controlled and analyzed. New climate indicators and trends will be published and an effort will be placed on making available gridded data for part of or the entire province, as required by clients and partners. The vast majority of Quebecers live in cities, which translates into increasing demand of weather and climate information relevant locally. To meet demand, the Ministry developed new methodologies to monitor weather and climate in urban areas. Results from short-term measurement campaigns and compact weather stations to be deployed in a number of residential neighbourhoods will also be presented.

Keywords: Québec, Canada, observations, climate products, urban climate
The use of observations in global Numerical Weather Prediction

Florence Rabier\textsuperscript{1}, Nathalie Boullot\textsuperscript{2}, Carla Cardinali\textsuperscript{2}, Fatima Karbou\textsuperscript{2}, Jean-Francois Mahfouf\textsuperscript{2}, Jean-Noel Thepaut\textsuperscript{1}

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Numerical Weather Predictions systems have undergone tremendous changes in the last decades. One of the most striking ones is certainly in the use of observations in their data assimilation systems. In parallel with the development of satellite instruments, the NWP community has devoted a lot of efforts to make the best of this new source of data, and has progressed to the point where satellite data now dominate in terms of number and impact. Major NWP centres have developed tools to quantify the impact of various types of observations, through Observing System Experiments, measures of the information content and of the reduction in forecast error brought by the different systems of observations. Results from ECMWF and Meteo-France will illustrate some of the similarities and differences in the use and impact of observations. Some examples will also be given on various developments taking place to enhance the usefulness of observations, such as bias correction, combining observations, using satellite data over land, sea-ice and clouds.

Keywords: Observations, Data assimilation, Numerical Weather Prediction
Parallel Session

SCI-PS106.02 - Assimilating cloud affected infrared radiances at the Met Office

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Infrared radiances from advanced atmospheric sounders (e.g. IASI, AIRS and CrIS), make a significant contribution to the accuracy of NWP model forecasts. They provide information on temperature, water vapour, cloud properties and surface variables. Initially the assimilation of infrared radiances was limited to clear-sky scenes, due to limitations in forward modelling and data assimilation techniques in cloudy situations. More recently progress has been made in extending the use of infrared observations to cloudy areas in order to extract more information to provide to the NWP analysis. However, the assimilation of cloud affected radiances has proven to be challenging, and work towards exploiting this information in operational NWP systems is still at an early stage. The scheme currently used operationally at the Met Office, describing its relative strengths and weaknesses will be outlined together with ideas for further development with the eventual aim of assimilating cloud information directly.

Keywords: Radiance assimilation, Infrared, Cloud, NWP
Parallel Session

SCI-PS106.03 – Withdrawn - Observation contribution in the analysis of CPTEC/INPE G3DVAR

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The Center for Weather Forecast and Climate Studies from the Brazilian National Institute for Space Research (CPTEC/INPE) is using the Global 3DVar (G3DVAR) as the operational data assimilation system at the center. The G3DVAR consists of the main subsystems: the Atmospheric Global Circulation Model (AGCM) developed at CPTEC/INPE; and the Gridpoint Statistical Interpolation (GSI) analysis system, jointly developed by NOAA, NASA, and NCAR. Efforts are presently on the way to evaluate G3DVAR using the latest components of the observing system. One evaluation of interest is the contribution obtained on the analysis with the addition of these components into the observing system. The present work outlines the effort under way to evaluate the observation contribution from these components into G3DVAR analysis using an observation impact tool formulated in the observation-space. Furthermore this presentation will show a briefly comparison using traditional methods and this observation-space metric inferring impacts.

Keywords: data assimilation, observation impact
Parallel Session

SCI-PS106.04 - A WRF-based mixed variational and nudging assimilation scheme for US Army convection-scale nowcasting

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The US Army Research Laboratory (ARL) has been developing and testing a WRF-based observation nudging FDDA (four-dimensional data assimilation) system to provide high spatial resolution (~ 1 km) and frequently updated (~ 1 hr) short range forecasts or “nowcasts” of the battlefield environment out to the 3-6 hr time frame. ARL calls this system the Weather Running Estimate-Nowcast (WRE-N) which assimilates asynoptic direct observations from sources such as local soundings, surface observations, and aircraft in-situ measurements. The FDDA nudging technique has been proven in past research to be efficient and effective at convection-resolving scales; however, it lacks capability to assimilate indirect observations such as radar radial wind/reflectivity and satellite radiance. In order to take advantage of indirect local observations from remote sensing instruments (often of resolution critical to convection-resolving scales), a mixed or “hybrid” data assimilation system is in the process of being developed and tested for the WRE-N model. This technique uses the observation or “station” nudging for direct observations in addition to three-dimensional (3D) grid nudging using analyses created by a different assimilation technique in order to combine the advantages of both nudging and 3DVAR. The 3D analyses used for the grid nudging will be produced by the Variational LAPS (Local Analysis and Prediction System) developed by National Oceanic and Atmospheric Administration (NOAA)’s Global System Division (GSD). It is expected that the WRE-N model utilizing both observation/analysis nudging and using the Variational LAPS analysis (assimilating radar and satellite data) will improve forecasting skill in the 0-3 hr period.

Keywords: WRF, data assimilation, nowcast, hybrid data assimilation
Parallel Session

SCI-PS107.01 - Evaluating the Impact of Aerosols on Numerical Weather Prediction

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The Working Group on Numerical Experimentation has organized an exercise to evaluate the impact of aerosols on NWP (WMO, http://www.wmo.int/pages/about/sec/rescrossect/resdept_wgne.html). This exercise will involve regional and global models currently used for weather forecast by the operational centers worldwide and aims at addressing the following questions: a) How important are aerosols for predicting the physical system (NWP, seasonal, climate) as distinct from predicting the aerosols themselves? b) How important is atmospheric model quality for air quality forecasting? c) What are the current capabilities of NWP models to simulate aerosol impacts on weather prediction? Toward this goal we have selected 3 strong or persistent events of aerosol pollution worldwide that could be fairly represented in current NWP models and that allowed for an evaluation of the aerosol impact on weather prediction. The selected events includes a strong dust storm that blew off the coast of Libya and over the Mediterranean, an extremely severe episode of air pollution in Beijing and surrounding areas, and an extreme case of biomass burning smoke in Brazil. The experimental design calls for simulations with and without explicitly accounting for aerosol feedbacks in the cloud and radiation parameterizations. In this presentation we will summarize the results of this study focusing on the evaluation of model performance in terms of its ability to faithfully simulate aerosol optical depth, and the assessment of the aerosol impact on the predictions of near surface wind, temperature, humidity, rainfall and the surface energy budget.

Keywords: aerosols, weather, prediction, radiation
Parallel Session

SCI-PS107.02 - Impact of aviation emissions on the Arctic environment – GEM-AC model simulations

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The continuing decrease of ice cover over the Arctic allows for the increase in shipping and industrial activities in the region. These activities will lead to the increase of anthropogenic emissions from shipping, prospecting, exploration, and smelting. Emissions from shipping are dominant and their magnitude and impact on the Arctic environment have been addressed in recent publications. The objective of this study is to investigate the impact of the increased demand for commercial aviation transport to the Arctic on air quality near the ground as well as the impact of aviation emissions injected at cruise altitudes (9–11 km) which in many cases will be above the tropopause. We will present results from the GEM-AC (Global Environmental Multiscale with Atmospheric Chemistry) model simulations for several aviation emissions scenarios. GEM-AC is a chemical weather model where air quality, free tropospheric and stratospheric chemistry processes are on-line and interactive in an operational weather forecasting model of Environment Canada. In vertical, the model domain is defined on hybrid levels from the surface to ~60km. The gas-phase chemistry includes detailed reactions of Ox, NOx, HOx, CO, CH4, NMVOCs, halocarbons, ClOx and BrO. Also, the model can address aerosol microphysics and gas–aerosol partitioning. Results from model simulations on a global variable grid with ~50 km uniform horizontal resolution over the Arctic for current climate and 2050 RCP 6.0 and 8.5 climate scenarios will be presented.

Keywords: Arctic emissions, Chemical modelling, UTLS, aviation emissions
Parallel Session

SCI-PS107.03 - Does natural and anthropogenic aerosol have an impact on numerical weather prediction?

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The relative importance of aerosol particles for weather forecast is yet not quantified. The treatment of the interaction of the involved processes requires a new class of weather forecast models. The model system COSMO-ART (Vogel et al., 2009, Bangert et al., 2012) is a comprehensive online coupled model system to simulate the spatial and temporal distributions of reactive gaseous and particulate matter. It is used to quantify the feedback processes between aerosols and the state of the atmosphere on the continental to the regional scale with two-way interactions between different atmospheric processes. To simulate the impact of the various aerosol particles on the cloud microphysics and precipitation COSMO-ART was coupled with the two-moment cloud microphysics scheme of Seifert and Beheng (2006) by using parameterisations for aerosol activation and ice nucleation. The model system was applied for different model domains and meteorological situations to quantify the direct and the indirect impact of the natural and anthropogenic aerosol particles. This includes the effects of mineral dust, seas salt, biomass burning as well as anthropogenic aerosol. As examples we quantified the impact of mineral dust on temperature forecast above Europe, the role of vegetation fires for static stability and atmospheric turbulence, and the impact of sea salt on heavy precipitation in the Mediterranean. An outlook is given up to which extend and for which purposes aerosols should be included in numerical weather prediction models in the future.

Keywords: aerosol, air quality, weather prediction
 Parallel Session

SCI-PS107.04 - Modelling the Canadian Arctic and northern air quality using GEM-MACH

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The Arctic is recognized as one of the key areas of the globe, both in terms of its sensitivity to climate change, and by the increasing economic activity associated with the opening up of Arctic waters in a warming climate. Environment Canada is undertaking an initiative to develop a GEM-MACH based air quality prediction capacity for the Canadian North and Arctic region, in the context of assessing the impacts of the current and future air contaminant emissions from shipping and other sources on the northern environment and human health. There are many challenges for modelling the Arctic air quality, such as capturing long-range transport of pollutants as well as local emissions (both anthropogenic and natural) and physical and chemical processes under the unique polar and northern environment. In this paper, we describe the current development being undertaken in addressing some of these challenges, including model configuration and science module updates. A preliminary evaluation of a series of model simulations for the year 2010 against available observations will be presented. The impact of chemical boundary conditions, removal processes, and the North American wild fire emissions on the model simulations will be discussed.

Keywords: Arctic air quality, air quality modelling, air quality prediction
Clouds play a fundamental role in shaping our weather and climate. They serve as a critical pathway in the cycling of water from and to the Earth's surface and profoundly affect the radiation balance of the planet. Thus, they provide a profound connection between water and energy, and this connection will be highlighted through the talk. Gaps in our understanding of radiative processes, cloud and precipitation processes, and the connections between them and aerosol will be highlighted. Sources of systematic error in models will be noted, and suggestions toward improving these systematic errors will be described.

**Keywords:** Cloud, Radiation
Parallel Session

SCI-PS108.02 - The influence of Cloud Radiative Effects (CRE) on the ITCZ position

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The double ITCZ problem in AGCMs is most probably caused by deficiencies in the parameterizations. The design of the parameterizations reflect the knowledge about the parameterized processes and their coupling to the dynamics. Therefore model errors hint at shortcomings in the understanding of the atmospheric processes. Therefore the analysis of model errors is also an opportunity to better understand these processes. The double ITCZ problem is also present on aqua-planets, which have the advantage that their simple surface conditions significantly eases the analysis of the convective organization processes. For ECHAM6 in aqua-planet mode the occurrence of deep convection strongly depends on free tropospheric humidity. For a single ITCZ to form the ITCZ must be moister than its surroundings. The humidity mainly depends on the large-scale vertical velocity, which depends on the sum of convective heating and radiative cooling. For a single ITCZ to form the CRE must be higher in the ITCZ than poleward of it. Sensitivity experiments with the ECHAM6 aqua-planet are performed where the cloud liquid, ice and cover input to the radiative transfer calculation is replaced by idealized climatologies. Results show that only the CRE of the ice anvils affect the ITCZ position. The ice anvil CRE depends on cloud cover and vertical ice distribution rather than total ice path. This means that the double ITCZ problem is insensitive to errors in liquid clouds, but to errors in the production of ice by deep convection and errors in the cloud cover of ice anvils.

Keywords: double ITCZ problem, Cloud Radiative Effect
Parallel Session

SCI-PS108.03 - Information content of infrared hyperspectral data: clear-sky vs. all-sky

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We examine the variability of the high-resolution infrared radiance (HIR) spectra in weather and climate variations, with a focus on the comparison of information contents of the data under clear- and all-sky conditions. Synthetic radiance simulated from weather and climate models will be compared to actual measurements (Atmospheric Infrared Sounder, AIRS). The investigation aims at understanding whether and how high temporal coverage HIR data, which may be made available by geostationary and highly elliptical orbit satellites, may impact weather forecast through data assimilation, may enable early detection of weather events, and may be used for validating climate models and diagnosing their biases through radiance-level comparison.

**Keywords:** high-resolution spectrum, cloud, radiation, information content
Deep convective clouds (DCCs) associated with tropical convection, are significant sources of precipitation and play a key role in hydrological and energy cycle. Weather Research and Forecasting model as a three-dimensional large-eddy simulation model with detailed bin-resolved microphysics is used to explore diurnal variation of DCCs under clean and polluted conditions. Sensitivity of the aerosol-cloud-precipitation interactions to variation of sea surface temperature (SSTs), free tropospheric humidity, large-scale divergence rate, and wind speed is assessed. Sign and magnitude of the Twomey effect, droplet dispersion effect, cloud thickness effect, and cloud optical depth (COD) susceptibility to aerosol perturbations is also evaluated. Twomey effect emerges as dominant in total COD susceptibility to aerosol perturbations. Dispersion effect is positive and accounts for 3% to 10% of the total COD susceptibility at nighttime, with greater influence in heavier drizzling clouds. The cloud thickness effect is negative for non/light drizzling cloud and positive for a moderate/heavy drizzling clouds; the cloud thickness effect contributes 5% to 22% of the nighttime total cloud susceptibility. Overall, the total COD susceptibility ranges from 0.28 to 0.53 at night; an increase in aerosol concentration enhances COD, especially with heavier precipitation and in a pristine environment. During the daytime, the range of magnitude for each effect is more variable owing to cloud thinning and decoupling. The ratio of magnitude of cloud thickness effect to that of the Twomey effect depends on cloud base height and cloud thickness in unperturbed clouds.

**Keywords:** aerosols, clouds, precipitation, convection
Parallel Session

SCI-PS109.01 - Tropical-Extratropical interactions illuminated through adjoint studies

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Adjoint-based tools can provide valuable insight into the mechanisms that influence the evolution and predictability of atmospheric phenomena. An adjoint model can be used for the efficient and rigorous computation of forecast sensitivity to changes in the initial state, and for the calculation of leading singular vectors, which are the fastest growing perturbations to a forecast trajectory. We apply adjoint-based tools from the non-hydrostatic Coupled Atmosphere/Ocean Mesoscale Prediction System (COAMPS) and the Navy Operational Global Atmospheric Prediction System (NOGAPS) to explore interactions between the tropics/subtropics and mid-latitudes that influence the predictability of both tropical and mid-latitude cyclones. The adjoint-based calculations illustrate complex influences on cyclone evolution from phenomenon that are often quite remote, and integration of the adjoint-based perturbation can illustrate rapid downstream energy propagation from the perturbed cyclone itself. Several examples of tropical-extratropical interactions are presented. Tropical cyclones that are recurving into the mid-latitudes show sensitivity to mid-latitude troughs several thousand kilometers upstream over a 48-h period. Subsequent evolution of these perturbations exhibits rapid downstream energy growth and propagation, crossing the North Pacific basin in 72 hours. The Northwestern Pacific Typhoons Lupit (2009) and Shanshan (2006) are used as examples to illustrate these complex interactions (Reynolds et al. 2009). We also explore how the development of mid-latitude cyclones, such as the powerful storm Xynthia, (Doyle et al. 2014) that had a severe socioeconomic impact on Europe, may be very sensitive to the subtropical environment, particularly subtropical moisture. Implications of these findings for the predictability of cyclones will be discussed.


Keywords: Predictability, Tropical-Extratropical Interactions, Adjoint Studies
SCI-PS109.02 - Dynamical processes and forecast uncertainty associated with extreme weather over North America during October 2007

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This study examines the large-scale dynamical processes and forecast uncertainty associated with three concurrent extreme weather events over North America during 22–25 October 2007: wildfires in southern California, a cold surge into eastern Mexico, and widespread heavy precipitation in the south-central United States. The events were dynamically linked to anticyclonic wave breaking (AWB) over central North America and the attendant formation of an elongated potential vorticity (PV) streamer, which occurred in connection with a high-amplitude Rossby wave train extending across the North Pacific. Examination of ECMWF ensemble forecasts from TIGGE indicates large uncertainty associated with the AWB and, correspondingly, large uncertainty and low skill in the precipitation and surface temperature forecasts over central and eastern North America, but not in the forecasts of wildfire conditions in California. It is found that the uncertainty in the AWB is closely related to variability in the representation of the interaction between a diabatic Rossby vortex and an upper-level PV disturbance over the eastern North Pacific. Specifically, ensemble members in which this interaction is too strong exhibit overly intense ridge amplification over western North America and produce the AWB too far west. These members exhibit large precipitation and surface temperature forecast errors over central and eastern North America, displacing the heavy precipitation to the west and failing to capture the Mexico cold surge. Conversely, ensemble members that more accurately represent the interaction produce the AWB farther east and exhibit more accurate precipitation and surface temperature forecasts over central and eastern North America.

Keywords: extreme weather, predictability, Rossby waves
Parallel Session

SCI-PS109.03 - Sensitivity and predictability of severe extratropical cyclones

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We explore initial condition sensitivity and predictability aspects of three extratropical cyclones, Xynthia (2010), Klaus (2009), and the St. Jude’s Day Storm (2013), which had a severe impact on Europe. We highlight how higher- and lower-latitude interactions contribute to the development of these cyclones. The adjoint, tangent linear, and nonlinear models for the atmospheric portion of the nonhydrostatic COAMPS are applied with 45 and 15 km resolution nested grids. The adjoint sensitivity results for all three storms underscore the importance of a plume of low-level moisture of sub-tropical origin. The adjoint diagnostics indicate that the intensity of severe winds in these storms just prior to landfall was especially sensitive to perturbations in the moisture and temperature fields and to a lesser degree the wind fields. Only a relatively small region of water vapor within an atmospheric river present at the initial time for all three storms was critically sensitive for the development of all three cyclones, in spite of the large differences between the storms in their structure and developmental evolution. The results of this study underscore the need for accurate moisture observations and data assimilation systems that can adequately assimilate these observations in order to reduce the forecast uncertainties for these severe extratropical cyclones. However, given the nature of the sensitivities and the potential for rapid perturbation and error growth, the intrinsic predictability of severe cyclones such as Xynthia, Klaus, and the St. Jude’s Day storm is limited.


Keywords: predictability, extratropical cyclones, adjoint
Parallel Session

SCI-PS109.04 - Predictability of explosive cyclogenesis over the northwestern Pacific region using ensemble reanalysis

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The predictability of explosive cyclones over the northwestern Pacific region is investigated using an ensemble reanalysis dataset. Explosive cyclones are categorized into two types according to whether the region of the most rapid development is in the Sea of Okhotsk or Sea of Japan (OJ) or in the northwestern Pacific Ocean (PO). Cyclone-relative composite analyses are performed for analysis increments and ensemble spreads at the time of the maximum deepening rate. The increment composite shows that the OJ explosive cyclone center is forecast too far north compared to the analyzed center, whereas the PO explosive cyclone is forecast shallower than the analyzed center. To understand the cause of these biases, a diagnosis of the increment using the Zwack–Okossi (Z-O) development equation is conducted. The results suggest that the increment characteristics of both the OJ and PO explosive cyclones are associated with the most important cyclone development mechanisms. The OJ explosive cyclone forecast error is related to a deeper upper trough, whereas the PO explosive cyclone error is related to weaker latent heat release in the model. A diagnosis of the spread utilizing the Z-O development equation clarifies the mechanism underlying the uncertainty in the modeled sea level pressure. For OJ explosive cyclones, the spread of adiabatic warming causes substantial sea level pressure spreading southwest of the center of the cyclones. For PO explosive cyclones, the latent heat release causes substantial sea level pressure spreading around the cyclone center.


Keywords: Explosive cyclone, Predictability, LETKF, AGCM
Parallel Session

SCI-PS110.01 - Interactions between equatorial waves and tropical cyclones

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This presentation will demonstrate observed associations between equatorial waves and tropical cyclones, covering how selected types of equatorial waves generate environments favorable for tropical cyclogenesis and will show the favored patterns in which tropical cyclones form within the waves. It will also show how tropical cyclones generate equatorial wave signals that help encourage formation of additional tropical cyclones in preferred geographical regions. The presentation will end with a demonstration of the impact of atmospheric Kelvin waves and tropical cyclone formation in the Atlantic main development region.

References: http://journals.ametsoc.org/doi/abs/10.1175/MWR3204.1

Keywords: cyclogenesis, equatorial waves, Madden Julian Oscillation, Kelvin waves
Parallel Session

SCI-PS110.02 - Tropical cyclogenesis in a tropical wave critical layer

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In general, observation has indicated that only a small fraction of the easterly waves occur in a single hurricane season contribute to tropical cyclogenesis. However, this small fraction includes a large portion of named storms. In addition, it has recently been shown that named storms in the Atlantic and eastern Pacific basins are almost all associated with a cyclonic Kelvin cat’s eye of a tropical easterly wave critical layer, located equatorward of the easterly jet axis. Therefore, to better understand the dynamics involved in tropical cyclogenesis, it is desirable to investigate the flow characteristics and the physical mechanism for an easterly wave to form a cat’s eye. Our methodology involves performing a climatological study of developing easterly waves covering the 1998-2001 hurricane seasons using the ECMWF ERA-Interim 6-hourly reanalysis data. Spatial and temporal filtering was applied to decompose the desired fields, and time-lagged composites were obtained in a translating reference frame following the disturbances. Statistical analysis is also used to determine the levels of confidence in the obtained pattern from the composite fields to assess the reliability of the results. Nonlinear shallow water model experiments are used to dynamically interpret the results of the climatological analysis. It is found that the nonlinear evolution of instabilities associated with critical layers play a significant role in generating coherent cyclonic vortices with spatio-temporal structures consistent with the tropical cyclogenesis analysis.

Keywords: tropical cyclogenesis, critical layer, Kelvin cat’s eye, easterly wave
Monsoon gyres (MGs) and monsoon depressions (MDs), commonly found over the western Pacific Ocean, are characterized by broad low-level cyclonic circulations that occur at a variety of spatial scales (1000-2500 km). Similar gyre circulations are also observed, but have rarely been studied, over Central America (CA) during the tropical cyclone (TC) season. A gyre event in late September 2010 that occurred in association with multiple TCs resulted in flooding rainfall exceeding 200 mm over a large swath of CA, the Caribbean Islands, and the eastern United States. The relative lack of prior research on CA gyre occurrences, their apparent links to TC activity, and their association with high-impact weather motivates this presentation. To study CA gyre occurrence, an algorithm was developed to objectively identify cyclonic circulations on the same spatial scale and characteristics as MDs and MGs. This algorithm included a series of tests to distinguish between gyre events versus null cases. The algorithm was used to produce an objective CA gyre climatology between May-November 1980-2010. A total of 42 CA gyre cases were identified objectively. A bimodal distribution in gyre activity was observed with peaks in May and October. Earth-relative CA gyre composites showed that anomalous zonal flow and precipitable water was present in the days prior to CA gyre formation. Stratification of the 42 gyre cases by the phase of the Madden-Julian Oscillation showed that over 75% of gyre events occur in phases 8, 1, and 2.

**Keywords:** Gyre, Anomalous Winds, Precipitable Water, MJO
The tropical cyclone (TC) boundary layer (TCBL) – featuring extreme winds over a rough ocean – is difficult to study observationally. With increasing computational power, high-resolution Large Eddy Simulation (LES) has become an attractive tool to advance understanding of the TCBL. Here, an idealized Cartesian-based LES is employed to investigate boundary layers driven by extreme TC-like winds. The LES includes the effects of centripetal acceleration through an “effective” Coriolis parameter $f^* = f + 2V/R$, with Earth Coriolis parameter $f$, interior wind $V$, and (fixed) radius $R$. Multiple LES experiments are conducted to elucidate how the boundary layer develops and persists in the strongly rotating TC environment. In all simulations, an overshooting jet develops, the height of which increases with $V$, $R$, and surface drag. Normalized jet strength also increases with $R$ and drag, but decreases with $V$. Turbulent diffusivity $K$ – which must be parameterized in mesoscale models but is explicitly resolved by LES – varies considerably both within and between simulations. Also evident is a damping inertial oscillation with a period close to the theoretical $2\pi/f^*$. The periodic lateral boundaries of the LES (that is, the LES acts as a box model) allow for a comparison with a linearized partial-slip Ekman spiral. The simulations agree with the linear model, except when the effects of $K$ overwhelmingly counter those of $V$. The box-model LES does not account for large-scale vertical motions or horizontal wind gradients, features known to be important in the TCBL.

**Keywords:** Large Eddy Simulation, Tropical Cyclone, Boundary Layer
Parallel Session

SCI-PS111.01 - Overview of the Polar Prediction Project

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The Polar Prediction Project (PPP) was established, under the World Weather Research Programme, to coordinate international research aimed at improving polar predictions on time scales from hours to seasonal. A key component of PPP is the Year of Polar Prediction (YOPP), which is planned for mid-2017 to mid-2019, centred on 2018. The goal of YOPP is to enable a significant improvement in environmental prediction capabilities for the polar regions and beyond, by coordinating a period of intensive observing, modelling, verification, user-engagement and education activities. This presentation will provide an overview of the scientific objectives and implementation plans for both the Polar Prediction Project and the Year of Polar Prediction.

Keywords: PPP, YOPP, WWRP
Parallel Session

SCI-PS11.02 - Reducing spread in climate model projections of a September ice-free Arctic

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This presentation addresses the specter of a September ice-free Arctic in the 21st century using newly available simulations from the Coupled Model Intercomparison Project Phase 5 (CMIP5). We find that large spread in the projected timing of the September ice-free Arctic in 30 CMIP5 models is associated at least as much with different atmospheric model components as with initial conditions. Here we reduce the spread in the timing of an ice-free state using two different approaches for the 30 CMIP5 models: (i) model selection based on the ability to reproduce the observed sea ice climatology and variability since 1979 and (ii) constrained estimation based on the strong and persistent relationship between present and future sea ice conditions. Results from the two approaches show good agreement. Under a high-emission scenario both approaches project that September ice extent will drop to \(\sim 1.7\) million km² in the mid 2040s and reach the ice-free state (defined as 1 million km²) in 2054-2058. Under a medium-mitigation scenario, both approaches project a decrease to \(\sim 1.7\) million km² in the early 2060s, followed by a leveling off in the ice extent.

Keywords: ice-free Arctic, climate model
SCI-PS111.03 - Overview of an integrated marine Arctic prediction system for METAREAs

Hal Ritchie¹, Natacha Bernier², Mark Buehner², Tom Carrières¹, Serge Desjardins¹, Luc Fillion², Diane Johnston⁴, Pierre Pellerin², Gregory Smith², Gilles Garric⁵

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In December 2007 Canada accepted official designation as the Issuing Service for meteorological Marine Safety Information in the form of forecasts / warnings and ice bulletins for METAREAs XVII and XVIII as part of the Global Maritime Distress and Safety System. These areas are in the Arctic bordering on Canada. An important part of Environment Canada’s involvement is the development of an integrated marine Arctic prediction system and satellite products in support of monitoring and warnings. In particular, our group is working on the development, validation and implementation of marine forecasts using a regional high resolution coupled multi-component (atmosphere, land, snow, ice, ocean and wave) modelling and data assimilation system to predict near surface atmospheric conditions, sea ice (concentration, thickness, pressure, drift, ice edge), freezing spray, waves and ocean conditions (temperature and currents). The core of the system consists of the GEM (Global Environmental Multi-scale) model as the atmospheric component coupled to the NEMO (Nucleus for European Modelling of the Ocean) ocean model, the CICE ice model and the WAVEWATCHIII® wave model. An ice-ocean data assimilation system is being developed in collaboration with Mercator-Océan using their system for ocean data assimilation together with the ice analysis system developed at Environment Canada. The METAREAs research and development is a cornerstone activity within the Canadian Operational Network of Coupled Environmental PredictTion Systems (CONCEPTS). This presentation will provide an overview of these activities, illustrate some results to date, discuss plans for future operational systems, and link with other complementary presentations at this meeting.

Keywords: Arctic, marine, coupled, forecasting
Observations of turbulent momentum and heat fluxes over the Arctic marginal ice zone will be presented. The observations were made via three aircraft-based field campaigns - in March and April 2013 with two aircraft, and in July 2013 with one - in the vicinity of Svalbard. The campaigns were part of the ACCACIA project: Aerosol-Cloud Coupling And Climate Interactions in the Arctic. Low-level aircraft legs have been used to estimate turbulent quantities, in particular the turbulent fluxes, roughness lengths and exchange coefficients. These are analysed as a function of sea-ice concentration and sea-ice morphology. Atmospheric boundary-layer profiles will also be used to characterise boundary-layer development. Typically flights range from moderately stable conditions (occasionally in cloud) to moderately unstable conditions across the MIZ. In some cases a well-developed internal boundary layer was in place. The sea-ice roughness lengths and exchange coefficients will be compared to recently published bulk flux algorithms appropriate for summer and marginal sea ice conditions.

**Keyword:** ACCACIA
Parallel Session

SCI-PS12.01 - Future Nowcasting Systems: Lessons from the WWRP Olympic Nowcasting Projects

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³China Meteorological Administration, Beijing, China, ⁴Roshydromet, Moscow, Russia

The World Meteorological Organization in co-operation with the host meteorological agency has organized several nowcasting Forecast Demonstration Projects related to the summer and weather Olympics. The service requirements of the Olympics are future looking. High accuracy but also high precision is required in space and time. The nowcasting of different weather elements besides precipitation, such as wind speed and direction, temperature and visibility are also required in the Olympics and these are new nowcast requirements. The projects bring together new systems as few address the breadth of the specificity of the nowcasting service requirements. A key element to all the projects was the availability and deployment of advanced monitoring and observations systems for understanding, assimilation, validation and verification of the nowcasts. Operational forecasting issues of technology transfer, forecaster training, development of new skill sets, work flow and service provision are equally challenging and impact on the design of the forecast system of the future and the process to get there, particularly, when no system is perfect and there are inherent technological limitations to the accuracy and precision of the predictions. While summer and winter have different challenges, a consistent message from these projects include the need for expertise to understand the weather, the need to understand the systems, the ability to create a learning environment for technology transfer, to need to create systems that have analysis and diagnosis capability and not just provide the answer and the development of trust with the system and with the end user.

Keywords: nowcasting, forecast systems, WWRP
Deep convection has high impact on flight safety and air traffic management (ATM) efficiency. Particularly organised convection (e.g. squall lines) leads to significant reduction of available airspace for air traffic. In addition isolated cells located at airports or on approach routes significantly reduce airspace capacity and affect ground handling. Complementary to mandatory aviation warning products a deep convection forecast product is operationally provided aiming to support operational decision making and strategic planning of ATM. The horizontal distribution of deep convection is forecasted for each air space sector as a measure of impact on air traffic capacity. The forecast range covers up to three hours for the approach sectors and up to six hours for the area control centre sectors. The operational product is manually generated by forecasters. A refined product incorporates input from automatic nowcasting and numerical weather prediction systems. This facilitates increased spatial and temporal coverage. Newly developed forecaster intervention tools allow manual modification of the automatic forecasts to improve the results. This way also a smooth transition between the nowcasting and longer range forecasting system results can be ensured. The product is designed to provide the relevant meteorological information in an easily and quickly perceivable way to ATM experts without meteorological background for lead times from several minutes up to several days. This is achieved by using simple pictograms in combination with clear color-codes on geographical maps.

Keywords: deep convection, air traffic management, forecaster intervention, air space capacity
SCI-PS112.03 - Impact of heat stress on agricultural crops

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In 2010, when more than 20% of Russian agricultural producing areas were affected by unprecedented extreme high temperatures, wheat prices increased by up to 50% in the international market. High temperatures are a major constraint to crop adaptation and productivity, especially when these temperature extremes coincide with critical stages of plant development. Mean temperature affects yield by determining the duration of developmental stages, while the impact of high temperatures, particularly near flowering, is primarily on the setting of fruit or grain. Peaks of high temperature, even when occurring for just a few hours, can drastically reduce the production of important food crops. Because interactions between the weather and crop are important, in particular at critical phonological stages, it is weather rather than climate prediction that is needed for crop modeling applications. Therefore, forecasts of heat stress on agricultural crops for the coming season require accurate seasonal weather forecasting. We perform an explicit assessment of heat stress at a global level for four important food crops (rice, maize, wheat and soybean) using the Global Seasonal Forecasting System. The crop damages by heat stress are found for continental lands at high latitudes, particularly in the Northern Hemisphere. Investment in local adaptive measures such as development of resistant varieties and changes in crop management are necessary to minimize risks to global food supply.

**Keywords:** heat stress, agriculture, Global Seasonal Forecasting System
Parallel Session

SCI-PS112.04 - The envisioned aviation weather services and challenges to nowcasting science

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The next generation aviation initiative, namely the Aviation System Block Upgrade (ASBU) endorsed by International Civil Aviation Organization in 2012, will see major enhancement to aviation meteorological services (MET) in the next 15+ years. The key concept in ASBU is the “Trajectory Based Operations” (TBO) which would integrate high resolution, rapidly updated nowcast and very-short-range forecast along the flight trajectory with the air traffic management (ATM) systems for strategic and tactical phases of the air traffic operation. This would impose quite significant requirements on the existing nowcasting products and high resolution numerical models for producing the appropriate TBO products. Under ASBU, not only the meteorological information’s spatial and temporal resolution and accuracy performance need to be enhanced, but also the uncertainties information would need to be provided for ATM risk assessment. Another important component under ASBU is the MET-ATM Integration, which requires the MET information (observations, nowcast/forecast data) to be translated into ATM impact for facilitating the end users, e.g., traffic controller and pilot, to make real-time (<20mins) and near-real time tactical (>20mins upto hours ahead) decisions. In addition, verification would be required to demonstrate the usefulness of these products. The WMO/WWRP, supported by WMO/CAeM, will set up an aviation specific Research Demonstration Project at several airports with a view to assessing the state-of-the-art and advancing the nowcast/very-short-range forecasting capabilities in order to meet the new aviation requirements. This paper will present the envisaged aviation weather services and point out the challenges for the meteorological community in this application area.

Keywords: Aviation Weather Services, ASBU, Nowcasting, WWRP & CAeM
UAS-PA400 Panel Discussion

Energy and transportation services, applications and decisions
Panelists representing or serving weather-sensitive agencies or enterprises in the energy and transportation sectors will share how their activities are affected by weather and climate and how they utilize weather information in their decision-making. The feedback will be used to guide the direction of future scientific research, applications and services.

Chair: Alberto Troccoli

UAS-PA400.01 - Panel Participant
Laurent Dubus¹
¹EDF, R&D, Chatou, France

UAS-PA400.02 - Integrating weather and power forecasts into an operational decision support system for transmission system operators
Daniel Lee¹, Isabel Alberts¹, Vanessa Stauch¹, Kristina Lundgren¹
¹German Weather Service, Offenbach, Germany

EWeLiNE is a cooperation between the Fraunhofer Institute for Wind and Energy System Technology, the German Weather Service and several transmission system operators (TSOs). The aim is to investigate the benefit of wind and solar power production data for weather forecasts, optimize weather forecasts as input for high accuracy renewable energy power production forecasts and incorporate probabilistic information into decision making tools for TSOs. The improvements in the weather and power models models and new products should aid TSOs in rising to the growing challenge of integrating weather-dependent energy sources into the power grid. The project is planned and carried out in close cooperation with the involved TSOs in order to ensure the usability of the products developed. It will conclude with a demonstration phase, in which the improved models and newly developed products are combined into a process chain and used to provide information to TSOs in a real-time decision support tool. This phase presents several challenges due to the heterogeneity of the TSOs' technical infrastructure and the degree of specialization in the information incorporated into the tool. In order for the products to be useful, it is essential that they are presented in a user-friendly fashion, and that highly specialized data concerning meteorological variables and energy infrastructure are presented concisely and in detail while remaining understandable for users without a background in meteorology. This presentation will highlight the opportunities and challenges encountered in the project and particularly in the demonstrator phase, as well as show the implementation plans.

Keywords: renewable energy, power forecast, user communication, grid integration
Sunday, 17 August 2014

UAS-PA400.03 – Panel Participant

France Bernard¹
¹Ville de Montreal, Montreal Canada

UAS-PA400.04 – Panel Participant

Sheldon Drobot¹
¹NCAR, Boulder, Co, USA

Please refer to the WMO website for presentations (if available) related to this panel
SCI-SPL01 - Science Plenary Session
The science of weather forecasting: past successes and future challenges.

Significant advances have been made during the last decade in the science and technology underpinning weather forecasting. Many of these have been translated into improvements in operational forecasting systems so that more detailed information is available to mitigate the impact of weather-related hazards on society, the economy and the environment. Through these advances we are closer to realising the vision of "seamless prediction of the earth system from minutes to months", achieving a truly seamless transition from weather to climate, and providing information on weather impacts that is tailored to user needs. In this plenary session we will explore this vision further, review the progress made in the THORPEX World Weather Research Programme (WWRP) and discuss future directions for WWRP and its linkage to WCRP.

Chair: Michel Beland

SCI-SPL01.01 - World Weather Research Programme (WWRP): achievements and the way forward

Gilbert Brunet¹
¹Met Office, Exeter, UK

SCI-SPL01.02 - The Achievements, Legacies and Challenges of the Ten-Year THORPEX Program

David Parsons¹
¹University of Oklahoma, Norman, OK, USA

SCI-SPL01.03 - From THORPEX to High Impact Weather

Sarah Jones¹
¹DWD, Offenbach, Germany
Parallel Session

UAS-PS304.01 - Spatially seamless forecasting of wind power generation with generalized power curves

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Denmark has the world largest wind power capacity in proportion to the size of the electricity consumption and in 2013, covered 33.2% of its electricity demand by wind power. It also has a long tradition in forecasting wind power generation for optimal power system operations. A challenge is to build computationally-efficient and high-quality forecasting methodologies for a large number of sites based on a combination of numerical weather predictions (NWP) and local observations, for lead times up to 48-72 hours ahead. The aim of this research is to examine different multi varying linear models for wind power prediction, describing their particularities and testing their performance. A spatial generalization of wind power prediction models is proposed, permitting to predict wind power generation at a large number of sites with a single model. Model coefficients are seen as spatial stochastic processes estimated by ordinary Kriging. Such an approach may also allow to readily provide forecasts at any new location where turbines are deployed. The ideas and methods are demonstrated on the test case of Denmark, based on a set of more than 200 wind farms. We observe that the usage of wind speed forecasts at 10m above ground level yields more accurate results than the multi varying model using wind speed forecasts at 100m. Besides, the spatial modeling approach provides a good tool to start issuing forecasts, particularly in coastal areas, where predictions exhibit a significant quality improvement with respect to forecasts made using a unique (average) power curve for Western Denmark.

Keywords: Wind power forecasting, renewable energy, Numerical weather prediction
Parallel Session

UAS-PS304.02 - Southern Africa's Hydro-Economy and Water Security (SAHEWS) - Integrating seasonal forecasting into decision-making

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Water security in Southern Africa is characteristic of global pressures on water: rapid population growth, chronic and drought-induced episodic food shortage, growing water scarcity and energy security problems coincident with rising demand, transboundary and regional allocation issues, and a strongly variable climate that will likely become drier and more variable in the future. Southern Africa's Hydro-Economy and Water Security (SAHEWS) is a two-year collaborative research program, funded through the Belmont Forum. The project is realising opportunities for more effective water management in Southern Africa by addressing crucial knowledge gaps and integrating climate information with better understanding of economic linkages in water, food and energy. This paper will describe the progress achieved thus far in SAHEWS and the ongoing project plans in the following areas: Improved understanding of the hydro-meteorological variability and seasonal forecast reliability across Southern Africa; Improved understanding and characterization of Southern Africa's hydro-economy and large-scale drivers of freshwater variability; Enhanced knowledge uptake by decision-makers in the region through case study collaborations in the application of extended-range forecasts, following a research co-design process. These collaborations are with partners concerned with water resources, flood protection and agricultural applications.

Keywords: Agriculture, Water resources, Water utilities, Food Security
Parallel Session

UAS-PS304.03 - Improved weather forecasts for energy operations within the German research project EWeLiNE

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As the share of wind and photovoltaic (PV) power production with respect to the total power production increases, reliable and accurate forecasts of these energy sources are essential for operating transmission systems in a secure way. A very high potential for improving the wind and PV power forecasts lies in improving the underlying weather forecasts, since these energy sources are highly weather dependent and as such fluctuating in time. In the German research project EWeLiNE, the overarching objective is to improve the forecasts of the power production from these renewable energies. In the context of EWeLiNE, DWD is aiming both to improve the deterministic and probabilistic numerical weather prediction (NWP) models towards energy operations. Some of the aspects that are being considered are improved initial conditions by introducing new observational data, e.g. measured power data and satellite data, to the LETKF based data assimilation system, optimized parameterized processes in the boundary layer, and improved generation and calibration of the ensemble products. In a first step, the predictability of renewable energy relevant parameters, e.g. wind speed profiles, global radiation, cloud cover, etc. is evaluated. Based on the verification of the NWP models, approaches to optimize the models are defined. Besides providing accurate forecasts, a strong focus is put on the development of new user specified products. For this reason, a close collaboration is being established to strengthen the dialog between meteorology and the energy sector. This contribution provides an insight into the current status and first findings within EWeLiNE project.

Keywords: energy meteorology, renewable energies, weather forecasts, wind and solar power
The first exploratory oil drilling in the Arctic Ocean north of Alaska since in the early 1990s commenced in September 2012 in the northeastern Chukchi Sea. In support of these drilling activities, National Weather Service Alaska provided sea ice forecast and weather information to assist the Department of Interior's Bureau of Ocean Energy Management (BOEM) in making regulatory decisions for operational and environmental safety associated with exploratory activities. The harsh climate of the Arctic, long distances from the main supply chain, and lack of rescue and clean up support create unique challenges to operators in this region. A late season oil spill, especially in sea ice conditions, would be extremely challenging to clean up. Despite the sea ice extent in the Arctic Basin reaching a record minimum in 2012 with total coverage less than 50% of the late 20th century long term mean, unusual local sea ice conditions impacted activities in the northern Chukchi Sea throughout the open water season. Additionally, the freeze-up at the primary test drill test occurred rapidly on October 30th; earlier than anticipated following several days of cold windy conditions. Ice formed well south of the main ice edge within 24 hours, expanding to cover an area approximately 150,000 km2. A discussion of the support provided to BEOM and the challenges for future support for government agencies, industry, and native populations due to changing sea ice conditions in the Arctic will be presented.

**Keywords:** Sea Ice Forecasting, Government Regulation, Arctic Decision Support, Changing Arctic
Parallel Session

UAS-PS305.01 - Agro meteorology, a need for an industrializing agriculture in the highlands of western Cameroon

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A mastery of weather forecast is a key factor for agricultural production in the process of industrialization in Africa in general and in Cameroon in particular. Farmers in western highlands of Cameroon are frequently complaining about the instability of precipitation. Indeed rainfall calendar has become so unstable in such a way that farmers can no longer rely on their past experience to organize their farming activities. This raises several issues among which we have the non-availability and accessibility of meteorological forecast data for agricultural purposes and illiteracy of farmers with regard to the reading and interpretation of meteorological data. This article presents meteorology as a pillar for agricultural production in West Cameroon. In this case, we are pointing out that there is a need to make meteorological data available and accessible to the Cameroonian agricultural population because this will make the use of these data easy for every one. Therefore, we are presenting the state of meteorology in Cameroon and measures being taken by different stakeholders to improve upon the present and future quality of meteorological services in the area of agriculture. We will in our conclusion make recommendations to decision makers to modify their methods of disclosure of meteorological data with the aim of ameliorating and maximizing agricultural production.

Keywords: Agrometeorology, Rainfall variability, Agriculture, stakeholders
Parallel Session

UAS-PS305.02 - Climate change adaptation of the agricultural seed business sector: A cross-country study

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Due to specific sectoral characteristics, agricultural seed business sector is exposed to direct physical impacts of climate change as well as to indirect risks due to impacts on farmers. While the sector needs to produce quality seed, climate change impacts hamper the desired level of seed production as well as the quality. The exposure of agricultural seed business sector is very high in Australia and Bangladesh due to their specific ecosystems and geographical locations while having distinct development status determining their distinct capacity to adapt. Considering such cross-country perspective, based on a qualitative study, this paper presents the business strategy concerning climate change adaptation by analysing the case of agricultural seed business sector operating in Australia and Bangladesh. The paper unravels that no specific pattern of adaptation strategies exists across companies in the agricultural seed business sector. Companies either follow a 'deliberate' strategy following a 'precautionary' approach, or an 'emergent' strategy relying on a 'wait and see' approach. Few companies also follow a 'subliminal' strategy contributing to climate change adaptation using a 'business-as-usual' approach. Overall, companies in the sector follow a mix of 'deliberate' and 'subliminal' strategy. In Bangladesh, business strategies are influenced and dictated more by government policy interventions and consumer concerns about relatively more predictable climatic impact. However, in Australia, such strategies are mostly guided by individual corporate policies with little influence of consumer concerns about climate change predictability. The paper has implications for national policies, corporate strategies and consumer welfare relevant to climate change adaptation.


Keywords: Climate change adaptation, Agricultural seed business sector, Bangladesh, Australia
Parallel Session

UAS-PS305.03 – WITHDRAWN - Farmers’ adaptive behaviour to climatic change

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Background: The study establishes the behavioural adaptive capacity of farmers to climatic change. The rationale of the study was to explore the cognitive and cultural scope in which farmers’ understanding of climate and climate information is grounded and the decision-making processes and environment which shape farmers’ adaptive strategies. Methods: Data was collected using semi-structured questionnaires, personal interviews and focus group discussions. Results: The study analysed methods to elicit how farmers perceive and predict climate events and how these perspectives relate to scientific forecasts. It addressed the long-standing question of whether and how farmers understand the probabilistic nature of climate forecasts and how they assess the credibility and accuracy of such information. It also examined approaches to characterizing the vulnerability of decision makers and to elucidating the configuration of options and obstacles that farmers face in using climate forecasts to mitigate risk. The complexities of farmers’ decisions and the difficulties of identifying the exact role that climate predictions play (and, therefore, of directly attributing impacts to them) were taken into account. The study highlighted efforts to transcend the localized focus of farmer-cantered approaches in order to capture interactions across sectors and scales. Conclusions: climate application research should move from a ‘technology-adoption’ paradigm to a broader perspective on vulnerability and adaptation. This shift will entail a cross-scale, multi-sited research design and an interdisciplinary mix of interactive and structured tools and techniques.

Keywords: Adaptive behavior, Climatic change.
About 40% of Maharashtra state in Western India falls under Drought Prone Area (DPA), having annual average rainfall less than 750 mm. Agriculture and allied activities such as livestock are the major income activities of over 64% of state population. Recurring drought is one of the major challenges of the farming community in this area, which needs prior attention and consideration. Before proceeding to drought mitigation, information on drought impacts and existing adaptation and mitigation measures are essential. This study is based on both primary and secondary data sources, collected through a structured questionnaire survey of 223 rural farming households. Households are selected by probability proportional to size sampling from three irrigation strata- less, medium and highly irrigated. During drought 2012-13, out of total 36 sub-districts in study area, 14, 15 and 7 sub-districts suffered severe, moderate and normal drought respectively. This study focuses on how rural farming community perceived socio-economic and environment impacts of drought, which were their adaptation activities at household level and administrative mitigation measures by government in qualitative terms? Also this study attempted to assess impacts of drought in quantitative terms. As consequences of drought respondents suffered loss in crop production & milk production, loss in agricultural labor opportunity, time spent for domestic water collection, indebtedness and delay in loan repayment etc. There was limited awareness and adoption of adaptation practices observed among the respondents. Drawbacks of current drought mitigation measures are also identified in this study and few recommendations are made considering public opinions.

**Keywords:** Drought, Impacts, Adaptation, Mitigation
Land-atmosphere interactions play an important role for weather and climate, in particular related to the occurrence of climate extremes such as heat waves and droughts (e.g. Seneviratne et al. 2012, 2013). The impacts of variations in soil moisture availability and surface albedo are particularly crucial for these interactions and feedbacks. This presentation will provide an overview on the underlying mechanisms, focusing on 1) historical and projected trends in droughts and their drivers (e.g. Orlowsky and Seneviratne 2012, 2013), 2) the role of soil moisture-temperature feedbacks for the occurrence of temperature extremes (e.g. Seneviratne et al. 2010, Hirschi et al. 2011, Mueller and Seneviratne 2012, Seneviratne et al. 2014), and 3) the impact of land cover and land use changes for climate extremes (e.g. Teuling et al. 2010, Davin et al., submitted). The relevance of the identified feedback processes in the context of weather, subseasonal, and seasonal forecasting will be discussed.


Keyword: Land-atmosphere interactions
Parallel Session

SCI-PS113.02 - Impact of land surface on subseasonal forecasting skill: Inter-model comparison

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Accurate initialization of land surface variables provides skills in subseasonal to seasonal atmospheric prediction. The impact of land surface on the forecasting skill is model-dependent. Based on the Global Land-Atmosphere Coupling Experiment (GLACE), the present study aims to understand how soil moisture, one of the most important memory components of the climate system, modulate the land surface–atmosphere interaction in the various climate modeling systems.

Keywords: soil moisture, land atmosphere interaction, subseasonal forecasting skill
Stationary convective bands are associated with high rain rates and can cause significant damage if they form over a region prone to flash flooding. Mountainous regions can initiate such stationary bands and are also particularly prone to flash flooding due to the terrain (e.g. steep sided valleys). The interaction of atmosphere and terrain could make these events more predictable than non-orographically forced convection. To understand the mechanisms involved and the predictability of the bands, a convection-permitting ensemble of the Met Office Unified Model is used to study a number of cases. The ensemble simulations are used to determine the required atmospheric ingredients for persistent banded convection and to establish the importance of both synoptic scale flow and mesoscale features in each case. The precise details of the large-scale pressure pattern can be important in controlling the wind upstream of and flow around the terrain. Furthermore, the local temperature and humidity are important in governing where the convection is and is not initiated. The location and stationarity of the band are critically dependent on the upstream flow conditions such that subtle changes in either the synoptic or mesoscale pattern disrupt the stationary band. Results from analysis of numerous cases over the UK will be presented, identifying the differing predictability of the cases.

**Keywords:** orography, predictability, ensemble, convection
Parallel Session

SCI-PS113.04 - Field evaluation of the Maximum Entropy Production transpiration model

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Accurate representation of the evapotranspiration (ET) is paramount to assessing the water balance. However, many hydrological models rely on empirical or semi-empirical formulations of ET because of their simplicity and their operational advantages. This poster presents an evaluation of the Maximum Entropy Production (MEP) transpiration model, where land surface fluxes (and therefore ET) are constrained by conservation of available energy at the surface. Simulations of ET are compared with observations derived from the eddy covariance method during a 133-day period, in 2007. Meteorological observations are provided by two stations located in potato crops, in the Province of Quebec. Besides, the availability of the field measurements allows assessing the results of a second model, i.e. the Canadian Land Surface Scheme (CLASS). MEP and CLASS respectively produced a cumulative ET of 377.9 mm and 349.4 mm while the observed value was 377.7 mm. At the onset of the season, both models tend to overestimate ET with greater biases in MEP transpiration model. Nevertheless, both models showed underestimation of ET during maturity and senescence, while overall the MEP transpiration model better fitted the observations. Over the whole period, the RMSE and PBIAS for ET calculated from both models were similar, respectively of 1.3 mm and (-2 %) for MEP, and of 1.1 mm and (-1 % ) for CLASS.

**Keywords:** Evapotranspiration, Case study, Micrometeorology
Parallel Session

SCI-PS114.01 - Toward improving the role of the static error covariance in hybrid 4D EnVar

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While the use of hybrid ensemble-variational data assimilation methods continues to expand, particularly in the operational numerical weather prediction community, many open questions remain. Given that we remain somewhat limited in terms of the size and resolution of the ensemble that is computationally feasible, some previous work has demonstrated that incorporating a time invariant, climatological error covariance estimate within a hybrid 4D EnVar context yields improvements. However, it is clear that the lack of temporal information in such a covariance estimate remains a significant hindrance. One of the advantages of the 4D EnVar algorithm is the lack of need for the tangent linear and adjoint models within the minimization algorithm. In this work, we explore the role of a static covariance contribution to the hybrid 4D EnVar solution. We will present results from experiments that attempt to add temporal information to the full rank static error covariance estimate without employing the full tangent linear and adjoint models. Once such proposal involves the use of a simple first order extrapolation in time to the observations (FOTO), which was successfully applied in the NCEP Climate Forecast System reanalysis. Experiments will be carried out for a simply toy model as well as global numerical weather prediction system.

**Keywords:** Data Assimilation, Hybrid, 4D EnVar
Parallel Session

SCI-PS114.02 – WITHDRAWN - Improving balance in the NCEP Hybrid Ensemble-Var data assimilation system

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Data assimilation strives to draw the state close to the observations; however, the corrections made to individual variables may not be in dynamic balance with one another. These imbalances in the initial conditions can create unphysical inertial-gravity waves that propagate in the model and degrade the forecast. NCEP’s Gridpoint Statistical Interpolation data assimilation system (GSI) contains the tangent-linear normal-mode constraint (TLNMC) to improve the balance of the analysis increments. The TLNMC procedure involves the calculation of incremental tendencies, which are then projected onto normal modes from which correction terms to the increment can be computed. The tendency model, however, uses dry adiabatic physics, which while improving forecasts over most areas, can inhibit the constraint from reaching its full potential, particularly in the tropics. Therefore, condensation and precipitation processes have been added to the tendency model, allowing moisture to impact the tendencies of the mass and wind variables. In addition, the tendencies due to turbulent vertical mixing were also incorporated into the tendency model. Experiments are performed using the GSI within the Global Forecast System (GFS). Results will be presented from applying these tendency model modifications within the Hybrid 3D-EnVar data assimilation scheme, with an emphasis on the impact on the balance of the analysis. The results will then be extended to include the 4D-EnVar. Other aspects of initialization within the 4D context can also be explored, such as incremental analysis update, weak constraint versus full field digital filtering, and the use of the TLNMC over multiple time levels.

Keywords: Data assimilation, Hybrid, Balance, Ensembles
SCI-POS1042 - Observability of precursors to instability in a 1D nonlinear wave model with local barotropic instability

Martin Deshaies-Jacques, Pierre Gauthier

In the presence of atmospheric instability, some meteorological situations remain difficult to predict because a small perturbation to initial conditions can lead to very rapid growth. Rossby wave trains (RWTs) can result from baroclinic instability triggered by potential vorticity forcing and are causes of high-impact weather, nonlocal error correlations and low predictability. During the T-PARC (THORPEX Pacific-Asian Regional Campaign), the life cycle of tropical depressions was observed to induce a downstream response in the north-east region of the Pacific and over North America. The interaction of these depressions with the Jet Stream could in turn create local instabilities leading to further developments downstream. In these unstable situations, the observability of the precursors to instability is of paramount importance for any analysis scheme to be able to include flow-dependent structures. Lupu and Gauthier (2011) proposed a criterion assessing the observability of precursors. In our study, a simplified representation of the onset of RWT on the Jet Stream is considered that leads to a nonlinear small amplitude wave equation corresponding to a modified Korteweg de-Vries equation including local barotropic instability. Singular vectors are produced to represent precursors and idealized OSSEs (observing system simulation experiments) are performed to study their observability at different stages of their growth. Different spatial and temporal observation distributions and levels of observation error are considered to assess the ability of data assimilation techniques to detect such a signal. Different strategies to sample such structures are considered with respect to their ability to improve the analyses and resulting forecasts.


Keywords: nonlinear waves, precursors to instability, observability, flow-dependent covariances
Parallel Session

SCI-PS114.03 - Outer loop tests and implementation plans of Hybrid 4D EnVar for the NCEP GFS

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The ability to incorporate flow-dependent, ensemble-based representations of background error covariances into variational data assimilation has recently been implemented for use in the NCEP data assimilation system (Gridpoint Statistical Interpolation, GSI) by utilizing the augmented control variable method. Experiments with the hybrid 3D Ensemble-Variational (EnVar) system for the NCEP Global Forecast System (GFS) model have shown that the hybrid paradigm can yield substantial reduction in forecast error relative to a control based on a 3DVAR system in both single and dual-resolution configurations. By taking the existing 3DEnVar algorithm and allowing for four-dimensional ensemble perturbations, a 4DEnVar capability has been developed and eliminates the need for tangent-linear and adjoint model, which are required in 4DVAR. Preliminary results using real observations have shown forecast improvements nearly as large as those found in moving from 3DVAR to hybrid 3DEnVar. The results from follow-on sensitivity experiments carried out over a northern hemisphere winter period using real data will be presented. In particular, outer-loop related issues will be explored and addressed through the use of multiple quasi-outer-loops (where only the deterministic, full resolution model is run but the ensemble perturbations are kept fixed) and/or rescaling of the weights to the static and flow-dependent covariances. Additional experimentation with the length of the assimilation window will be explored and presented. Lastly, plans will be discussed regarding the operational implementation of 4DEnVar as well as potential long term development path for the NCEP GDAS/GFS.

Keywords: Data Assimilation, Global Modeling, Weather Forecasting
Parallel Session

SCI-PS115.01 - The ECMWF Data Targeting System (DTS) and its use in THORPEX field campaigns

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ECMWF developed the Data Targeting System (DTS) as an interactive web-based system to allow users in different centres to participate in real-time adaptive control of the observing system with a minimum of manual effort. The DTS provided a facility to efficiently manage the data targeting process from weather event selection to issuing requests for additional observations, and has been used in several THORPEX field campaigns. The DTS enables users to a) identify potential high-impact weather events, in particular cases with large uncertainty; b) request computation of sensitive areas (regions where additional observations are likely to have most impact in reducing the forecast uncertainty); c) identify and issue requests for additional real-time observations; and d) monitor the observation requests and confirm their subsequent deployment. Field campaigns using the DTS have been able to issue requests for additional radiosonde ascents from 20 different participating countries, and for AMDAR aircraft observations and radiosondes from ASAP ships participating in the EUMETNET observing programme. In addition, the DTS has allowed users to identify sensitive areas for research aircraft observations. The presentation will describe the development and functions of the DTS and review its use in a long-term quasi operational trial (EURORISK PREVIEW) as well as in field campaigns, including summer and winter THORPEX-Pacific Asian Regional Campaign (T-PARC), and most recently MEDEX and HyMeX campaigns to study the predictability of high-impact weather over the Mediterranean.

Keywords: data targeting, adaptive observations, field campaign
Parallel Session

SCI-PS115.02 - Highlights of studies at DLR and LMU based on aircraft observations during TPARC

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A unique set of airborne observations including more than 1500 dropsondes, 2500 wind and 3900 water vapor lidar profiles was collected during TPARC 2008. These observations were assimilated in a number of global and regional models to draw conclusions on the benefit of targeted dropsonde observations for typhoon and mid-latitude forecasts, to evaluate different targeting strategies and to evaluate the potential of lidar instruments for the initialization of weather prediction models. In addition, airborne lidar cloud top observations were used to develop a height correction method for AMVs that is now tested using CALIPSO observations. Major findings from these studies include: (a) Targeted dropsondes overall improve typhoon track predictions, but their impact significantly depends on the assimilation system; (b) targeted dropsondes only have a small impact on mid-latitude forecasts and the impact is mainly due to improved typhoon tracks that indirectly lead to mid-latitude improvements; (c) dropsondes in the vicinity of typhoons have the largest impact, whereas the impact of dropsondes in distant sensitive regions and the core and eyewall region is small; (d) wind lidar observations have a comparably high impact, which underlines high expectations for the ADM-Aeolus satellite lidar and suggests considering the deployment of wind lidars on commercial airplanes in the future (e) the average impact of water vapor lidar observations is small, but forecasts can be affected considerably under certain conditions; (f) lidar cloud top observations can be used to adjust the height assignment of AMVs and by this significantly reduce their wind errors.

Keywords: Data assimilation, Targeted observations, Lidar, Dropsondes
Over the past years airborne observations constituted an important component of THORPEX. The research aircrafts Falcon and recently the new airborne platform HALO participated in several airborne campaigns that directly originated from THORPEX or that provide a strong link to relevant topics. This presentation shows selected results of past campaigns with a focus on observations that are used to investigate the importance of diabatic processes for the predictability in the extratropics. A case study shows water vapour lidar observations in the inflow of a warm conveyor belt and highlights the sensitivity of the structure of the extratropical cyclone and the dynamics at upper levels to the low level humidity. Additionally Lagrangian observations in WCBs over Europe are presented that aimed at quantifying diabatic processes along WCBs. First data of the HALO aircraft performing flights in weather systems over Europe highlight the new potentials for aircraft observations of cyclones from synoptic to meso-scales. In addition, we will give a brief outlook to the internationally coordinated field experiment THORPEX North Atlantic Waveguide and Downstream Impact Experiment (T-NAWDEX) in September and October 2016 whose science objectives are strongly motivated by the results from the previous campaigns. Flights with HALO will be conducted over the North Atlantic to investigate the triggering of disturbances along the North Atlantic wave guide, their subsequent evolution and the associated downstream impacts over Europe. We give an outlook on the plans, strategy and instrumentation for the Swiss / German contribution with HALO.

**Keywords:** HALO, lidar, T-PARC
Parallel Session

SCI-PS115.04 - An interactive method to predict warm conveyor belt occurrence for aircraft-based field campaigns

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We propose a method to predict a probability of warm conveyor belt (WCB) occurrence for use in flight planning during aircraft-based field campaigns. The method is based on Lagrangian particle trajectories computed on the forecast wind fields of the ECMWF ensemble prediction system. By filtering the trajectories according to a user-specified ascent-criterion and by gridding the filtered trajectories, three-dimensional probability fields are derived. Despite data volumes of multiple GB of trajectory data per time step, we are able to enable the user of our method to interactively adjust the ascent-criterion as well as several gridding parameters. This allows to on-the-fly explore the sensitivity of the derived WCB probability to these parameters. The probability fields can be visualized in the context of the ECMWF ensemble forecast in the interactive 3D forecasting tool “Met.3D”. Flight tracks can be planned in direct relation to the predictions. In this presentation, we explain the method and discuss its sensitivity to trajectory seeding and grid resolution. Our method will be used to support flight planning during the internationally coordinated field experiment “T-NAWDEX” (THORPEX North Atlantic Waveguide and Downstream Impact Experiment), which is scheduled to take place in September and October 2016. T-NAWDEX will use the German research aircraft HALO to conduct flights over the North Atlantic. Here, we demonstrate our method’s capabilities by revisiting flight planning cases from the former “T-NAWDEX-Falcon” field campaign, which preceded the 2016 T-NAWDEX campaign in October 2012.

Keywords: warm conveyor belts, research flight planning, uncertainty visualization, ensemble prediction
Parallel Session

SCI-PS116.01 - The OQ-Net VHF radar wind profiler network: Comparisons with winds from radiosondes and NWP models

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A dense network of ten VHF wind profilers has been installed in southern Ontario and neighboring areas of Quebec. They are programmed to produce hourly average winds at heights from 500m to 15 km with a resolution of 500m. Some data are assimilated by ECMWF and the UK Met Office global models, NOAA are assimilating a selection into their RAP model and these data are available at https://madis-data.noaa.gov/cap/profiler.jsp. Data are also provided to Environment Canada. We have recently undertaken an extended comparison between profiler winds and radiosonde data and a comparison with model predictions from the Canadian operational GEM model. Comparisons with radiosonde data are fully satisfactory, the comparisons with GEM analyses and forecasts suggest significant errors in wind direction. One of the OQ-Net profilers, at Aumond (46.45N, 75.90W) is close to the Manawaki, Quebec, radiosonde site (46.38N, 75.96W). For heights 2-7 km the MAE in relative wind speed is about 12%. Wind direction differences are small with a near zero bias and an MAE of about 10º. Given the differences between radiosonde ascents and hourly averaged data we consider these MAE differences to be acceptable. Comparisons between profiler measurements and GEM analyses and forecasts show that there are significant differences in wind direction, especially to low levels - which we would attribute primarily to model error. The bias error is modest but MAE is generally 30º at 1 km, reducing to 15º at 5km. Relative wind speed MAE is typically about 20% at all heights.

Keywords: Wind Profiler, Regional network, Upper level winds
Parallel Session

SCI-PS116.02 - Raman lidar and microwave radiometry synergy for high vertically resolved temperature and water vapor profiles

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Humidity and temperature are key meteorological variables and accurate, continuous and highly resolved measurements are required for a better understanding of many atmospheric phenomena. In particular their strong relation to land surface processes leads to high variability in the atmospheric boundary layer, which is difficult to capture from satellite measurements. Unfortunately, instruments available so far do not provide sufficient resolution to describe short time scale processes such as convection, cloud formation or boundary layer turbulence. In the last years, in order to overcome the specific limitation of a given instrument, scientific community started merging different data from several ground-based instruments. In this work, the synergy of a Microwave Radiometer (MWR) and a Raman Lidar (RL) system is presented. On the one hand, RL provides high vertically resolved measurements of temperature and humidity profiles, but it presents important weaknesses (i.e. “blindness” in and above clouds, noisy daytime operation) and therefore cannot be considered operational. On the other hand, MWR offers a much more limited vertical resolution on the retrieval of atmospheric profiles. But it is able to provide accurate integrated quantities such as Integrated Water Vapor (IWV) or Liquid Water Path (LWP). This instrument also allows continuous data acquisition in all weather conditions but rain. The retrieval method that brings together these two instruments is built up in an Optimal Estimation Scheme (OES) that allows a comprehensive uncertainty assessment. The method is applied to field campaigns in different climate regions where auxiliary measurements, e.g. radiosondes, allow evaluation of its performance.

Keywords: remote sensing, microwave radiometer, raman lidar, atmospheric profiles
Parallel Session

SCI-PS116.03 - Continuous water vapor profiling with a diode-laser-based Differential Absorption Lidar (DIAL)

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The atmospheric sciences research and forecasting communities have a clearly-stated need to obtain improved measurements of water vapor. Montana State University (MSU) has pioneered an alternative low-cost active remote sensing capability which has the potential to help fill the observational gap for range resolved measurements of atmospheric water vapor. This technology employs the well-known differential absorption lidar (DIAL) technique and uses diode-laser- based technologies for the transmitter which significantly reduces the initial and operational costs. Since June of 2011, MSU and the National Center for Atmospheric Research (NCAR) have worked together to expand and evaluate the capability of this new technique. In 2012 the MSU prototype water vapor DIAL was modified to allow for unattended operations with a completely eye-safe beam. The modified instrument was field tested over a wide range of atmospheric conditions alongside other instrumentation to evaluate its performance. The evaluation indicated that the technology was well-suited for autonomous, long-term measurement of water vapor over a wide range of concentrations and atmospheric conditions. However, significant engineering modifications were required to make the instrument capabilities useful for the atmospheric science community. The revised design, now being constructed and tested, will be discussed. It should allow measurements closer to ground level, improve performance in the presence of clouds and during daytime, and improve the system's stability and reliability. Furthermore, the prototype instrument would have the potential to form the basis of a ground-based network of eye-safe autonomous instruments.

Keywords: water vapor profiling, new technology
SCI-PS116.04 - CICERO: A cellular observing system for weather data acquisition

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CICERO (Community Initiative for Continuous Earth Remote Observation) is a grassroots effort to deploy a cellular space-based observing system to acquire global weather, climate and space environmental data from low Earth orbit at extremely low cost. The central idea is to place low-cost sensors on nanosatellites (or cells) deployed in large numbers for diverse applications. Scores of relatively simple cells will combine to form a global super-sensor of astonishing power. Built in lots of dozens, these tiny craft will cost a few M$ each to build and launch. GeoOptics has created an array of novel cellular observing technologies, from original sensor and nanosat designs to unique on-orbit cell configurations, designed to maximize information return. The approach consolidates diverse sensing techniques into integrated sensors to yield a breadth of observational products. CICERO will offer new launches every year to expedite deployment of new sensing techniques. When fully deployed, CICERO will provide, among other things: • Atmospheric radio occultation based on signal refraction; • Continuous global 3D ionospheric electron density mapping; • Geostrophic wind mapping in the upper troposphere and stratosphere; • Moisture and ozone sensing with crosslink occultation based on absorption; • Ocean scatterometry and altimetry from opportunistic signal reflections; • Continuous, comprehensive mapping of Earth’s magnetic field. CICERO will be a self-supporting enterprise of the science and data user communities, who will share in its design, evolution, and success. This presentation will cover the rationale for CICERO, its baseline design, and its current status.

Keywords: CICERO, Cellular, Nanosatellite, Nanosensor
Parallel Session

SCI-PS117.01 - Application of satellite land measurements in improving NCEP numerical weather prediction

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Over the past two decades, satellite measurements are being increasingly used in weather and climate prediction systems and have made a considerable progress in accurate numerical weather and climate prediction. However, it is noticed that the utilization of satellite measurements over land is far less than over ocean, because of high land surface inhomogeneity as well as emissivity variability of time and space and with surface characteristics. In this presentation, we will discuss the application of satellite land measurements in the the National Centers for Environmental Prediction (NCEP) operational Global Forecast System (GFS) and our efforts to improve the global numerical weather prediction. Our study focuses on use of satellite data sets such as vegetation type and green vegetation fraction (GVF), assimilation of satellite products such as soil moisture retrieval, and direct radiance assimilation.

**Keywords:** Satellite Land Measurements, Numerical Weather Prediction
Parallel Session

SCI-PS117.02 - Recent progress and perspective on the observation data use in JMA NWP

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The Japan Meteorological Agency (JMA) has been operating three scale numerical weather prediction (NWP) models with their specific data assimilation systems. The outputs are used for issuing official weather forecasts and alerts in Japan. Focusing on the global NWP system, the assimilated data volume has increased three times or more in this decade and various activities to use more observation data for the better atmospheric analysis have been continued energetically. In 2013, JMA started using AVHRR and LEOGEO atmospheric motion vectors, the radiance from AMSR2 onboard JAXA’s GCOM-W1 satellite, and the data from five instruments aboard Metop-B satellite. In 2014, JMA is starting using world’s GNSS zenith total delay (ZTD) data. Before their introductions, the observation system experiments (OSEs) for evaluating their impacts were conducted in advance. Such OSEs provide us various informations which would contribute to improve the NWP systems. For the operational NWP, data collection is one of the most prioritized issues. In case of AMSR2, the data has been provided timely from the early stage after its launch under the cooperation between JMA and JAXA. Such cooperation with space agencies will be continued and enhanced for the future satellite missions. In case of GNSS-ZTD, although there must be a large number of GNSS receivers in the world, quite limited number of the data is being exchanged. Such ground based remote sensing data should be exchanged in real time, especially among neighboring countries. In this presentation, such activities for the better analysis will be presented.

Keywords: NWP, assimilation, observation
SCI-PS117.03 - A case study of adaptive observation technique in a UAS OSSE on hurricane track

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An unmanned aerial system (UAS) OSSE for improving hurricane track forecasts has been studied under the NOAA joint OSSE system. Due to the limited number of dropsondes, adaptive observation schemes have to be considered in these experiments in order to fully take advantages of this observation system. Among the existing adaptive observation schemes, we investigated ensemble transform (ET) based methods and proposed a new ET method for better performance in both computational efficiency and analysis quality. The proposed ET-based sensitivity (ETS) method, which calculates the gradient of forecast error variance reduction to analysis error variance reduction, is proposed to specify regions for possible adaptive observations. ETS is a first order approximation of the ET, but only needs one single calculation of transformation matrix, and increases computation efficiency. The ETS method was applied in a UAS OSSE for calculating sensitivity regions for UAS dropsonde deployment. The impact of the adaptive dropsonde data assimilation on analyses and forecasts of a simulated hurricane will be presented.


Keywords: Adaptive observation, UAS, OSSE, Hurricane track forecast
Parallel Session

SCI-PS117.04 - Downscaling FY3-MWRI soil moisture integrating FY3-VIRR/MERSI visible/infrared data

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FY3 Microwave Radiometer Imager (MWRI) is a 10-channel five-frequency linearly polarized, passive microwave radiometer imager system onboard the FY3, which measures atmospheric, ocean, and terrain microwave brightness temperatures at 10.65, 18.7, 22.3, 36.5, and 89 GHz. And the FY3-MWRI Soil Moisture products with 25 × 25 Kilometers resolution have been developed based on QP parameter physical model with higher inversion precision which error is less than 0.05g/cm3. In this paper, a downscaling approach to improve the spatial resolution of FY3-MWRI Soil Moisture estimates with the use of higher resolution visible/infrared satellite data of FY3-VIRR/MERSI is presented. The algorithm is based on the 'universal triangle' concept that relates visible/infrared parameters, such as NDVI and LST data derived from FY3-VIRR/MERSI, to the soil moisture status. It combines the accuracy of FY3- MWRI observations with high spatial resolution of FY3-VIRR/MERSI data into accurate soil moisture estimates at high spatial resolution (in 1Km and 250m resolution, separately). And the soil moisture products with higher spatial resolution were tested using field observations data of soil moisture wireless sensor measurements network of Hebi agriculture meteorological experiment station in Henan province of China. Results showed fairly good agreement with ground-based soil moisture measurements and illustrated the strength of the link between visible/infrared satellite data and microwave soil moisture.

Keywords: Downscaling, FY3-MWRI Soil Moisture, FY3-VIRR/MERSI, Visible/Infrared data
Parallel Session

SCI-PS118.01 - High definition clouds and precipitation for climate prediction –results from a unified German research initiative

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We present results from the German BMBF initiative “High Definition Cloud and Precipitation for advancing Climate Prediction - HD(CP)2”. This initiative addresses many relevant cloud problems in one, unified approach: cloud physics, convection, boundary layer development, radiation and subgrid variability are approached in one organizational framework. HD(CP)2 merges both observation and high performance computing / model development communities to tackle a shared problem: how to improve the understanding of the most important subgrid-scale processes of cloud and precipitation physics, and how to utilize this knowledge for improved climate predictions. HD(CP)2 is a coordinated initiative to: (i) realize; (ii) evaluate; and (iii) statistically characterize and exploit for the purpose of both parameterization development and cloud / precipitation feedback analysis; ultra-high resolution (100 m in the horizontal, 10-50 m in the vertical) regional hind-casts over time periods (3-15 y) and spatial scales (1000-1500 km) that are climatically meaningful. HD(CP)2 thus consists of three elements (the model development and simulations, their observational evaluation and exploitation/synthesis to advance CP prediction) and its first three-year phase has started on October 1st 2012. Within this presentation, we will give a short overview on HD(CP)2, show results from its observation campaign HOPE and the LES simulations of the same domain and conditions and will discuss how these will lead to an improved understanding and evaluation background for the efforts to improve the representation of clouds in our climate model.

Keywords: Clouds, Precipitation, High resolution modelling, Climate Sensitivity
Parallel Session

SCI-PS118.02 - Stationary orographic cloud bands: Dynamic and sportive interests link satellite observations with mesoscale modelling

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75 years ago, Joachim Kuettner first published a study which linked a regular series of up-draughts and down-draughts in the lee of the mesoscale mountain range “Riesengebirge” at the Polish-Czech border with distinct cross-mountain flow. Data had been collected during a regional gliding contest by no less than 22 sailplanes. Horizontal wavelength amounted to around 10 km and vertical velocities exceeded several meters per second. Such lee waves, which can lift sail planes to high altitudes, were hypothesized to fill the entire troposphere in the lee of any mountain range under suitable atmospheric conditions. On 1 February 2014 stationary clouds bands were visible in imagery of both, polar orbiting as well as geostationary satellites, in the entire region from the main crest of the Alps towards the medium height ranges as Riesengebirge some 500 km further north. Horizontal wavelengths varied between a few and 15 km. The case is used to test the ability of current high resolution mesoscale model simulations to infer the relevant patterns of vertical velocity and clouds depending on the horizontal grid size. The poster presentation aims to put the 75-year old and the recent findings into perspective with studies made after the MAP special observation period of 1999, a research and development project under the auspices of WWRP.


Keywords: Satellite observations, Mesoscale modelling
Parallel Session

SCI-PS118.03 - A new approach for parameterizing cloud microphysics based on prediction of ice particle properties

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The representation of cloud microphysics continues to be a source of uncertainty in atmospheric models. Traditionally, microphysics schemes partition ice-phase particles into pre-defined categories with prescribed bulk characteristics. This approach, which is used in nearly all existing schemes, is intrinsically restrictive and imposes the need for conversion between categories, which are poorly constrained processes and often unphysical. In recent years, there has been a paradigm shift in the parameterization of ice microphysics towards emphasizing the prediction of bulk properties of hydrometeors, rather than categories. In this study, a fundamentally new approach is proposed and a new microphysics scheme has been developed. In the new parameterization, ice particle properties are predicted and evolve locally in time and space by prognosing four independent mixing ratio variables: number concentration, vapor deposition mass, rime mass, and rime volume. From these variables, important physical properties that describe the ice hydrometeors at a given point in time and space can be derived. This allows the full range of ice particle types to be represented by a single ice category. The new approach thus eliminates the need for conversion rates and thresholds between different ice categories. The behaviour of the new scheme is illustrated with 3D simulations over a wide range of conditions, including winter orographic precipitation and different types of convective storms. Results are compared to observations and simulations using other bulk microphysics schemes. Despite its simplicity, the new scheme produces a realistic simulation of meteorological phenomena and with a very competitive computational cost.

Keywords: microphysics, parameterization, ice, properties
Parallel Session

SCI-PS118.04 - Evaluation of coupled versus uncoupled cloud physics and radiation in WRF

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The various radiation schemes in WRF have very weak linkages between the assumptions within the cloud schemes and how the cloud optical depth, tau, is computed inside the radiation parameterizations. Most simply use only the mixing ratio of cloud water and cloud ice and nothing further. The RRTMG scheme (Iacono et al. 2000) sums the snow into the cloud ice. None of these treatments exploits the possibility of linking explicitly computed water droplet and ice crystal sizes known within the microphysics schemes directly into the calculations of tau. This missing link is now remedied in the combination of the RRTMG short and longwave radiation parameterization in combination with the Thompson et al (2008) microphysics scheme. A simple diagnostic routine is added within the microphysics code to calculate the proper radiation effective diameters of cloud droplets, cloud ice, and snow and these are communicated to the radiation codes where they are individually applied into the calculation of tau. The newly connected physics was tested over the contiguous U.S. for nearly 40 days in late Spring 2013. Results of various sensitivity experiments will be presented.


Keywords: clouds, radiation, numerical weather prediction
Parallel Session

SCI-PS119.01 - Upscale error growth in simulations with resolved and (stochastically) parametrized convection: A comparison

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It is well established that forecast errors grow rapidly in regions with moist convection, limiting the predictability of such events to a few hours. In addition, the resulting uncertainty on convective scales will propagate upscale and project onto the balanced motions. This balanced perturbation continues to grow on synoptic scales driven by baroclinic instability. We present several error growth studies on a convective summertime weather event over Europe using a limited area model at different resolutions with and without convection parameterizations. First we show results from a convective permitting study characterizing the three stages of error growth described above. By repeating these experiments with lower resolutions and using a standard convection scheme we further show that the initial error growth rate as well as the eventual large-scale error reduces, indicating an intrinsic overconfidence of such model settings. Finally we demonstrate that by using a stochastic convection scheme (Plant-Craig), the upscale error growth found in the convection permitting simulations can be reproduced even with much coarser grid lengths. Further analysis suggests that gravity waves may be important for the transition of the error through the mesoscale to geostrophically balanced scales. These results suggest that with the Plant-Craig convection scheme the upscale effects of convective uncertainty can be reasonably well simulated without having to resolve the convection. Future studies with a global model are planned to assess the contribution of unresolved convective variability to model error and medium-range predictability.

Keywords: error growth, stochastic parameterization, predictability, convection
Parallel Session

SCI-PS119.02 - Predictability and error growth dynamics of moist baroclinic waves under varying baroclinic and convective instabilities

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This study explores the intrinsic predictability and error growth dynamics of moist baroclinic waves under varying baroclinic and convective instabilities using “identical twin experiments” with initial perturbations of different scales and amplitudes. For large-scale baroclinically unstable initial perturbations, the error growth is dictated by the growth rate of the large-scale background baroclinic instability with a strong sensitivity to the amplitude of the large-scale initial perturbation. Whereas for small-scale random initial perturbations, it is demonstrated that the error growth is characterized by an upscale growth through moist convection following the conceptualized error growth model developed in Zhang et al. (2007 JAS). The PV generated by the convection will induce a large-scale error that may further grow according to the baroclinic growth rate. The large-scale error introduced by this upscale growth process is determined by the amount of convection generated PV. There are strong nonlinearities in this upscale error growth with only weak sensitivity to the initial amplitude of the initial random perturbation. The stronger the background baroclinic and/or convective instability are/is, which is likely the case for most extreme events, the faster the error grows, and the more limited mesoscale predictability is.


Keywords: Moist Baroclinic waves, Error growth dynamics, Potential vorticity, Identical twin experiments
Parallel Session

SCI-PS119.03 - Diabatic processes in extratropical cyclones: Dynamics and relevance for forecast accuracy

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The prediction of the track, intensity and structure of extratropical cyclones is of key importance for accurately forecasting surface extremes associated with these weather systems. In addition to the primary agents of baroclinic instability and typically an upper-level cyclonic potential vorticity (PV) anomaly, moist diabatic processes that occur in saturated ascending airstreams are essential for the evolution of cyclones, the associated surface weather, and the downstream flow evolution. Results from complementary studies, mainly based upon ECMWF data, will be shown to illustrate that (i) the diabatic PV production in the low troposphere is essential for the formation of intense extratropical cyclones, (ii) diabatic processes are particularly intense in so-called warm conveyor belts, i.e., in moist ascending airstreams associated with extratropical cyclones, (iii) a major part of precipitation extremes occurs in associating with extratropical cyclones and/or warm conveyor belts, (iv) exceptionally poor global model medium-range weather forecasts in Europe are often associated with errors in the representation of warm conveyor belts, and (v) during the previous 10 years, the accuracy in predicting the intensity and location of these moist ascending airstreams has improved for the ECMWF high-resolution model. The presentation will also emphasise (a) the usefulness of investigating dynamical processes in ensemble predictions, (b) the need for field experiments dedicated to observing diabatic processes in mid-latitude weather systems, and (c) the value of a systematic feature-based forecast validation of weather systems with NWP and climate models.


Keywords: extratropical cyclones, diabatic processes, potential vorticity, weather prediction
SCI-PS119.04 - Impacts on extended-range predictability of midlatitude weather patterns due to recurving tropical cyclones

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Many errors in extended-range forecasts of midlatitude weather patterns have been found to originate from the tropics. Tropical sources of errors are related to convection and the organization of convection by the Madden-Julian Oscillation (MJO) and convectively-coupled equatorial waves. The role of tropical convection as a source of errors in midlatitude forecasts has been predominantly examined during winter periods when the midlatitude jet stream is strong and the jet shifts equatorward such that there are dynamic and thermodynamic linkages between the tropics and midlatitudes. Recurving tropical cyclones are identified as sources of errors and uncertainty in midlatitude forecasts. Although the jet stream shifts poleward and is weaker in summer, a recurving tropical cyclone increases linkage between the tropics and midlatitudes. Upper-level outflow from the tropical cyclone can merge with and increase the intensity of the midlatitude jet stream. In study tropical cyclone impacts on predictability over the midlatitudes are measured relative to a baseline measure of predictability, which is defined as spread among ensemble members, to establish overall significance. Ensemble extended-range predictions of synoptic-scale fields from the National Centers for Environmental Prediction Global Ensemble Forecast System Reforecast-2 are used to examine predictability in forecasts over Northern Hemisphere midlatitudes. Using the long period of forecasts provided in the reforecast data set, climatological values of predictability and uncertainty are computed. Forecast attributes associated with recurving tropical cyclones are statistically compared to climatological values to establish whether recurving tropical cyclones are associated with periods of reduced predictability in downstream midlatitude weather patterns.

Keywords: Predictability, Tropical Cyclones, Ensemble forecasts
Parallel Session

SCI-PS120.01 - Necessary conditions for intensification of tropical cyclones: The role of mesoscale systems and convective intensity

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There has been a long-standing debate about the requirements for tropical cyclogenesis, and for rapid intensification of tropical cyclones, once formed. One school of thought, stimulated by the original “hot tower” hypothesis from the Riehl-Malkus era, can be framed as “the more intense the convection, the better”. This talk examines the evidence from 12000 overpasses of tropical cyclones from 16 years of data from the Tropical Rain Measuring Mission (TRMM) satellite, from a number of investigators, that suggests a different conclusion. While there is no doubt that intense convection in the eyewall or in rainbands can contribute to deepening, the more important requirement seems to be for a greater degree of symmetry in the convection, and in latent heat release in the inner core of the storm.

Keywords: Mesoscale Systems, Convective intensity, intensification
SCI-PS120.02 - Convective and Vortex-scale interactions during the rapid intensification of Hurricane Earl (2010)

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This talk will examine the inner-core structure and evolution of Hurricane Earl (2010) during its rapid intensification (RI) as revealed by airborne observations and the basin-scale HWRF numerical model. Earl was intensively sampled, with NOAA P-3 flights occurring every 12 h for 60 h, encompassing the period before, during, and at the end of RI. The results shown depict two stages of Earl’s RI: an early stage, covering ~24 h, where Earl was a tropical storm experiencing moderate northeasterly shear, an asymmetric distribution of convection, and an upper-level circulation center significantly displaced from the lower-level circulation. By the end of this stage the vortex was aligned and extended over a deep layer, and RI began. During the late stage, RI continued and the vortex remained aligned in the presence of weaker vertical shear. Convective bursts were noted near the radius of maximum winds during this stage, with the majority of bursts located just inside the radius of maximum winds. Each of the two stages described here raises questions about the role of convective- and vortex-scale processes in RI. During the early stage the focus is on the role of convective bursts, and their associated mesoscale convective system, on vortex alignment and the onset of RI. During the late stage the focus is on the processes that explain the observed radial distribution of convective bursts which peak inside the radius of maximum winds. The implications of accurately capturing these inner-core structures with the basin-scale HWRF for RI prediction are also discussed.

Keywords: Rapid intensification, Convection
Parallel Session

SCI-PS120.03 - Intensification of a sheared tropical cyclone in a WRF Simulation: The evolution of a mesovortex

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Although vertical wind shear of the environmental flow is well-known to be a negative influence on tropical cyclone (TC) intensity, cases of highly sheared, asymmetric tropical cyclones undergoing significant to rapid intensification have been documented and discussed in the literature. The physical understanding of these asymmetric intensification events remains incomplete. In this study, the asymmetric rapid intensification of Tropical Storm Gabrielle (2001) was simulated at 1-km horizontal resolution using the Weather Research and Forecasting (WRF) model. As the simulated tropical cyclone intensified, intense convective cells with associated cyclonic vorticity anomalies developed preferentially downshear. One particularly strong mesovortex developed initially downshear-right, revolved cyclonically around the TC center for several hours, and subsequently merged with the broader TC vortex. The mesovortex was quite small (~5 km across), was located on the inward edge of the updraft region of an adjacent convective cell, and had a bottom-heavy vorticity profile that resulted predominantly from stretching of cyclonic vorticity in the low levels. The thermodynamic structure of the mesovortex and the surrounding TC vortex will be assessed. Throughout the simulation, the TC vortex was tilted in the downshear-left direction, with the tilt turning clockwise with height. The influence of the TC vortex tilt on the formation, axisymmetrization, and merging of the mesovortex and other cyclonic vorticity anomalies with the TC vortex will also be discussed.

Keywords: Tropical Cyclone, Shear, Convection
Parallel Session

SCI-PS120.04 - Eyewall convection during the rapid intensification of Hurricane Rita (2005)

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Tropical cyclone(TC)eyewall convection plays a critical role in intensity change. Recent studies have suggested that the radial location of eyewall convection relative to the radius of maximum wind is an important component of intensification efficiency. However, our understanding of the physical processes that determine the location and strength of eyewall convection is still incomplete. Axisymmetric conceptual and numerical models of the eyewall are characterized by moist neutral ascent forced by boundary layer convergence. In contrast, three-dimensional models suggest that a significant fraction of eyewall convective elements may contain positive buoyancy, and that asymmetric forcing by vertical shearing flow and mesoscale vorticity anomalies may play an important role. This study presents an analysis of the structure and forcing of eyewall convection observed during the rapid intensification of Hurricane Rita (2005) from the RAINEX/IFEX field campaign. A spline-based variational analysis is conducted to combine Doppler radar with aircraft and dropsonde observations. Improved retrievals of high-resolution winds and pressure gradients in the TC boundary layer are used to assess low-level forcing, and a novel thermodynamic retrieval is used to assess buoyancy and pressure perturbations in the free troposphere. These new mesoscale analysis techniques suggest that buoyancy, low-level supergradient winds, and vortex asymmetries all contribute to eyewall convective forcing, but the relative importance of different mechanisms evolves throughout Rita’s life-cycle due to the changing dynamic and thermodynamic environment. Comparisons with eyewall convection in a numerically simulated Rita and implications for predictability will also be discussed.

Keywords: Tropical cyclones, Rapid Intensification, Tropical convection
Our community may be approaching a tipping point concerning the balance between model advances and associated observational requirements. While there continues to be rapid increases in temporal and spatial model resolution and the proliferation of ensemble systems, there has been a marked stagnation in the construct of our observing systems, especially the needs of mesoscale models. Those needs are based on an approach to network design that recognizes it’s not feasible to fully resolve mesoscale weather phenomena with measurements alone, but it is feasible to observe the atmosphere at a resolution that enables faithful representation in NWP models. Notable advances have been achieved in the area of surface measurements owing to the increased availability of observations from a plethora of automated weather stations. Perhaps even more important are the significant, new technological achievements, such as the use of cosmic ray absorption and GPS noise to obtain area-averaged estimates of near-surface soil moisture. Another new surface data source comes from smartphones, some of which have embedded high-quality pressure sensors. Yet lower tropospheric profile measurements, especially within the planetary boundary layer, are both much needed and slow in coming. We explore new developments that hold promise for providing cost-effective, high-resolution profiles of water vapor and aerosol concentration using lidar techniques. Also considered is the recent progress involving dense networks of short-wavelength radar networks and development of phased-array radar systems. Several other profiling concepts are also discussed – all in historical context and with a view to the future.


Keywords: observations, profiles, PBL, mesoscale
Nowcasting of severe weather events is not only important but also challenging. This challenge becomes even bigger when nowcasting has to happen in regions where observation data is sparse. Large parts of the world, especially the African continent lack observations systems – not only at the surface (rain gauges), but also remote sensing observation systems such as radar networks. Nevertheless the need still exists to warn the public of pending severe weather events. Geostationary satellites and the use of Numerical Weather Prediction (NWP) models are sometimes the only tools available for the important task of issuing warning to the public. The Meteosat Second Generation (MSG) satellite has proven extremely valuable for African countries to monitor weather events. When the MSG data is used in combination with NWP, a number of applications have been developed. The Nowcasting Satellite Application Facility (SAF) has developed several products to aid nowcasting. These include precipitation products, satellite based instability indices as well as identification and tracking of Rapidly Developing Thunderstorms (RDT). This software has been installed in South Africa and examples of some of the precipitation products as well as the RDT product will be shown. These products will be validated against rain gauges and data from the lightning detection network in South Africa to demonstrate how these can benefit nowcasting in data sparse regions.

**Keywords:** nowcasting, data sparse
Parallel Session

SCI-PS121.03 - The German polarimetric weather radar network: the new radar data processing chain

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The German Meteorological Service DWD is introducing new polarimetric weather radar systems in their weather radar network employing the STAR-Mode concept (Simultaneous Transmit and Receive). With the introduction of those systems it is expected that the quality of existing data and products are improved and new products such as a hydrometeor classification can be provided. In order to obtain the full benefit from a polarimetric radar system a comprehensive quality assurance and radar data processing scheme is required. The focus of that scheme is to provide and guarantee high data quality, and to monitor the longterm radar system health in order to guarantee a high data availability. With the new radar data processing scheme (named POLARA) a hydrometeor classification and quantitative precipitation estimates are available. In particular the hydrometeor classification is a novel product in DWD from which the severe weather warning algorithms will benefit in the future. In this contribution we discuss aspects of the radar data quality control. The necessity to implement a comprehensive data quality scheme is highlighted using example products from the new radar data processing chain and which are verified with in-situ measurements.

\textbf{Keywords:} polarimetric radar, data quality control, hydrometeor classification
Parallel Session

SCI-PS121.04 - Towards collaborative developments applied to meteorology

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The Canadian Meteorological Centre (CMC) delivers a large number of numerical weather prediction products to various weather offices and clients throughout Canada and abroad. In order to address the maintenance of post production efficiently, an innovative system, SPOOKI (Système de Production Orienté-Objet contenant une Kyrielle d’Informations – Object oriented production system containing a myriad of information) and its development methodology were developed several years ago. It is based on a modular approach where each plug-in component is specialized, reusable and autonomous, allowing for quick adaptation to the rapidly evolving world of operational weather prediction. The system is now operational and is used to review in depth the whole approach to the operational post production of the CMC. This user-friendly system also facilitates further innovative development of weather products for aviation, summer and winter high impact phenomena, etc... by the collaboration of partners throughout Canada. Recently using SPOOKI, snow line forecasts have been easily and rapidly developed in experimental mode, in partnership with the National Lab for Coastal & Mountain Meteorology in Vancouver, using work done for convective storm diagnostic fields, from the Hydrometeorology and Arctic National Lab in Edmonton, showing the benefit of the partners’ collaboration via a common development platform. This type of system can be used by the community at large and across several disciplines.

Keywords: SPOOKI, Products, Collaboration, Partners
UAS-PS307.01 - Moving towards a resilient transport network for the future: integrating meteorology, engineering and social perspectives

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Transport systems are a vital part of DRM but are frequently also vulnerable to multiple hazards because of their extended infrastructure. Assessing these vulnerabilities has typically been done from a historical perspective in which infrastructure risk is considered as a series of isolated engineering structures each with a record of failures in particular weather conditions. Such an approach can provide valuable data for improvement or replacement of such structures but may not be adequate to predict future impacts within a changing social and environmental context. Achieving a more holistic view requires the integration of knowledge about individual structures within a framework capable of looking at the transport system more widely. This includes its social and DRM service provision roles, and likely patterns of future meteorology. This integration has many challenges, not least of which is that the timescales of meteorology, social change, economic investment and engineering structural lifetime are very different. Bridges, for example, may be designed for 50-100 year life during which time the social and economic services they are asked to provide, and the weather that impacts them, may change dramatically but cannot be reliably predicted at the design stage. One approach could be to over-engineer such structures but this is often seen as not viable economically because of the future uncertainty. Adopting a future scenario approach, coupled to a systems engineering modelling framework, may provide a way forward by quantifying system resilience with stakeholder endorsed metrics. Such an analysis will be illustrated for the UK rail network.


Keywords: Infrastructure, Adaptation, Scenarios, Modelling
Parallel Session

UAS-PS307.02 - Attenuating disruptive effects of bad weather on air travel – minimizing stranded travelers

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In an EU study named Management of Weather Events in the Transport System (MOWE-IT) is assessed how large disruptions of air transport, caused by bad weather, can be better accommodated by improved cooperation across transport systems. Assessed substitution options are, retention of passengers and freight at their origin, rerouting within air travel, transfer of passengers to nearby airports, modal switch to high speed rail, and trucking (air cargo) for a selection of major hubs in Europe. The effective exploitation of these options faces many obstacles, including capacity limits for transfers, ticket acknowledgement, luggage handling, accountability issues, information access, timing of warnings, spillover effects to national and regional transport systems, etc. Furthermore, some adverse weather conditions are also disruptive for (most) other modes, whereas others disturb only air transport. This affects the judgment of the mode switching options. Both better institutional arrangements and more intelligent, anticipatory and responsive information provision will be required to attenuate the disruptive effects. This includes the weather information provision to the aviation sector, regional transport authorities and travelers, in terms of timing, probabilities and alternatives. The presentation will discuss the results regarding the regulatory and economic feasibility to accommodate travelers stranded in major hubs via alternative channels so as to reduce disruptive effects. The presentation will also illustrate how the realization of benefits of improved weather service provision hinges on regulatory changes and investments. Finally, the presentation will review under what conditions improvements in the resilience of air transport can be expected to produce net benefits.

References: MOWE-IT project web-site http://www.mowe-it.eu/ Performance Review Unit (2011), Performance Review Report covering the calendar year 2010 (PRR 2010), Eurocontrol,

Keywords: Disruption, Crisis management, Inter-modal, Extreme weather
Winter weather presents significant risks for road transportation. While a range of responses is available to public transport agencies, including warning messages and enhanced driver training, the primary response is the prevention and clearing of snow and ice from road surfaces. Winter maintenance activities vary spatially because of the phasing in of new technologies and regional variations in maintenance practices, the latter of which reflect local climates. However, temporal patterns in winter maintenance mainly reflect variations in winter weather. It is precisely this weather variability that predicates the need for, and defines the utility of, winter severity indices. This paper summarizes and critiques several winter severity indices that have been developed for use by road authorities. It then provides a framework for developing simple-to-calculate, regional-specific indices for monitoring—and potentially forecasting—winter maintenance operations and budgets. The framework is based on assigning each individual day a weather score based on hourly and daily data from either national weather observation networks or road weather information systems. There is flexibility in how days are scored so as to reflect the sensitivity of different road treatments to specific weather conditions. These daily scores can then be aggregated by week, month or season. Preliminary analysis of Canadian data from multiple jurisdictions demonstrates the value of this approach.

Keywords: road transportation, winter maintenance, weather indices
Parallel Session

UAS-PS307.04 - The Pikalert Road weather hazard forecast system

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With funding and support from the U.S. Department of Transportation’s (USDOT) Research and Innovative Technology Administration (RITA) and direction from the Federal Highway Administration’s (FHWA) Road Weather Management Program, the National Center for Atmospheric Research (NCAR) is conducting research to develop the Pikalert Road Weather Hazard System that incorporates vehicle-based measurements of the road and surrounding atmosphere with other, more traditional weather data sources, and creates road and atmospheric hazard products for a variety of users. In the fourth phase of this research, NCAR and FHWA are partnering with three State Departments of Transportation (Minnesota, Michigan, and Nevada) to pilot two applications. These applications blend traditional weather information (e.g., radar, surface stations) with mobile vehicle data (e.g., temperature, yaw rate, headlight status) to diagnose current weather conditions. These weather conditions, and other road-travel-relevant information, are provided to users via web and phone applications. Several road hazard algorithms, including precipitation type (rain, ice, snow, hail), qualitative precipitation amount (rain - none, light, moderate, heavy; ice - none, slippery; snow - none, light, moderate, heavy), wind conditions (wind - none, light, moderate, extreme), road visibility (fog, dust, haze, blowing snow, sleet, hail), and flash flood danger are provided. This presentation will outline development and testing of the applications, as well as future directions for this research.

Keywords: road weather, decision support, connected vehicles, hazards
Parallel Session

UAS-PS308.01 - A spatio-temporal analysis of climate cost of cultivation in rural India

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Climate variability is the major factor governing year to year fluctuations in crop productivity. Changing climate patterns pose an additional risk to farmers, especially in developing countries. Sustaining agriculture dependent livelihoods in the face of climate change demands an improved quantitative understanding of how climate variables impact agriculture both temporally and spatially. The quantification of risk will provide the base for location specific climate change adaptation measures. This background motivated a study conducted in two blocks of Vaishali District, Bihar State, India, to develop a methodology for quantifying Climate Cost of Cultivation (CCC) in the agriculture sector. The methodology has been applied to maize (a rainy season crop) and wheat (a post rainy season crop) in the study area. The proposed methodology incorporates climatic and biophysical parameters. Climate variability in rainfall and temperature were considered as key parameters significantly impacting a crop. Thus, CCC was calculated for three climatic situations: deficit rainfall, excess rainfall and high temperature in three time periods, namely (1961-1990), (1991-2000), and (2001-2010) for both the crops. We observed significant spatial variations in CCC because of biophysical differences related to groundwater depth, soil type and elevation profile. Moreover, an overall increase in CCC in recent time (1990 onwards) compared to the base period of 1961-1990 for maize and wheat has been identified. This implies that location-specific biophysical parameters have a large impact on how climate variability affects farmers and that climate change has already increased the farmers’ financial burden and risk significantly over the last decades.

Keywords: Climate variability, Climate cost of cultivation, Spatial variations, Location specific
Parallel Session

UAS-PS308.02 - Determinants of farm-level adaptation diversity to climate extremes: Insights from farm households in India

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The livelihoods of farmers in the eastern coastal states of India are susceptible to cyclones and floods, and an adaptation policy should be designed to promote farm-level adaptations. It is therefore imperative to identify the determinants of farm-level adaptations, so that such factors can be targeted through policy. In view of this, previous studies examine factors influencing farmer’s decision to adapt, to undertake various not mutually exclusive options and to choose options over no adaptation. Moreover, the options are undertaken at different points depending on the nature of extreme events, and among them, some are ex-ante, while others are ex-post. In addition to assess determinants of adaptations to enhance specific options, it is also imperative to identify factors influencing farmers’ decision to undertake an additional option. This will help to raise the adoption rate of farm-level options. Using a survey data of 285 farm-households, this study aims to assess determinants of adaptation diversity, i.e. a number of adaptation mechanisms undertaken by the farmers. This finds that cyclone affected farmers are likely to take up higher levels of adaptation diversity than those of flood affected. Further, size of household, farming experience, per capita income, agriculture as major source of income and received formal crop loss compensation are some of the important determinants.

Keywords: adaptation diversity, determinants, Cyclone and Flood, Eastern India
UAS-PS308.03 - Integrated Interdisciplinary approach to drought risks and water management

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Drought is a challenge faced by communities across the United States, exacerbated by growing demands on water resources and climate variability and change. This study focuses on the Arbuckle-Simpson Aquifer (ASA) in south-central Oklahoma which is situated in the heart of the Chickasaw Nation and is the state’s only sole-source groundwater basin. The recent comprehensive hydrological studies of the aquifer indicate the need for sustainable management of the amount of water extracted. However, the question of how to deal with that management in the face of increasing drought vulnerability, diverse demands, and climate variability and change remains. To examine this question, we are conducting an investigation of drought risk from multiple disciplines. Anthropological data comes from stakeholder interviews that were designed to investigate conflict over water management; these data are analyzed to understand how people perceive risk differently based on different opinions about the structure of the resource, varying levels of trust in authorities, and unequal access to resources. Meteorological analyses of longitudinal data indicate periods of drought that are noted in stakeholder interviews. Analysis of hydrologic data investigates the influence of climate variability on local hydrologic impacts, such as changing groundwater levels and streamflows, that are relevant to planning and management decisions in the ASA. Finally, climate model projections are downscaled to the local level using a hybrid statistical and dynamical approach; this is used to characterize future drought risks and uncertainties relevant to the impacts and values identified in the stakeholder interviews.

**Keywords:** Interdisciplinary, Drought Risks, Water Management
While research and development efforts to mitigate weather related risks in agriculture are many, finding practical solution to manage risks in agriculture remains a challenge. This study explores how innovative financial instruments, supported by weather information, help cash constrained farmers in Ethiopia to mitigate major risks in agriculture- the lack and erratic distribution of rainfall. Through group discussions on the relevance and potential challenges of index based weather insurance scheme, farmers overwhelmingly support the idea. Farmers and researchers also agreed on potential problems: the lack of cash and scattered/unreliable weather stations. To solve the cash problem, cash constrained farmers are allowed to pay insurance premium in labor as long as they invest their labor in voluntary works (e.g. tree planting and soil and water conservation) on public land. Using choice experimental methods, both payment in labor and cash methods were examined. It is shown that cash constrained farmers are more likely to invest their labor to get insurance protection than those who have cash. However, substantial improvement was needed to better correlate the weather index and actual productivity loss on the farm. Thus, any innovative insurance products capable of managing drought risk requires improved weather information to minimize basis risk and standardize payouts.

Keywords: index based weather insurance, Agricultural Risk, in-kind premium, Weather information
Parallel Session

UAS-PS309.01 - Unidata’s vision for Transforming Geoscience by moving data services and software to the Cloud

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Universities are facing many challenges: shrinking budgets, rapidly evolving information technologies, growing data volumes, multidisciplinary science requirements, and high student expectations. Most faculty and researchers would prefer to focus on teaching and doing science rather than setting up computer systems. These changes are upending traditional approaches to accessing and using data and software; Unidata has been providing data services to the atmospheric sciences community for more than a quarter century. Now cloud computing technologies have matured. Cloud environments can reduce the amount of time and money spent to procure, install, and maintain new hardware and software, reduce costs through resource pooling and shared infrastructure, and provide greater security. Given this trend and the enormous potential of cloud-based services, we propose to gradually augment Unidata’s products and services to align with cloud-computing paradigm. Specifically, we will work to establish a community-based development environment that supports the creation and use of software services to build end-to-end data workflows. The design will encourage the creation of services that can be broken into small, independent chunks that provide simple capabilities. Chunks could be used individually to perform a task, or chained into simple or elaborate workflows. The services we envision will be loosely coupled to meet user needs rather than tightly coupled into a monolithic system. The services will be portable, allowing their use in researchers’ own cloud-based computing environments. We present a vision for cloud-enabled data services for advancing weather and climate research.

Keywords: Data Services, Tools
Parallel Session

UAS-PS309.02 - Engaging stakeholders as part of the MSC Services Strategy

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In an ever changing global climate, Canadians have a growing interest in climate-related information. In the past decade, the Meteorological Service of Canada (MSC) has provided most of its extensive climatological archives to public access via the Internet. However, some users find it challenging to find the information they desire. Also while traditional products such as climate normals and extremes are pertinent to many user needs, Canadians are increasingly seeking information on climate extremes, trends and climate change. The MSC will develop and implement a comprehensive climate services strategy. This strategy sets the direction for service delivery over the coming decade (2013-2023). It includes plans to develop enhanced web-based tools to access and analyze climatological information. Climate services will be expanded beyond the provision of historical data. Routine, long-range forecasts on the monthly to seasonal time scale may be expanded. In order for the MSC to deliver a more effective service, a cultural change is needed both internally within our organization, and also amongst our users and stakeholders. In more practical terms, this effort implies:  •Engaging stakeholder and users to better understand their decision-making processes and needs;  •Managing stakeholder/user feedback to ensure communication throughout MSC’s entire services value chain;  •Understanding MSC’s current and potential future capabilities;  •Working with stakeholders/users to jointly develop products and services that are useful and useable;  •Disseminating products effectively;  •Guide stakeholder/users in the interpretation and use of MSC’s products and services

Keywords: climate services, stakeholders, government, consultation
Parallel Session

UAS-PS309.03 - Providing an increasing range of CMC Numerical Environmental & Weather Prediction to expert users

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The Meteorological Service of Canada’s Canadian Meteorological Center (CMC) runs operational 24-7 Numerical Weather and Environmental Prediction Systems providing data and products to its forecast centers as well as to a wide range of external users. These systems, developed in R&D over many years, are implemented following a rigorous technical transfer process. As more and more components of these atmosphere, ocean, ice, land-surface and air quality modeling systems are coupled together they are becoming a truly integrated environmental prediction system from minutes to seasons. This opens the door to provide an expanded range of guidance products to expert users and decision makers. Emphasis in future operational systems will be on providing probabilistic information and uncertainties about prediction through reliable ensemble prediction systems while sharper deterministic systems will see further improvements through increases in resolution. Ocean modeling systems including ice will play a key role in the future in coupling with atmospheric prediction systems. This will contribute to improve our atmospheric prediction system and will allow for new datasets and products into services. These increasingly integrated systems will provide guidance capabilities to an expanded range of applications not only in operational forecasting and high impact weather assessment but also in a wide variety of environmental applications in emergency management and risk assessment. The presentation will describe plans on our operational systems and address the challenge of providing timely access of these Numerical Weather and Environmental Prediction data and products to expert users and in support to decision makers.

Keywords: Operational NWP systems, Environmental prediction
Parallel Session

UAS-PS309.04 - Weather, water and food security

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The new ICSU program ‘Future Earth’ combines IGBP, IHDP, Diversitas and WCRP. How can the atmospheric sciences community assist? Three of the constituent bodies of IUGG have initiatives: The IAMAS resolution urges atmospheric sciences communities to engage with the new activity. The International Association of Hydrological Sciences has a decade-long research program, Panta Rhei, seeking to answer: “How do changes in hydrological systems interact with and feedback on natural and social systems driven by hydrological processes?” The UCCEC seeks to interact with other international scientific unions to examine Weather, Climate and Food Security. Climate and especially severe weather – are known to impact on food security through disruption to agriculture and diminution of food availability. The effects on food availability, distribution and logistics result from: volcanic eruptions, earthquakes, floods, landslides, avalanches, tsunamis and storm surges as well as the hydrometeorological effects of rain, hail, and strong winds. Weekly to six month forecasts are mentioned in the WMO ‘climate services’ framework. They are important for food security through predictions of monsoon onset and intensity, especially in Africa where much of agriculture is rain fed. Knowledge of natural hazards and extreme events, on agriculture and food security, as well as on disaster risk reduction needs to be integrated to produce a research program capable of ensuring food security in the face of extreme weather.

Keywords: Food Security, Climate, Water, Weather
The theme of WWOSC2014 is seamless prediction and this refers to both predicting the meteorology of the atmospheric system with the same approach on all time-scales and to predicting non-meteorological aspects of the system such as atmospheric composition and flooding in an integrated way. Referring to this as seamless meteorology is to contrast with the modern fashion to instead use the phrase “weather and climate”. In this Townhall meeting we aim to discuss how various aspects of what it might take to establish a seamless approach to the science, prediction and use of such information.

Chair: Alan Thorpe

SCI-SPL02.02 – Panel Participant

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Please refer to the WMO website for presentations (if available) related to this panel
Joint Plenary Session

WW-JPL03.01 - How social sciences are and are not being woven into meteorological science

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New professional work is underway that has strong potential to reduce losses from severe weather. Unlike in the past the greatest advancements are not coming from forecasting improvements on the meteorological side. New collaborations between meteorologists, emergency managers, planners, hydrologists, and anthropologists, geographers, economists, communication experts and others are developing in ways that are transforming how weather-sensitive decisions are made at personal and professional scales. While there is limited opportunity for integrated training some people are getting credentials in meteorology and communication or anthropology or another social science. Successful case studies will be briefly reviewed with recommendations for how to accelerate the rate of change. How can the research-to-operations model be re-imagined to start with the expressed decision support needs of weather-sensitive stakeholders rather than the next possible forecasting technology? Examples of less promising efforts will also be presented along with explanations of why those efforts are more likely to continue the add-on tradition of social science rather than its integration and be less likely to reduce weather-related losses. How can this maturing holistic set of approaches be defined, accelerated and evaluated?

Keywords: social science, integrated approaches
Joint Plenary Session

WW-JPL03.02 - Advances in global numerical weather prediction and future prospects

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Over the past 30 years the skill of global numerical weather predictions has significantly improved; high-resolution global forecasts now routinely exceed a defined level of skill up to ~6½ days ahead, with particular forecasts extending considerably further. The rate of improvement continues at about 1 day per decade of research and development. Weather forecasts are constructed from accurate and reliable numerical predictions of the most likely future weather and a quantitative measure of the confidence that can be placed on that most likely outcome. These advances have arisen from scientific developments that have: reduced and quantified initial condition uncertainties, improved models, and predicted probability distributions. Numerical weather prediction is now based on the underpinning concept of estimating the initial-time probability density function and predicting its evolution by using an ensemble of complete realizations of the system. Further skill improvements are needed particularly for extreme weather and weather regimes. Looking forward, it is becoming apparent that many components of the Earth-system (e.g., atmosphere, oceans, composition, land, cryosphere) are influential for medium-range weather predictions. Also analyses and predictions of these components, on a range of time-scales, have societal significance and so numerical weather prediction is evolving into numerical environmental prediction. Exploration of the forecast skill horizon in a systematic way will enable us to determine what can be predicted and over which time-ranges and spatial-scales there is predictability.

**Keywords:** Prediction, Forecasts, Predictability, probability
Parallel Session

SCI-PS122.01 - Impact of weather and climate variability on terrestrial fluxes: integration of EO data into models

Jean-Christophe Calvet1, Gianpaolo Balsamo2, Alina Barbu1, Alessandro Cescatti3, Sébastien Lafont1, Fabienne Maignan4, Dario Papale5, Camille Szczypta1, Balazs Szintai6, Bart van den Hurk7

1CNRM-GAME (Meteo-France, CNRS), Toulouse, France, 2ECMWF, Reading, UK, 3IES (DG-JRC), Ispra, Italy, 4LSCE (CEA, CNRS), Gif-sur-Yvette, France, 5Tuscia University, Viterbo, Italy, 6OMSZ (Hungarian Meteorological Service), Budapest, Hungary, 7KNMI (Dutch Meteorological Service), De Bilt, The Netherlands

Assessing the terrestrial fluxes of carbon and water is a multi-scale problem in space and in time. Land surface models (LSMs), associated to Earth Observation (EO) data at various spatial scales, constitute a powerful tool to integrate various scales and observations. During the last decade, efforts were made in Europe to perform the greening (plant growth and CO2 responsive capability) of the land surface operational platforms of meteorological services. Since November 2011, ECMWF predicts the terrestrial carbon flux at a global scale with a spatial resolution of 16 km x 16 km. These forecasts are used by the Copernicus Atmosphere service to monitor carbon sinks and sources, using atmospheric CO2 concentrations. Meteo-France and OMSZ have developed regional Land Data Assimilation Systems (LDAS) within the SURFEX platform. The two LDAS cover France and Hungary, respectively, at a resolution of 8 km x 8 km and are able to integrate EO data such as Leaf Area Index (LAI) and surface soil moisture products. They are used to analyze the vegetation biomass and the root-zone soil moisture. The ongoing developments aim at (1) developing global versions of the LDAS able to integrate more EO products, (2) using the carbon options of operational LSMs into climate models or in offline simulations forced by downscaled climate scenarios, (3) applying these methods for agriculture (adaptation of agriculture to climate change, seasonal predictions), (4) producing multi-decadal reanalyses coupled to hydrology, (5) describing sub-km scales over specific regions using dynamic land cover maps.

Keywords: Land surface models, Data assimilation, Vegetation, Soil
Parallel Session

SCI-PS122.02 - The effect of Interannual climate variability on the methane emissions of tropical wetlands

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Methane emission from tropical/subtropical wetlands contributed about 78% global methane emission from nature wetlands. Decreased wetland CH4 emissions could act as a negative feedback to future climate warming and vice versa. Recent study suggested that powerful warming events in the eastern equatorial region, known as El Niños, are likely to double as greenhouse-gas emissions rise this century. However, the impact of ENSO on wetland emission variability has been paid less attention and remained poorly quantified at both regional and global scales. Here, we used an improved global greenhouse gases dynamic model of TRIPLEX-GHG to investigate the impacts of interannual variations on CH4 emissions in tropical wetlands during the period 1950 to 2010. Our modeled results suggest that CH4 emissions from tropical wetlands respond strongly, with larger negative anomalies during El Niño years and larger positive anomalies in La Niña years, to repeated ENSO events throughout 1950s-2000s, which has probably contributed to the recent decrease in the atmospheric growth rate of CH4 concentration during 1980s-1990s and stabilized observed atmospheric CH4 concentrations during 1999-2006.


Keywords: Global warming, climate change, greenhouse gases, modeling
Parallel Session

SCI-PS122.03 - Near-neutral atmospheric conditions over boreal wetlands improve the estimation of daily evapotranspiration in remote areas

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1INRS - Eau, Terre et Environnement, Quebec City, Canada, 2Polytechnique Montreal, Montreal, Canada, 3Universite Laval, Quebec City, Canada

A significant fraction of the energy supply to eastern Canada and northeastern USA comes from large hydropower plants located in the Canadian boreal shield. In this terrestrial ecosystem, boreal forest is predominant landscape, but wetlands represent another key landscape element. Needless to say, water exchanges between wetlands and the atmosphere greatly affect hydropower production and, therefore, have to be measured and modelled. The general objectives of this study were to gain a better understanding of the evapotranspiration processes over boreal wetlands using field observations, and to find a simple model to estimate daily evapotranspiration rates from wetlands using basic weather instruments. The study site was a 60-ha bog (53.7°N, 78.2°W) located in the La Grande River watershed. The analysis relied on turbulent flux data collected during a field campaign during summer 2012, as well as detailed measurements of the water budget. The eddy covariance data revealed that the atmosphere was neutrally-stratified for more than 60% of the summer. This unusual feature greatly simplifies the Monin-Obukhov Similarity equations for wind speed, temperature and humidity profiles. Precisely, when assuming a wet surface, the equations can be solved with only air and surface temperature, humidity and pressure, wind speed and average vegetation height. The model leads to an excellent approximation of daily evapotranspiration fluxes, which compares well with other classic models such as Priestley-Taylor that require more data inputs. The evapotranspiration model was also successfully applied at two other Canadian wetlands with different climates.

Keywords: atmospheric boundary layer, evapotranspiration, atmospheric stratification, hydrology
Parallel Session

SCI-PS122.04 - Modifications of the atmospheric moisture field as a result of cold-pool dynamics

Linda Schlemmer¹, Cathy Hohenegger¹
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This study investigates how precipitation-driven cold pools aid the formation of wider clouds that are essential for a transition from shallow to deep convection. In connection with a temperature depression and a depletion of moisture inside developing cold pools, an accumulation of moisture in moist patches around the cold pools is observed. Convective clouds are formed on top of these moist patches. Larger moist patches form with time supporting more and larger clouds. Moreover, enhanced vertical lifting along the leading edges of the gravity current connected to the cold pools is found. The interplay of moisture aggregation and lifting eventually promotes the formation of wider clouds that are less affected by entrainment and become deeper. The modifications of the moisture field are investigated in more detail using Lagrangian particles. The individual sources of the moisture in the wet-patch area are thereby isolated. The moisture sources consist of a direct evaporation of rainfall, a dynamical modulation of the primary moisture field by the cold-pool wake and a modification of the surface moisture fluxes by the cold-pool. The individual contributions are quantified over the course of the diurnal cycle.

Keywords: Clouds, Convection, Cold pools, Precipitation
Parallel Session

SCI-PS123.01 - From climate to weather: air-sea coupling scales

Baylor Fox-Kemper

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The oceans possess over 90% of the thermal capacity of the earth system and are responsible for the majority of the carbon uptake on decadal timescales, yet the atmosphere and hydrological cycle dominate the meridional transport of energy and carbon. Thus, climate modelers have long recognized the need for accurate air-sea coupling for projections. For similar reasons, medium-range weather forecasts increasingly incorporate air-sea-wave and ice dynamics. However, the contrast in duration of climate projections and weather forecasts leads to different model resolutions and performance metrics. I will discuss some of the consequences—in accuracy, dynamics, and numerics—of different scales in the boundary layers of atmosphere and ocean. Particular emphasis will be placed on mesoscale and submesoscale ocean dynamics and ocean surface waves and their effects on boundary layer turbulence and ocean fronts and filaments. Connections will be made to synoptic variability and air-sea coupling of heat, momentum, and gasses.


Keywords: annual cycle, submesoscale, boundary layer turbulence, dynamics
Parallel Session

SCI-PS123.02 - The impact of well resolved air-sea coupling on global weather extremes.

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Effective climate adaptation and mitigation efforts rely on robust information about changes in the statistics of extreme weather and climate events. Interactions between the atmosphere and the ocean are known to influence the frequency and intensity of such events and must therefore be represented in global climate simulations. The impact of well resolved air-sea coupling on global extremes is studied here within the HadGEM3-KPP framework which comprises the Hadley Centre atmospheric model (GA3.0) coupled to the K Profile Parameterization mixed-layer ocean model. In HadGEM3-KPP, at minimal computational cost, the vertical resolution of the upper-ocean and air-sea coupling frequency can be set to 1m and 3h, respectively. Coupled simulations using HadGEM3-KPP are compared with atmosphere-only integrations forced by (a) climatological and (b) time-varying sea surface temperatures (SSTs) from the coupled model. This experimental setup allows the impact of introducing inter-annual variability in SST to be separated from the impact of having well resolved air-sea coupling. Analysis of the mean-state shows that the impact of coupling is to moisten the tropical lower-troposphere, cause an equatorward shift in the subtropical jets, reduce the dynamical range of precipitation and produce systematically less cloud. These changes result in an improved representation of tropical precipitation and MJO (Madden-Julian Oscillation) propagation. Furthermore, this framework is used to investigate the impact of coupling on the representation of extra-tropical weather extremes, such as minimum winter temperatures and intense precipitation events over Europe.

Keywords: air-sea coupling, extremes, variability, mixed-layer ocean

Monday, 18 August 2014
11:00 - 11:20   Room 519 A
Parallel Session

SCI-PS123.03 - Global Coupled Atmosphere/Ocean Model for Seasonal and Climate Forecast Applications at NOAA/ESRL

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A coupled global model aimed at intra-seasonal and interannual prediction is under development at NOAA's Earth System Research Laboratory. It uses the FIM atmospheric model and a new ocean model "iHYCOM", basically an icosahedral grid version of HYCOM. Both components are 3-dimensional grid point models, laid out on a common icosahedral horizontal grid and using an adaptive hybrid-isentropic/isopycnic vertical coordinate. The fact that FIM and iHYCOM share a horizontal grid allows us to couple the atmosphere and ocean model directly without the need for an interpolating flux coupler and without coastline ambiguities. The atmospheric model uses column physics from the U.S. Weather Service’s GFS/CFS. Initial results showed large regional biases in cloud cover, and hence shortwave radiative flux, in both coupled and uncoupled (AMIP style) global simulations. In an attempt to reduce these biases, we have changed vertical resolution and developed and tested modifications for shallow and deep convection schemes. A number of 1-year AMIP tests on 60km and 120km horizontal meshes were performed exploring the sensitivity to these changes/parameters. Results of these tests and an optimal configuration of the FIM-iHYCOM coupled model are presented, together with comparisons to CFSv2 and NASA CERES data.


Keywords: coupled model, seasonal forecast
Parallel Session

SCI-PS123.04 - Why a warmer ocean might mean less rain

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Conventional wisdom is that higher sea surface temperatures (SSTs) favour higher rainfall rates, because warmer air reaches saturation with a higher specific humidity. However, relative humidity (RH) near the surface is more closely correlated with rainfall than specific humidity in some regions, such as western Europe, that lie immediately downwind of oceans, so other SST aspects may be of greater importance. Using observational data, idealised numerical model runs (simulating a cyclone using the Met Office unified model) and operational model reruns with a different underlying SST (using the ECMWF model), this has been investigated. The hypothesis under test was that the SST (anomaly) gradient along the incoming airmass trajectory is key. The conceptual model is that when SSTs remote from western Europe are below average, and SSTs closer to western Europe are above average, incoming airmasses will be warmed more from below, and therefore their boundary layer RH on reaching land will be relatively lower, and therefore rainfall relatively lower also. Each of the 3 components supported the hypothesis, as will be illustrated. Separately, each component also provided further insights. For example, observations suggest that surprisingly small SST anomalies, of order 1 degree Celsius or less, can have a statistically significant impact, whilst the ECMWF model component highlighted the need for a detailed representation of the ocean’s upper layers in coupled models. Though the study was localised to the North Atlantic / western Europe, the physics applies generally, and could have special relevance to other areas, such as southwest Australia.

Keywords: Sea surface temperature (SST), Ocean fluxes, Boundary layer, Humidity
Parallel Session

SCI-PS124.01 - Demonstrating a strategy for verifying km-scale NWP forecasts at observing sites

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Routine traditional verification of Numerical Weather Prediction (NWP) forecasts from convection-permitting or near-convection-resolving km-scale NWP models has shown that it is hard to consistently prove that km-scale models are more skillful. Furthermore we are now also interested in understanding the added value of km-scale ensembles over a single km-scale deterministic forecast. Here a recently developed strategy is used to evaluate km-scale model forecasts at observing sites over a period of ~2 years. This involves replacing conventional metrics and precise matching of the forecast to conventional synoptic observations in space and time with the use of inherently probabilistic metrics such as the Brier Score, Ranked Probability and Continuous Ranked Probability Scores. Six surface parameters are considered: 2 m temperature, 10 m wind speed, total cloud amount (TCA), cloud base height (CBH), visibility and hourly precipitation. The results show that more than precipitation forecast skill is compromised when using a traditional verification approach. The benefit of km-scale ensembles can also be clearly demonstrated.


Keywords: neighbourhood, ensemble, deterministic, verification
Parallel Session

SCI-PS124.02 - Forecast verification framework and some early results of the Sochi 2014 Winter Olympics

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The WMO/WWRP heritage of organizing Forecast and Research Demonstration Projects (FDP/RDP) during Olympics Games continued during the 2014 Winter Olympics in Sochi, Russia, within the framework of the FROST-2014 (Forecast and Research in the Olympics Sochi Testbed) project. Weather forecast verification was, as before, an integral and fundamental research component in the assessment of forecast performance of the end-user focused high-impact events. Several international partners from Austria, Canada, Finland, Italy, Norway, Russia, South Korea and USA contributed to FROST-2014 by running their own state-of-the-art deterministic and probabilistic nowcasting and forecasting systems during February-March 2014. The forecast products and producers had a big challenge to depict the evolution of high-impact weather phenomena affecting the time and space critical sports events taking place in a complex terrain at altitudes ranging from 500 m to 2500 m, thus posing also a demanding verification challenge. An overarching verification undertaking was launched by the Finnish Meteorological Institute by adapting the in-house real-time verification system for the Sochi environment. This led to high spatial resolution point verification over the c. 30 surface weather stations located at or close by the explicit sports sites. The presentation will first introduce the FROST-2014 forecast verification framework, thereafter provide details on the various prerequisites that needed to be taken into account and, finally, show illustrative cross-cutting early results of the performance of various forecast systems and components.

Keywords: Forecast verification, Sochi Winter Olympics
Parallel Session

SCI-PS124.03 - A wavelet-based verification approach to account for the variation in sparseness of gauge observation networks

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Forecasts defined over spatial domains are often characterised by a coherent spatial structure and the presence of features. Verification methods ought to account for this intrinsic spatial structure. However, when gauge observations are used for the verification, this task becomes particularly challenging because of the variation in sparseness and scale representativeness of the observation network across the domain. This study addresses some of the issues related to the verification of spatial forecasts against observations unevenly distributed in space. A wavelet-based approach to reconstruct a precipitation field from sparse gauge observations is introduced. The reconstructed field preserves the observed value at the observation location, represents the coherent spatial structure characterising the field, and accounts for the network density, so that more details are shown where the observation network is more dense. The wavelet reconstructed fields are used to perform a scale-oriented verification. Different scale components are isolated by a 2D Haar wavelet transform. Scales not represented in the observations are disregarded in the forecast prior to verification. Continuous verification statistics are then evaluated on each scale. Forecast and observation scale structure, the scale dependency of the bias error, and the no-skill to skill transition scale are analysed. The sensitivity of the scale-based verification statistics to the network density, and the effects of including satellite clear-sky data in the wavelet reconstruction are also illustrated.

Keywords: wavelet, scale-oriented verification, sparse observation network
Parallel Session

SCI-PS124.04 - Points and pixels, gage and sky: Choosing the right observations to verify forecasts

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As numerical models become increasingly product-rich, better resolved, and global in extent, decisions about verification datasets accordingly become more complicated. Often the choice is not simply between observation types, but between different analyses of observations. In the case of hydrologic variables including precipitation and integrated water vapor (IWV), analyses that combine point measurements, radar and/or satellite estimates, and occasionally short-term forecasts or historical adjustments, have been used to initialize and verify forecasts. Often lost in these applications is the substantial impact that the simple choice of data can have on verification results. Indeed, differences related solely to datasets can overwhelm differences in model performance that verification activity is intended to assess.

Presented in this paper are several verification results that illustrate the character and magnitude of these differences during severe precipitation episodes in the coastal and Sierra Nevada mountain ranges in California. These results summarize part of a collaboration between the Developmental Testbed Center (DTC) and the Hydrometeorological Testbed (HMT) to assess high-resolution model forecasts of precipitation and associated meteorological fields. Direct comparisons are made between verification at point rain gages in the California domain and at grid points of the Stage IV precipitation analysis produced at the Environmental Modeling Center (EMC). Similar comparisons are shown for verification using point IWV observations as contrasted with parallel verification at grid points of the Local Analysis and Prediction System (LAPS). We also compare precipitation verification scores using traditional Stage IV estimates with those using the new Climatologically Corrected Precipitation Analysis (CCPA).

Keywords: verification, ensembles, observations, precipitation
The accuracy of numerical weather prediction at the medium-range (lead times ranging from 3 to 15 days) has significantly increased over the last 20 years. These improvements are due to a variety of factors: a better observational network, more sophisticated data assimilation techniques, more precise dynamical cores, better parameterization of relevant sub-grid scale physical processes, better coupling with environmental models, more powerful supercomputers, etc. In order to continue improving the accuracy of medium-range forecasting over the coming decade, our research community will have to face additional challenges. This presentation will describe research activities undertaken at the Meteorological Research Division of Environment Canada (EC) aiming at providing better medium-range forecasts. At EC, these new challenges include: 1) the assimilation of more and more diverse remotely sensed and in situ observations, 2) the development of hybrid and scalable ensemble-variational (En-Var) data assimilation techniques and ensemble Kalman filters (EnKF) for deterministic and probabilistic forecasting, 3) the two-way coupling of the atmospheric model component to a global ice-ocean prediction system, 4) the development of a scalable and more accurate dynamical core for the atmospheric component, 5) the improvement of physical parameterizations, especially those related to moist and tropical processes, 6) the inclusion of stochastic processes in models for probabilistic forecasting. Results from recent experiments including the above-mentioned elements will be shown. Given the anticipated changes in supercomputer architectures, EC’s strategy on the scalability of its weather and environmental prediction systems will be discussed.

Keywords: ensemble-variational data assimilation, ensemble Kalman filter, Yin-Yang domain decomposition, atmosphere-ocean coupling
Forecasting severe weather conditions is one of the key aspects of weather forecasting. For many years it has been viewed as a close to of impossible task for global models, and still is for some types of events (e.g. tornadoes). However, other cases such as hurricane Sandy have shown a signal one week in advance. During recent years the forecast performance for a number of severe weather cases has been investigated in detail at ECMWF. Among the cases are tropical cyclones including Sandy and Haiyan, European wind storms as St Jude and Xaver and floodings as the ones affecting Central Europe and Colorado in 2013. From each case relevant aspects of the forecasting system have been investigated. The case studies are complemented by systematic verification of different types of severe weather, by calculating frequency biases and a range of scores. In this presentation we will highlight findings from the case studies together with results from the general verification. Evaluating the forecasts we find that for many cases the synoptic situations are well captured but e.g. the details are still an issue and the model resolution plays a role. For the general verification of rare/severe events, observation data, sample size choice of metric all need careful consideration. The procedures applied at ECMWF will be discussed.

**Keywords:** Severe weather, Diagnostics
Hurricane Sandy was the most destructive hurricane of the 2012 Atlantic hurricane season. It developed from a tropical wave on October 22 and became a Category three storm at its peak intensity on October 25. Early on October 29 Sandy became a post-tropical cyclone with hurricane-force winds and made landfall along the New Jersey seashores. A few hundred people were killed along the path of the storm and the damage amounts to more than $65 billion in the United States alone. While all NWP models correctly predicted that the storm will strike the New Jersey Seashore within 72 hours of its landfall, most models struggled to predict its path at longer forecast lead times. The United States GFS (Global Forecast Systems) predicted a northeast instead of northwest path from the forecast cycles before October 25 and a path biased toward the north from the cycles before October 27. In this study, the impact on GFS predicted Sandy storm path and intensity of supplemental radiosonde observations launched at 06 and 18Z starting from October 25 will be examined. The sensitivity of the GFS forecast of Hurricane Sandy to model resolution and different physics options will be investigated. In particular, the calling frequency of radiation will be changed from hourly to every model physics timestep to enhance radiation-cloud interaction. A GFS with more than doubled horizontal resolution will also be used to test the sensitivity of predicted storm path and intensity to model resolution.

**Keywords:** Hurricane Sandy, Track and Intensity, NCEP GFS
Ideally, ensemble predictions provide a random sample of the possible future weather states. In practice, ensemble predictions have systematic deficiencies that have been hard to overcome, including biased mean forecasts and a lack of spread. Over the past 10 years, a number of approaches have been attempted for overcoming these deficiencies. These include the development of improved ensemble prediction systems, the use of multi-model ensembles, and statistical post-processing of ensemble guidance. This talk will review developments primarily for this third approach, statistical post-processing, whereby past forecasts and observations/analyses are used to develop methods for correcting deficiencies in the real-time guidance. The talk will review the use of reforecasts, the range of methods that have been attempted for post-processing, and the impacts they have had on improving the forecasts, and some of the key remaining scientific and practical issues in statistical post-processing. Oral strongly preferred.

**References:**

**Keywords:** ensemble prediction, statistical post-processing, reforecasts
How to specify observation-error correlations for AMSU-A radiances is an open problem. An operational practice is to neglect error correlations and inflate error variances. This approach is convenient as it permits well-posed and efficient matrix operations on the now diagonal observation-error covariance matrix. However, it is essentially ad hoc and it is not obvious how to relate the adopted observation-error variances to actual properties of the observations. The ensemble Kalman filter (EnKF) has attractive features for studying the problem. Following the underlying Monte Carlo methodology, different ensemble members are generated using realistic random perturbations to any uncertain input values. With regard to the observations, one thus needs a different perturbation set for each ensemble member. For the radiance observations, using evolving random fields, it is possible to generate these perturbations so that they respect desired spatial and temporal error correlations. From the ensembles of forward operator values and observation errors combined with actual differences between the background and the observations, it can be verified if the assumed error statistics agree with observed radiance innovation statistics. Results will be shown using a research configuration of the operational Canadian global EnKF. Here, to reduce the computational cost involved with solving the analysis equations, the observations need to be grouped into batches of approximately independent observations.

**Keywords:** radiance, ensemble Kalman filter
Parallel Session

SCI-PS126.02 - Application of the WRF – LETKF System over Southern South America: Sensitivity to model physics.

Maria Eugenia Dillon\textsuperscript{1,2}, Yanina Garcia Skabar\textsuperscript{1,2,3}, Juan Ruiz\textsuperscript{3,4}, Eugenia Kalnay\textsuperscript{5}, Estela Collini\textsuperscript{2,6}, Pablo Echevarria\textsuperscript{2}, Marcos Saucedo\textsuperscript{3,4,7}, Takemasa Miyoshi\textsuperscript{8}

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In order to improve the initial conditions for short–range numerical weather prediction, the Local Ensemble Transform Kalman Filter system with the Weather Research and Forecasting model (WRF-LETKF), developed at the University of Maryland, has been implemented experimentally at the National Weather Service of Argentina. In this study, results obtained from a 60-day regional data assimilation cycle over Southern South America using the WRF-LETKF system are presented. In order to consider the effect of model error, we implemented a multi-model scheme using different combinations of the cumulus and boundary layer parameterizations. Adaptive multiplicative inflation is also used to take into account observation densities and the model error. The prepbufr observation data from the National Centers for Environmental Prediction (NCEP) and the boundary conditions from the NCEP GFS forecasts were used. A super-observation technique is applied to the surface wind retrievals from the ASCAT to reduce the impact from the correlated observation errors. The impact of this data assimilation system on the forecast was found to be positive. We also compare the results of the multi-model physical parameterizations with a single model scheme. Finally we document the progress towards the implementation of a state-of-the-art, real time, data assimilation system at the National Weather Service of Argentina.

Keywords: data assimilation, multi-model scheme, super-observation technique
A Regional Ensemble Kalman Filter (REnKF) is being developed in view of operational transfer to the Canadian Meteorological Centre in 2015-16. This assimilation system is a prerequisite to a coherent data assimilation system for: 1) the operational Canadian Regional Ensemble Prediction System (REPS at 15-km grid spacing), and 2) the upcoming Pan-Canadian High-Resolution Deterministic Prediction System (HRDPS at 2.5-km grid spacing). This REnKF currently runs at 15-km grid spacing with 192 members. It will provide background error statistics to be used by the Regional (deterministic) Ensemble-Variational Analysis (RenVar), as well as an ensemble of initial conditions for the Regional Ensemble Prediction System. The cycling procedure of the REnKF together with its design will be compared with those of the operational Canadian Global EnKF system (GEnKF). Results of continuous one-way cycling for summer and winter test cases with the REnKF will be presented and compared with the GEnKF. In addition, the impacts of the REnKF analyses on the performance of the REPS at 15-km grid spacing will be presented.

**Keywords:** Ensemble Data Assimilation, Regional Data Assimilation, Regional Ensemble Prediction
Parallel Session

SCI-PS126.04 - Comparison of GSI-based EnKF and 3DVar for multi-scale data assimilation and prediction of continental convection

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A Gridpoint Statistical Interpolation (GSI)-based Ensemble Kalman Filter (EnKF) system is configured to provide seamless analysis and prediction across a broad range of scales, in the context of mid-latitude continental convection forecasts. Conventional regional and synoptic scale observations are assimilated every 3h on an outer domain with 12km grid spacing. The outer domain analysis ensemble provides initial and lateral boundary conditions (IC/LBCs) for an inner domain analysis and forecast ensemble at 4km grid spacing. Radar reflectivity and velocity observations are assimilated on the inner domain every 5min.

The multi-scale GSI-based EnKF system is compared to a similar GSI-based 3DVar system that does not benefit from the flow-dependent background error covariances of EnKF. A case study characterized by initially small storms that grow upscale into a Mesoscale Convective System (MCS) during the forecast period is used to demonstrate the advantages of the GSI-based EnKF system over the 3DVar system. Advantages include smaller first guess errors of all observed variables for EnKF during the assimilation period and a more accurate forecast of the MCS. The comparison is then extended to an 11-case reforecast period of convectively active cases to obtain more robust results. In addition to exploring the differences of different data assimilation methods on the forecast of continental convection, the impacts of the multi-scale flow dependent ensemble IC perturbations naturally produced by the ensemble data assimilation system on multi-scale probabilistic forecasts are also evaluated. Key results from both perfect model Observation System Simulation Experiments and real data experiments will be presented.

Keywords: data assimilation, multiscale, convection-permitting
SCI-PS127.01 - A future ground-based network of thermodynamic boundary layer profilers: The infrared spectrometer option

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Many august bodies, including the U.S. National Research Council, have argued strongly that the Nation needs a network of ground-based instruments that are able to profile temperature and water vapor throughout the atmospheric boundary layer at high temporal and vertical resolution. The instruments need to be able to provide temperature and humidity profile data in a wide range of atmospheric conditions for both operational and research objectives. This presentation presents one vision for such a network, wherein ground-based infrared spectrometers serve as the core instruments at each station. A novel algorithm was recently developed that is able to retrieved thermodynamic profiles and cloud properties simultaneously from downwelling infrared spectra. A full error covariance matrix of the solution is also provided by the method that enables the evaluation of the accuracy of the profile under different weather conditions. This presentation will give an overview of the instrument and retrieval technique, and provide several examples to illustrate the accuracy of the retrieved thermodynamic profiles and the value of these profiles to understand different evolving weather conditions. Furthermore, the strengths of the infrared spectrometer approach will be discussed, relative to other technologies, and several examples that illustrate the technique and its potential will be provided.

Keywords: Infrared spectrometer, Thermodynamic retrievals
Parallel Session

SCI-PS127.02 - European ceilometer and Doppler lidar network for operational boundary layer monitoring

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Improvement and validation of short-term and high-resolution numerical weather predictions require dense observational networks which provide high quality data with sufficient temporal (1-5 minutes) and vertical (30 m) resolution of the atmospheric boundary layer. In Europe, a network of more than one hundred ceilometers and over 20 Doppler lidars has been built up by national weather services and research institutes. Recently, a framework called “Towards operational ground based profiling with ceilometers, Doppler lidars and microwave radiometers for improving weather forecasts (TOPROF)” was initiated as European Union funded project. In TOPROF special attention is given for data quality and uncertainty estimation with focus on backscatter and Doppler velocity. As an example, different calibration methods for backscatter profiles are planned to be tested and recommendations on data processing for stakeholders will be provided. In addition, the framework aims for synchronised retrieval of boundary layer properties (e.g. wind profiles, mixing layer depths, and cloud base heights). However, several different measurement strategies and subsequent retrieval methods exist. Therefore, it is important to harmonize measurement strategies where possible and to find the most promising methods for boundary property retrievals. In the conference the very latest status of ceilometer and Doppler lidar network and activities around it will be presented.

**Keywords:** Ceilometer, Doppler lidar
The wind is an important parameter to quantitatively describe the state of the atmosphere. Numerical weather prediction (NWP) needs precise 3D wind measurements to estimate the initial state of the model as accurately as possible. Only a few observing systems are able to routinely provide vertically resolved wind measurements throughout the atmosphere, notably Radiosondes and aircraft observations. Spaced based systems are hitherto only able to infer winds from cloud motions. Ground-based remote measurements by radar wind profiler (RWP) have the ability to provide vertical profiles of the horizontal wind components at high temporal resolution in both the cloudy and the clear atmosphere. The presentation will discuss benefits as well as the challenges of operational ground based wind profiling based on the experience gained with the European network CWINDE (Co-ordinated wind profiler network in Europe). While it could be demonstrated that profiler data are able to provide a higher positive impact in NWP than Radiosondes, it is mandatory to both perform a strict quality control in real-time data processing and to continuously monitor and maintain the instruments hardware. Especially important is the availability of uncontaminated RF spectrum. Recently, a new class of compact fiber-optics based infrared Doppler lidars has been developed which have the potential to operate as fairly robust laser wind profilers for the boundary layer. They can complement, but not replace, RWP’s, as will be illustrated with results from a quasi-operational one year trial.

**Keywords:** Radar wind profiler, CWINDE network, Lidar wind profiler
Parallel Session

SCI-PS127.04 - A system for monitoring in-situ soil moisture in Canada’s agricultural landscapes.

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Agriculture and Agri-Food Canada is developing a system for monitoring of soil moisture in order to meet increasing needs within agriculture for more proactive information to understand weather, climate variability and to better assess risk of flooding and drought. An in-situ monitoring network was established from 2011-2013 at three agricultural locations in Canada, including Manitoba (12 sites), Ontario (5 sites) and Saskatchewan (8 sites). The sites were established in fields with active agricultural practices and the fields were instrumented to gain information from a wide range of soil texture and crop conditions through the rootzone. Climate variables are also monitored at most stations. Data from the sites are collected and distributed in near real-time and are used for a variety of purposes including flood risk assessment, agronomic planning and to validate remote sensing estimates of surface soil moisture. The data are also input into the Canada Land Data Assimilation System to support enhanced weather forecast modeling. Information gained from operation of these sites is being used to develop best practices for design, establishment and operation of future soil moisture monitoring networks. This presentation will discuss how the preliminary data is being used for characterizing site conditions, for calibrating the moisture probes, for validating a soil moisture retrieval method using C-band Synthetic Aperture Radar (SAR) data and L-Band passive microwave data, and for validating the root zone soil moisture for drought analysis.

Keywords: soil moisture, agriculture, soil, data distribution
Data assimilation at convection-permitting scales presents a number of fundamental challenges. Typically, convective-scale events develop on short timescales ranging from minutes to hours. It is therefore important to have both observations that sample fine-scale weather at high time-frequency (e.g. radar) as well as models that can accurately represent the important processes (e.g. convection, cloud physics, etc). Data assimilation techniques need to take account of nonlinearities and complex error structures of both observations and high-resolution models. Operational analyses need to be produced within a very short period of time, e.g. a few minutes if required for nowcasting severe convection. This talk will begin with a review of these many scientific challenges that face implementation of operational, convective-scale data assimilation. The talk will then provide a brief review of current and planned future operational data assimilation capabilities at the Met Office and elsewhere. In parallel with the development of data assimilation techniques for convective-scale, a wide array of high temporal/spatial resolution observation types are being assessed/under development for application in km-scale NWP. Results from recent high-resolution observation system (OSEs) experiments will be presented, giving an indication of relative impact in high-resolution UK data assimilation.

Keywords: Data assimilation, NWP, High-resolution, Convection
Parallel Session

SCI-PS128.02 - ACCESS Convective Scale Data Assimilation

Peter Steinle\textsuperscript{1}, Susan Rennie\textsuperscript{1}, Xingbao Wang\textsuperscript{1}, Yi Xiao\textsuperscript{1}, Justin Peter\textsuperscript{1}, Alan Seed\textsuperscript{1}, Mark Curtis\textsuperscript{1}

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Over the past 3 years, the Australian Bureau of Meteorology has been assessing the potential of a convective scale numerical weather prediction (NWP) system capable of assimilating radar data – both Doppler radial winds and precipitation data. The aim is for the new NWP system to bridge the gap between observation based precipitation nowcasting and existing NWP systems. The system is being developed as part of the Australian Community Climate and Earth System Simulator (ACCESS, Puri et al. 2013). The NWP components of the system are based on the UK Met Office Unified Model and variational assimilation system – specifically the 1.5km UKV system (Dixon et al. 2009). An important part of this system is the ability to provide rapid update forecasts, using an hourly (or 3-hourly) assimilation cycle. Extensive trials have been carried out from September 2011 to July 2012, as well as for specific periods over 2010-11 and 2013. Despite the differences in observation networks and weather conditions between Australian and the UK, the system is providing guidance far superior to existing global and regional NWP systems. This presentation will discuss some of the challenges in applying this system to semi-tropical conditions as well as an overview of the performance of the 1.5km system relative to other systems. These issues cover various aspects of data assimilation: from quality control, error covariances, dealing with large scale errors and model errors, particularly as they impact on short term prediction of intense rainfall events.


Keywords: Convective, NWP, Assimilation
Parallel Session

SCI-PS128.03 - Various strategies to increase temporal frequency in the AROME-France Convective-Scale Data-Assimilation System

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AROME-France is the operational convective-scale Numerical Weather Prediction system in operations at Météo-France since the end of 2008 [1]. It uses a 3D-Var Data Assimilation (DA) scheme in a 3-h continuous assimilation cycle in order to determine its initial conditions at the horizontal resolution of the model (2.5km). In addition to conventional and satellite observations, regional high-resolution observations are assimilated, such as, screen-level observations, total zenith delays from ground based GPS stations and radar measurements (radial winds and reflectivities). The weakness of the representation of the temporal dimension in this system leads to an inefficient use of these observations with high temporal (and often spatial) coverage. Different ways to improve the use of such observations are discussed here: First the increase on the assimilation cycle frequency (using a 1 h period) is investigated, allowed by the reduction of the numerical noise in the first ranges of the model forecast. Then the use of a 3D-FGAT scheme and first steps towards a 4D-Var system in the 3-h assimilation cycle are illustrated. Finally the potential of a one-hour non-cycled data assimilation for nowcasting applications will be shown. This last configuration led to the AROME-nowcasting system that will become operational soon in Meteo-France.


Keywords: data assimilation, meso-scale
Parallel Session

SCI-PS128.04 - Super high-resolution mesoscale NWP with the K-computer

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A research on super high-resolution mesoscale numerical weather prediction with the K-computer is introduced. This research project is one of the five fields of the MEXT-funded national research project in Japan, the Strategic Programs for Innovative Research (SPIRE). Following three subjects are underway to show the feasibility of precise prediction of severe mesoscale phenomena: 1) Development of cloud resolving 4-dimensional data assimilation systems, 2) Development and validation of a cloud resolving ensemble analysis and forecast system, and 3) Basic research with very high resolution atmospheric models. In the presentation, development of advanced data assimilation methods (e.g., cloud resolving 4D-VAR, two-way nested LETKF) is introduced, and examples of high-resolution and super high-resolution data assimilation/ensemble experiments of severe weathers (typhoon, torrential rain, and tornado) are shown. A realistic simulation of observed 3-dimensional structure of the sea-breeze front head with a nested building-resolving LES model will also be presented.


Keywords: K-computer, data assimilation, ensemble prediction, high-resolution NWP
Parallel Session

SCI-PS129.01 - Coupled meteorology-chemistry models: needs and benefits for Numerical Weather Prediction, Air Quality and Climate communities

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The COST Action ES1004 EuMetChem - European framework for online integrated air quality and meteorology modelling (eumetchem.info) - is focusing on a new generation of online integrated Atmospheric Chemical Transport and Meteorology models with two-way interactions between different atmospheric processes including chemistry, aerosols, clouds, radiation, boundary layer, emissions, meteorology and climate. The focus on integrated systems is timely, since recent research has shown that meteorology and chemistry feedbacks are important in the context of many research areas and applications, including NWP, AQ forecasting as well as climate and Earth system modelling. However, the relative importance of online integration and of the priorities, necessary requirements for representing different processes and feedbacks can greatly vary for these related communities. This study summarises the current status of European online coupled modelling practices (Baklanov et al., 2014) and tries to give some answers on the above questions. For example, NWP might not depend on detailed chemical processes but considering the cloud and radiative effects of aerosols can be important for fog, visibility and precipitation forecasting. For climate modelling, feedbacks from GHGs and aerosols become extremely important. However for long-lived GHGs fully online integration of full-scale chemistry and aerosol dynamics is not always critically needed. For chemical weather forecasting and prediction of atmospheric composition in a changing climate, the online integration definitely improves AQ and composition projections. The different modelling communities had different targets with respect to temporal as well as spatial scales, but also to processes under focus.


Keywords: meteorology, chemistry, online coupled models, aerosol feedbacks
Parallel Session

SCI-PS129.02 - A study of feedbacks between weather and air-pollution using GEM-MACH

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Atmospheric chemistry and transport models may be “off-line” wherein meteorological inputs are provided by an a priori simulation using a weather forecast model, or “on-line”, wherein the chemical and meteorological components are contained within the same model. On-line models may be “partially coupled”, with the meteorological components only being used to drive the atmospheric chemistry, or “fully coupled”, wherein the chemical components are also allowed to affect the meteorology. A fully coupled, on-line model, will thus allow feedbacks between atmospheric aerosol formation and weather to be simulated. Phase 2 of the Air-Quality Model Evaluation International Initiative is a multi-model inter-comparison of coupled models and observation network data, for domains covering Europe and North America. An important part of this international collaboration is the focus of this work: to examine the extent to which feedbacks influence forecast predictions of atmospheric aerosols and meteorology. Model simulations were carried out for the years 2006 and 2010 for a North American domain, and one year (2010) for a European domain. The effects of including feedbacks on weather (and for some models on chemistry) were carried out with “basecase” and “feedback simulations, using the models GEM-MACH, WRF_CMAQ, and WRF-CHEM). Time series of hourly statistical comparisons between “base case” and “feedback” simulations were used to examine these effects, as were annual statistics calculated at each grid-square, for common AQMEII2 comparison grids. The incorporation of feedbacks was found to be capable of changing seasonal weather and chemical variables significantly, depending on the time period and variables examined.

Keywords: Feedback, Direct Effect, Indirect Effect, Air Pollution
Parallel Session

SCI-PS129.03 - Evaluation of meteorological models used in Phase II of AQMEII for North America

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A large international contingent of atmospheric modeling groups from Europe and North America evaluated the performance of numerous meteorological and chemical transport model simulations as part of AQMEII, the Air Quality Model Evaluation International Initiative – Phase I. This effort, which was unprecedented in scope, evaluated model performance over both continents for an entire year (2006). Building on the success of that effort, the modeling community has begun Phase II, in which a similar evaluation will be conducted for the year 2010. This latest annual simulation/evaluation will afford several additional opportunities: first, in contrast to Phase I, Phase II is aimed at “coupled” or “in-line” meteorology-chemistry model configurations in which feedback associated with air quality (i.e. aerosol radiative forcing) is allowed; and second, an additional year will allow for a dynamic evaluation for those modeling groups examining the efficacy of major emission control strategies. This abstract will focus on the meteorological performance of five modeling configurations supplied by three Nations: 1) Weather Research and Forecasting (WRF) – Community Multi-scale Air Quality (CMAQ) [U.S. EPA]; 2) WRF-Chem [U.S. NCSU]; 3) WRF-Chem [UCAR]; 4) WRF-Chem [U. Murcia, Spain] and 5) Global Environmental Multi-scale - Modelling Air quality and CHemistry (GEM-MACH) [Environment Canada]. The meteorological parameters most relevant to air quality processes (transport and mixing, chemistry, and surface fluxes) such as 2-m temperature, 10-m wind speed and direction, PBL height, precipitation and radiation will be emphasized. Both model-to-model and model-to-observation evaluations will be performed.

Keywords: AQMEII, Meteorological models, Evaluation
Model evaluation studies are essential for determining model performance as well as assessing model deficiencies, and are the focus of the Air Quality Model Evaluation International Initiative (AQMEII). The chemistry-transport model system COSMO-MUSCAT (Wolke et al. 2012) participates in this initiative. One aim of the second phase of AQMEII is the investigation of the influence of the aerosol distribution on the radiation and, consequently, on the atmospheric dynamics. In this paper the impact of widespread agricultural burning and forest fires in western Russia on the air quality in Central Europe and the feedback of the modelled high levels of particulate matter (PM) concentrations on the meteorological model are analysed. The COSMO-MUSCAT results are evaluated in comparison with ground-base measurements and satellite data. The analysis is performed for a selected period in April 20010 which are characterized by elevated concentrations of PM. The model sensitivity is studied against changes in the meteorological forcing, the fire emissions and the applied feedback approach. Possible reasons for differences in model results will be discussed.


Keywords: air quality modeling, particulate matter, Aerosol feedback on dynamics, impact of wild-land fires
Parallel Session

SCI-PS130.01 - The influence of tropical cyclones on the predictability of mid-latitude weather systems

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A tropical cyclone undergoing extratropical transition (ET) can modify the midlatitude flow both in the vicinity of the ET event and further downstream. The interaction can result in a severe reduction of the forecast quality in the midlatitudes. In this presentation an overview is given of the dynamical mechanisms that characterize the modification of the midlatitude flow during ET. We consider both the interaction of the low-level tropical cyclone circulation with midlatitude frontal zones and the modification of the tropopause by the upper-level outflow, and emphasise the role of diabatic processes. The impact of all these processes on downstream predictability is shown to be related to the excitation and modification of Rossby wave trains. The impact on the midlatitude predictability is illustrated based on case studies and experiments with the ECMWF ensemble prediction system. Analysis of the variability in ensemble forecasts during extratropical transition confirms the importance of the dynamical mechanisms for the predictability. Investigation of the impact of different forms of perturbations in the ECMWF Ensemble Prediction System provides further insight into the importance of diabatic processes as well as giving information on the sensitivity of ensemble forecasts to the different perturbation methods.

Keywords: Tropical Cyclone, Extratropical Transition, Ensemble Prediction System
Parallel Session

SCI-PS130.02 - Sensitivity of the downstream impact to the eddy kinetic energy budget of transitioning tropical cyclones

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The extratropical transition (ET) of a tropical cyclone (TC) may strongly impact the midlatitude wave pattern by amplifying or triggering a Rossby wave train and thus facilitate high impact weather events even in regions lying far downstream of the transitioning TC. The processes involved in the transition and interaction are often not well represented in numerical weather prediction (NWP) systems. As a result, predictability for downstream regions is frequently reduced during ET. A better understanding of the important processes and their representation in NWP systems will help to overcome those issues in predictability. Our study aims to identify the impact of a transitioning TC as an additional source of kinetic energy on the modification of the midlatitude flow and the associated forecast uncertainty. We employ ECMWF ensemble forecasts to gain multiple solutions for the interaction of two transitioning TCs with the midlatitude flow. By determining the sensitivity of the amplifying downstream wave train to the eddy kinetic energy (Ke) budget within the ensemble, we are able to identify the role of the ET in modifying the midlatitude flow configuration. Specific features of the Ke budget associated with the transitioning cyclone are found to have a significant impact on the amplification of the downstream wave train, while the Ke budget of the upstream midlatitude flow seems to be of secondary importance. We further seek to link the identified dependencies to predictability in downstream regions.

Keywords: extratropical transition, eddy kinetic energy, ensemble sensitivity analysis, predictability
Parallel Session

SCI-PS130.03 - Tropical cyclone – Rossby wave train interaction in idealized scenarios of extratropical transition

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Rossby wave trains (RWTs) are fundamental to the midlatitude dynamics and play an important role in the development of midlatitude weather systems. One particular process that may significantly modify RWTs is the interaction with a tropical cyclone undergoing extratropical transition (ET). This interaction often increases uncertainty for medium-range predictions significantly. The general understanding of the physical processes underlying this interaction has improved in the last decade but still remains incomplete. This presentation summarizes results from a suite of idealized numerical ET scenarios with increasing complexity of the midlatitude flow: a straight jet, a developing wave train, and a high-amplitude wave. Quantitative analyses of ET’s impact on the midlatitude flow are presented in a potential vorticity – potential temperature framework. For the direct impact, our results emphasize the importance of both the upper-level outflow and the cyclonic ET circulation. Uncertainties in the evolution of the ET system translate into uncertainties in the midlatitude flow in the farther downstream region. The existence of bifurcation points in the steering flow in prototypical ET scenarios indicates that track predictability is inherently low. This notion offers one explanation for the often-observed increased forecast uncertainty downstream of ET. Arguably, the most pronounced impact is associated with the modification of the RWT’s leading edge. In this case, the modification of the downstream cyclone constitutes an important step in the further dispersion of the downstream impact. Modification of the high-amplitude wave is less pronounced and exhibits more complexity than in the developing-wave scenario.

Keywords: extratropical transition, Rossby wave train, downstream development, tropical - extratropical interaction
The interaction between the outflow of a tropical cyclone (TC) undergoing extratropical transition (ET) and the midlatitude flow often results in a diffluent flow configuration in the midlatitudes. Such a flow configuration was shown to be frequently accompanied by poleward anticyclonic Rossby wave breaking (P2-RWB) and the subsequent formation of blocking events. This raises the question about the existence of a relationship between ET and P2-RWB events, which we aim to address with this work. To investigate if and how ET events may impact RWB and the formation of blocking events over Europe, we employ ECMWF ensemble forecasts or the ET of four Atlantic hurricanes. All of the forecasts chosen show diverging storm tracks for the TCs, which enables us to distinguish scenarios with and without ET. Using an Empirical Orthogonal Functions (EOF) analysis and a subsequent fuzzy clustering, we extract different scenarios for the development of the upper level flow and analyse their representation of RWB events. A wave activity flux is further used to quantify the detection of RWB. Our results indicate that in cases with ET an existing ridge amplifies and preferentially experiences a poleward and anticyclonic wave breaking. In contrast, RWB in cases without ET differs or does not occur at all. Furthermore, the phasing between the transitioning storm and the midlatitude flow has a strong impact on the RWB event. In addition, our studies underline that the generation of an anticyclonic vortex in the upper troposphere is necessary for P2-RWB.

Keywords: Extratropical Transition, Rossby Wave Breaking, Blocking
Parallel Session

SCI-PS131.01 - Tropical cyclone formation: findings from PREDICT

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The Pre-Depression Investigation of Cloud Systems in the Tropics (PREDICT) field phase occurred in August and September of 2010 and focused on pre-genesis disturbances over the Atlantic Ocean and Caribbean Sea. This talk will review many of the salient findings from the project thus far and will present new results concerning the formation of hurricane Karl. The days leading to the genesis of Karl represent perhaps the best-observed pre-genesis period of any Atlantic tropical cyclone. In particular, this talk will address a conundrum that has emerged from recent research on tropical cyclone formation. Composite analyses and case studies suggest that prior to genesis, the atmosphere presents a mid-tropospheric vortex that is strong compared to the cyclonic circulation in the boundary layer. Accompanying this vortex is near saturation from the boundary layer through at least 5 km, sometimes more, and a nearly balanced weak negative temperature anomaly below the vortex and stronger positive temperature anomaly above. This thermodynamic state is one of high moisture but low buoyancy for lifted parcels (i.e. low convective available potential energy). However, observations also suggest that widespread deep convection accompanies genesis, with cloud top temperatures becoming colder near the time of genesis. The apparent conundrum is most likely resolved as a sequence of related events rather than an apparently simultaneous inconsistency. The driver of these events appears to be a strengthening mid-tropospheric circulation, consistent with other findings, as will be explained in the talk.

Keywords: tropical cyclone, tropical convection, mesoscale, field program
A new dynamical pathway to secondary eyewall formation (SEF) in tropical cyclones has been advanced from the axisymmetric perspective in our two companion works published in 2012, based on a dataset with model simulations and ensemble Kalman filter data assimilation of the special data collected in Typhoon Sinlaku (2008) during T-PARC (THORPEX - Pacific Asian Regional Campaign). It was demonstrated that the unbalanced dynamics within and just above the boundary layer on account of the storm’s expanding swirling flow serves as an important mechanism for initiating and sustaining a ring-like deep convection in a narrow supergradient-wind zone outside the primary eyewall. This follow-up study provides further dynamical analyses to examine such a pathway to SEF. Based on momentum budget analyses, this presentation attempts to demonstrate 1) how the tangential winds broaden prior to SEF; 2) how the secondary tangential wind maximum forms; and 3) how unbalanced processes impact the radial distribution of the boundary layer inflow. Meanwhile, to improve the representation of dynamics in the inner core of a tropical cyclone, the role of unbalanced processes in SEF is further examined based on simulations of Sinlaku under finer model grid spacing (1.67 km). The robust feature of developing unbalanced flow prior to SEF and the momentum budget analysis both provide clear signature of the dynamically unbalanced pathway to SEF. Analyses of the remaining 28 ensemble members are further carried out to validate the robustness of the presented pathway to SEF and to assess the predictability and uncertainty of SEF.


**Keywords:** secondary eyewall formation, unbalanced dynamics, supergradient, boundary layer
Parallel Session

SCI-PS131.03 - Asymmetric convective bursts and the problem of hurricane intensification.

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The role of asymmetric convection to the intensity change of a weak vortex, is investigated with the aid of a "dry" thermally forced model. Numerical experiments are conducted, starting with a weak vortex forced by a localized thermal anomaly. The concept of wave activities, the Eliassen-Palm flux, and eddy kinetic energy are then applied to identify the nature of the dominant generated waves and diagnose their kinematics, structure and impact on the primary vortex. The physical reasons for which disagreements with previous studies exist, are also investigated utilizing the governing equation for potential vorticity (PV) perturbations and a number of sensitivity experiments. From the control experiment, it is found that the response of the vortex is dominated by the radiation of a damped sheared vortex Rossby wave (VRW) that acts to accelerate the symmetric flow through the transport of angular momentum. An increase of the kinetic energy of the symmetric flow by the VRW is shown also from the eddy kinetic energy budget. Additional tests performed on the structure and the magnitude of the initial thermal forcing confirm the robustness of the results and emphasize the significance of the wave-mean flow interaction to the intensification process. From the sensitivity experiments, it is found that for a localized thermal anomaly, regardless of the baroclinicity of the vortex, the radial and the vertical gradients of the thermal forcing, the resultant PV perturbation follows a damping behavior, suggesting therefore that deceleration of the vortex should not be expected.

Keywords: vortex Rossby waves, wave-mean flow interactions, hurricane intensification, numerical simulations
Parallel Session

SCI-PS131.04 - The structure and dynamics of coherent vortices in the eyewall boundary layer of tropical cyclones

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The boundary layer within the eyewall of intense tropical cyclones has been shown to be both highly turbulent and to contain coherent small-scale (of order 1 km) vortices. Dropsonde observations have indicated that extreme updrafts of 10-25 m/s can occur in the lowest 2 km, sometimes as low as a few hundred meters above the surface. These updrafts are often collocated with or found very nearby to local extrema in horizontal wind speed, which sometimes exceed 100 m/s. Here, the CM1 model is used to simulate intense tropical cyclones in an idealized framework, with horizontal grid spacing as fine as ~30 meters. At this grid spacing, the scales of the vortices are well resolved. By examining individual features and compositing over many updrafts, we find that there is a consistent structure and relationship between vorticity, vertical velocity, and near-surface windspeeds. We quantitatively show that buoyancy is not responsible for the acceleration of strong boundary layer updrafts. Instead, the updrafts are forced by dynamical pressure gradients associated with strong gradients in the velocity fields. It is currently unknown whether dropsonde observations represent quasi-vertical profiles through the features, or if instead the sondes are horizontally advected through the features. Simulated dropsonde trajectories are used to answer this question, and to aid in the interpretation of the observed kinematic and thermodynamic profiles. In observations, extreme updrafts are almost exclusively found in Category 4 and 5 hurricanes. We conduct simulations at varying intensity to investigate whether or not similar features exist in weaker storms.

Keywords: tropical cyclones, eyewall, vortices, boundary layer
Parallel Session

SCI-PS132.01 - Processes influencing predictability of sea ice on subseasonal and longer timescales

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In both hemispheres, sea ice conditions exhibit significant autocorrelation on subseasonal and longer timescales, suggesting potential predictability in ice conditions. Additionally, the autocorrelation structure of sea ice suggests a “re-emergence” of predictability with enhanced correlations occurring at seasonal lags. A number of mechanisms contribute to this potential predictability of sea ice, with different dominant processes acting at different times of year. Here we discuss observational and climate modeling evidence of these relevant processes. This includes an assessment of sea ice conditions in both hemispheres and throughout the annual cycle. Analysis of “perfect model studies”, in which the model is predicting its simulated behavior with a near-perfect knowledge of initial conditions, provide insight on the relevant mechanisms and give an upper bound on the potential predictability. We discuss how these studies can inform the development of operational sea ice forecasting systems.

Keywords: sea ice, predictability
Parallel Session

SCI-PS132.02 - What causes foehn warming? – The Antarctic Peninsula as a natural laboratory

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The foehn effect is well known to meteorologists and geoscientists: it is the warming, drying and cloud clearance experienced on the leeside of mountains during ‘flow over’ conditions. Foehn flows were first described more than a century ago, when two mechanisms for the warming effect were postulated. Namely, a latent-heating mechanism, where air cools less on ascent – due to condensation and latent heat release – than on descent on the leeside; and an isentropic drawdown mechanism, where potentially warmer air from aloft is brought down adiabatically. Interestingly, the second of these established mechanisms was lost to the scientific literature for several decades before becoming re-established as qualitatively important. Here we demonstrate quantitatively that a third warming mechanism, namely turbulent mixing of the foehn flow, can be just as important as the other two mechanisms. In fact depending on the flow dynamics any of the three warming mechanisms can dominate. We make use of a novel Lagrangian trajectory technique, high resolution numerical modelling and aircraft observations from a unique natural laboratory – one that allows unambiguous quantification of the leeside warming – the Antarctic Peninsula and Larsen C Ice Shelf. We show that the use of a high resolution model with a horizontal grid size at least as small as 1.5 km is essential to adequately reproduce the leeside response. The demonstration that all three foehn warming mechanisms are important has ramifications for weather forecasting in mountainous areas and associated hazards such as avalanches and ice shelf melt.


Keywords: Foehn, Adiabatic warming, Antarctic Peninsula, Larsen Ice Shelf
Parallel Session

SCI-PS132.03 - The influence of stochastic sea ice parameterization on potential polar predictability

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A stochastic sea ice strength parameterization is implemented in a global coupled model to include a first estimate of model uncertainty in the assessment of potential sea ice predictability. Four sets of ensembles with different perturbation methods are investigated: reference ensembles initialised with moderate atmospheric initial perturbations; ensembles with atmospheric initial perturbations of the magnitude of interannual variability; ensembles including the stochastic ice strength parameterization; and ensembles featuring both the moderate atmospheric initial perturbations and the estimate for model uncertainty in the sea ice dynamics. Integrations are carried out for lead times of one year, initialised both in January and July. Results show that especially during the first weeks the inclusion of model uncertainty estimates in the sea ice dynamics significantly increases sea ice ensemble spread in the central Arctic and along coastlines when compared to the reference ensembles. The latter, in contrast, produce comparatively larger variability along the ice edge. During the early stage of the integration, a combination of both, initial and model perturbations, leads to the accumulation of spread from both uncertainties. After the first few weeks, however, differences between ensemble spreads become rather insignificant. Also, during the course of the integration the sea ice strength perturbations lead to a shift in the mean Arctic sea ice distribution and make a direct comparison of ensemble spread between setups increasingly difficult. For the Antarctic, differences in sea ice spread of the four sets of ensembles are less pronounced, throughout the year.

Keywords: Potential predictability, Sea ice, Stochastic parameterizations, Ice strength
Polar lows are intense, mesoscale cyclones developing over open waters at high latitudes. Despite recent improvements in numerical weather prediction, these high-latitude phenomena still represent a major challenge for forecasting in polar areas. A significant fraction of polar lows develops in so-called reverse-shear conditions, which are characterised by a low-level wind that is opposite to the thermal wind and mean flow. This is in contrast to the standard model for baroclinic instability, where the low-level wind is usually aligned with the thermal wind. So far, the standard model of baroclinic instability has mainly been employed for research on polar low dynamics. Thus, our knowledge about the dynamical nature of reverse-shear polar lows is rather limited. However, if we want to make improvements in numerical prediction of these phenomena we need to guide our model development to the processes and sensitivities with respect to this type of polar lows. To shed light on the dynamics of reverse-shear cyclogenesis, we utilize an idealized baroclinic channel setup with WRF. This setup allows us to explore the sensitivity of the development to pertinent parameters in reverse-shear conditions, including the strength of the vertical shear and the height of the wind reversal. In addition, we explore the role of moisture in reverse-shear conditions. We present the synoptic evolution of these reverse-shear polar lows as well as their energy cycle pinpointing the relative contributions of shear, moisture, and wind reversal to the rapidity of the development.

**Keywords:** polar low, reverse shear
Parallel Session

SCI-PS133.01 - Recent advances and challenges in sub-seasonal to seasonal predictions: predictability, dynamical and physical processes

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The sub-seasonal to seasonal variability at mid-latitude is largely determined by weather regimes (e.g. Atlantic blockings) and large scale oscillations and patterns, like the North Atlantic Oscillation (NAO). The NAO modulates high-impact weather like the exceptional spells of 2013/14 winter storms associated with severe coastal damage and sustained flooding in the UK. Positive NAO phases are associated with stormy weather in the UK. These events were connected with the exceptional rainfall observed over the West Pacific, Indonesia and the eastern Indian Ocean during December and January 2013/14 (Slingo et al., 2014). Similar tropical rainfall patterns have been correlated significantly with positive phase of the NAO in observations and model output by Lin et al. (GRL, 2005). The latter study identifies an increasing trend in this relationship for the 51 winters of 1948/49 to 1998/99. The Quasi-Biennial Oscillation (QBO) is an inter-annual tropical mode of variability that can increase the seasonal occurrence of positive NAO phase. The Madden-Julian Oscillation (MJO) is the dominant mode of sub-seasonal variability in the tropics. There is a significant two-way interaction between the MJO and the NAO. By analyzing the output of sub-seasonal hindcasts, it was shown that this two-way interaction was important for Numerical Weather Prediction (NWP) forecast skill of the MJO and NAO. We will discuss recent research progress to clarify the role of these different tropical and mid-latitude modes of variability in terms of predictability, dynamical processes, weather impacts and predictive skill for the sub-seasonal to seasonal prediction problem.


Keywords: sub-seasonal predictions, seasonal predictions, predictability, dynamical and physical processes
SCI-PS133.02 - Seasonal predictability over Europe arising from El Niño and stratospheric variability

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The predictability arising from stratospheric variability is analyzed in a seasonal prediction system including a high top atmosphere model and a full ocean. Stratospheric variability is suggested to enhance tropospheric predictive skill through the downward influence of Sudden Stratospheric Warmings as well as the remote influence of El Niño pathways through the stratosphere. Here, we aim to quantify predictive skill on seasonal timescales with a focus on the extratropical Northern Hemisphere. We use a seasonal prediction model based on the MPI-ESM coupled climate model system initialized from reanalysis data for the atmosphere, ocean, and for sea ice. Hindcast ensemble runs with start dates in November are investigated. Stratospheric variability is reproduced well with a realistic frequency of sudden warmings, with the ensemble spread representing the variability of reanalysis data. ENSO variability is captured in the tropical Pacific with a high predictive skill for 5 months. The suggested relationship between El Niño and stratospheric polar cap temperatures is reproduced. We also investigate predictive skill in the North Atlantic / European sector as a function of stratospheric variability. While the North Atlantic / Europe sector traditionally exhibits little skill in seasonal prediction models, our analysis of a seasonal forecast system presents a promising step towards assessing the influence of stratospheric variability on the predictability of tropospheric variability on seasonal timescales.


Keywords: seasonal predictability, El Niño, stratospheric variability
We examine the predictability and prediction skill of the Madden-Julian Oscillation (MJO) using hindcasts from the two ocean-atmosphere coupled forecast systems of ECMWF VarEPS and NCEP CFSv2. The VarEPS hindcasts with 5 ensemble members for the period 1993-2009 and the CFSv2 hindcasts with 3 ensemble members for the period 2000-2009 are compared. Potential predictability remains above 32 days lead time in both hindcasts, while the practical prediction skill is about 27 days in VarEPS and 21 days in CFSv2. Initially strong MJOs possess greater prediction skill compared to the weak MJOs or periods when there is no MJO. By comparing the ensemble spread and forecast error, it is found that both ensemble prediction systems are under-dispersive. That is, the error grows faster than the ensemble spread, especially in CFSv2. Dependency of MJO predictability and prediction skill on the initial MJO phases is also assessed. While the prediction skill differs by MJO phases in both hindcasts, the potential predictability is not sensitive to MJO phases. In both hindcasts, the MJO propagation speed is slower and the MJO amplitude is smaller than observed. Both hindcasts possess higher potential predictability and prediction skill when strong MJOs are targeted than to a weak/non MJO. Both systems have predictive skill about 30 days ahead of strong MJO and about 10 days ahead of a weak/non MJO.

Keywords: MJO predictability, MJO prediction
Parallel Session

SCI-PS133.04 - MJO hindcasts with the Super-parameterized CCSM4

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The forecast skill of MJO is analyzed in a suite of hindcasts with a fully coupled general circulation model (CGCM) in which subgrid-scale moist convection is explicitly represented through embedded 2D cloud-resolving models. To evaluate the impact of cloud processes representation on the model forecast skill the same set of experiments is repeated with the CGCM in which cloud effects on the large-scale circulation are represented via parameterization. Estimates of the limit of predictability are based on both deterministic (ensemble spread and root mean square error) and probabilistic measures (relative operating characteristics). The analysis examines both oceanic and atmospheric variables in the Indian Ocean and West Pacific Warm Pool region. Preliminary results suggest a strong impact of the subgrid-scale representation on the model forecast skill.

Keywords: MJO, S2S, subgrid-scale parameterization
UAS-PA401 - Panel Discussion
Collaboration across disciplinary and practitioner boundaries: Breaking barriers and building bridges

Panelists representing a range of academic disciplines and/or professions will discuss how they define, approach, analyze, and address weather-related problems and the merits and challenges of doing so in collaboration with people from other fields and occupations. The feedback will be used to guide the direction of future research, applications and services.

Chair: Eve Gruntfest

UAS-PA401.01 - Panel Participant

Linda Anderson-Berry¹
¹Bureau of Meteorology, Melbourne, Australia

UAS-PA401.02 - Panel Participant

Emma Porio¹
¹Ateneo de Manila University, Manila, Philippines

UAS-PA401.03 - Panel Participant

Jeff Lazo¹
¹UCAR, Boulder, CO, USA

UAS-PA401.04 - Panel Participant

Celeste Saulo¹
¹CONICET/UBA, Buenos Aires, Argentina (Now National Meteorological Service – Argentina)

Please refer to the WMO website for presentations (if available) related to this panel
UAS PA402 - Panel Discussion
The WMO/World Bank/Climate Services Partnership Guidance document on Assessing the Socio-economic Benefits of Meteorological and Hydrological Services

A guidance document is being developed for National Meteorological and Hydrometeorological Services (NMHS) and other organizations to assist them in the assessment of the socio-economic benefits of weather, water and climate services. The work is a combined effort of economists, social scientists, and meteorological experts affiliated with the WMO, World Bank, and Climate Services Partnership. The special session will be used to review the status of the report and to engage the audience in a discussion of practical and methodological issues associated with the application of recommended assessment techniques, and the communication of results.

Chair: Brian Mills

UAS-PA402.01 – Panel Participant

Adriaan Perrels¹
¹Finnish Meteorological Institute, Helsinki, Finland

UAS-PA402.02 – Panel Participant

Jeff Lazo¹
¹UCAR, Boulder, CO, USA

Please refer to the WMO website for presentations (if available) related to this panel
Parallel Session

SCI-PS134.01 - The ECMWF coupled Ensemble: from medium to extended range forecasts

Frederic Vitart\textsuperscript{1}, Roberto Buizza\textsuperscript{1}, Franco Molteni\textsuperscript{1}, Martin Leutbecher\textsuperscript{1}  
\textsuperscript{1}ECMWF, Reading, UK

Since November 2013, the ECMWF flagship medium- to extended-range ensemble is based on a fully coupled ocean, land, atmosphere model. 51-member ensembles of 15 day integrations are produced twice a day (00Z and 12Z), with initial perturbations generated using an ensemble of data assimilations and singular vectors, and model uncertainty simulated using two stochastic schemes. The atmospheric resolution is 32 kilometres up to day 10 and 64 kilometres after day 10. The model integrations are extended to 32 days twice a week at the 64 kilometre resolution. A set of 5-member ensemble re-forecasts covering the past 20 years are produced routinely to calibrate the ECMWF extended-range forecasts and some of the medium-range ones (e.g. the Extreme Forecast Indices). The skill of the ensemble has improved significantly over the past decades, with gains of about a week over in the extended-range forecasts. This will be documented both by average verification statistics and by the analysis of few extreme weather conditions. The improvements are due to a combination of improved physical parameterisations, coupling to an ocean model, better definition of the initial conditions and improved ensemble design. Some of the recent changes, including the coupling to an ocean model from day 0, the increased vertical resolution in the stratosphere and of the size of the ensemble of data assimilation, will be presented. Finally, future plans to increase the atmospheric and oceanic resolution, to enlarge the size of the re-forecast and to extend the forecast length to 45-60 days will be discussed.

Keywords: ensemble prediction, skill scores, extreme events, extended range forecasts
Parallel Session

SCI-PS134.02 - Implementation of a new dynamical core in the Met Office Unified Model

Andrew Brown

1Met Office, Exeter, UK

For over 25 years the Met Office has been taking a seamless approach to modelling, with the Unified Model being developed for both weather and climate prediction. Overall we believe that this approach has given enormous benefits, both scientific and in terms of efficiency. However, it does mean that any major change to the model has to be tested – and shown to perform acceptably – across a very wide range of applications. In recent years we have been working on just such a major change – in this case to the dynamical core at the very heart of the model, which is typically upgraded about once a decade. The new ENDGame core remains semi-implicit, semi-Lagrangian, but has a number of significant changes relative to its predecessor (including an iterative timestep structure) designed to improve accuracy, scalability and stability. The approach taken to testing and implementation will be presented, including the way in which the core upgrade was combined with other changes to the model physics, data assimilation and use of satellite data. Key results will be shown from global and regional NWP tests and from seasonal and climate runs. Pleasingly the results are very largely positive and, consistent with the seamless paradigm, improvements seen on weather timescales (e.g. improved variability) have typically also been seen in the longer simulations. Accordingly the ENDGame global models will shortly be implemented operationally, and the regional models are expected to follow just a few months later.


Keywords: dynamical core, seamless, Unified Model
Parallel Session

SCI-PS134.03 - Skill improvements in the ECMWF forecasting system

Erland Källén¹, Linus Magnusson¹, András Horányi¹
¹ECMWF, Reading, UK

During the past 35 years the skill in ECMWF numerical weather forecasts has steadily improved. There are three major contributing factors: 1) improvements in the forecast model, 2) improvements in the data assimilation, and 3) the increased number of available observations. In this study we are investigating the relative contribution from these three components by using a simple error growth model together with the results from the ECMWF Re-Analysis Interim (ERA-Interim) reforecasts where a skill improvement can only be due to improved observations. We are also applying the growth model on “lagged” forecast differences in order to investigate the usefulness of the forecast jumpiness as a diagnostic tool for improvements in the forecasts. The main finding is that the main contribution to the reduced forecast error comes from significant initial condition error reductions between 1996 and 2001 together with continuous model improvements. The changes in the available observations contribute to a lesser degree, but we note that all the ERA-Interim forecasts are from the satellite era and here the focus is on the midtroposphere in the extratropics. For the tropics an increase in wind observations is likely to have a large impact as demonstrated in observation system experiments in preparation for the Doppler wind lidar ADM-Aeolus mission to be launched in 2015.

Keywords: weather prediction, predictability, observation impact
Parallel Session

SCI-PS134.04 - Seamless prediction from the surface to the exobase: First Whole Atmosphere Model (WAM) medium-range forecasts

Houjun Wang¹, Rashid Akmaev², Fei Wu¹, Jun Wang³

¹University of Colorado, Boulder, USA, ²NOAA Space Weather Prediction Center, Boulder, USA, ³NCEP Environmental Modeling Center, College Park, USA

We present first medium-range weather forecasts with the Whole Atmosphere Model (WAM) focusing on recent sudden stratospheric warming (SSW) events. WAM is built from the NCEP operational Global Forecast System (GFS) model for ionospheric space weather applications by extension of the model top from about 60 km to the exobase (about 600 km). Highly dissipative dynamics eliminate the need for artificial "sponge layers" near the model top in the upper thermosphere. Recent observations have associated SSWs with drastic changes in the equatorial ionospheric plasma distribution and its diurnal variation suggesting global long-range connections between the winter polar stratosphere and the equatorial F2 layer at altitudes 250-350 km. Initialized from analyses of operational data by the Whole-atmosphere Data Assimilation System (WDAS), WAM produces useful medium-range forecasts of ionospheric plasma in good agreement with observations. The raise of the model top also results in a substantial increase of the forecast lead time (by a few days) of the timing and magnitude of the warmings in the stratosphere, including the recent major event in January 2009. The improvement of stratospheric forecasts may be indicative of potential benefits of vertically extended models for conventional medium-range weather prediction.


Keywords: medium-range weather forecast, whole atmosphere model, whole atmosphere data assimilation system, sudden stratospheric warming
Observations and predictions of near-zero positive variables such as aerosols, water vapor, precipitation and plankton concentrations have error distributions whose standard deviations are typically proportional to the value of the variable. Many of these variables play a critical role in climate and weather prediction. The Kalman filter and ensemble Kalman filter are both ill-suited to estimating distributions of these variables because they incorrectly assume that error variances are independent of the actual values of the variables. Here, we present a new tool (the gig filter) that solves the classical filtering and prediction problem for the non-linear case in which errors are proportional to the underlying magnitude of the variable being estimated rather than independent of this magnitude. In such systems, error dynamics are often non-linear. The proposed approach precisely solves Bayes’ theorem in special cases where the observation error likelihood and prior forecast error distributions take the form of gamma and inverse-gamma (gig) distributions. Regardless of the precise form of the prior and likelihood distributions, the gig filter delivers the minimum error variance estimate as well as a posterior error covariance matrix consistent with the assumption that analysis error magnitudes are proportional to the magnitude of the analysis mean. A simple coordinate transformation allows the gig filter to simultaneously accommodate variables whose error variances are independent of variable magnitude (such as temperature). Idealized systems are used to compare and contrast the gig filter with the Ensemble Kalman filter.

**Keywords:** Non-linear-data-assimilation, Aerosol-data-assimilation, Variance-smoothing, Hydrometeor-data-assimilation
Parallel Session

SCI-PS135.02 - How do model error and localization approaches affect model parameter estimation in the LETKF?

Juan Ruiz¹, Takemasa Miyoshi², Masaru Kunii³
¹University of Buenos Aires, Buenos Aires, Argentina,
²RIKEN Advanced Institute for Computational Science, Kobe, Japan,
³Meteorological Research Institute, Tsukuba, Japan

This study explores how localization methods affect model parameter estimation using the local ensemble transform Kalman filter (LETKF) with the Weather Research and Forecasting (WRF) model. The impact of different localization approaches is investigated in the real-world case of Typhoon Sinlaku (2008). Horizontal localization has been considered either as two dimensional fields or as global constants. The effect of applying vertical localization for the estimation of surface parameters is also explored. The effect of model error upon the estimation of the model parameters is investigated in a set of twin experiments with realistically distributed observations. In all cases, the LETKF successfully identified better parameter values of the sea-surface moisture exchange coefficients and improved the forecast of atmospheric variables near the surface, leading to a significant reduction of the moisture and temperature biases near the surface. The results indicate that the localization approach plays an essential role in parameter estimation and thus the analysis and forecast quality. Model error also produces an important impact upon the estimated parameters, reducing the improvement introduced by the estimation of the model parameters.

Keywords: Data assimilation, parameter estimation, local ensemble transform Kalman filter
Parallel Session

SCI-PS135.03 – NEW - Hierarchical Bayes Ensemble Variational Data Assimilation

Michael Tsyrlunikov¹, A. Rakitko¹
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A new approach to ensemble-variational data assimilation is proposed. The core idea is to treat the background-error covariance matrix $B$ as a random matrix, specify its prior probability distribution, and update it in an extended analysis along with the state. In this update, ensemble members are assimilated as generalized observations. An importance sampling based numerical algorithm is proposed. In a toy problem, numerical experiments with synthetic truth show that the new technique outperforms the existing variational, ensemble Kalman filter, and traditional ensemble-variational analyses.

Keywords: Ensemble variation, Kalman filter
Parallel Session

SCI-PS135.04 - Rapid, short-term ensemble forecast adjustment through offline data assimilation

Luke Madaus¹, Gregory Hakim¹
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Rapid updates of short-term numerical forecasts remain limited by the time it takes to assimilate observations and run the dynamic model to produce new forecasts. Here we use a statistical method to rapidly adjust a user-defined subspace of the forecast grids based on ensemble data as observations become available. Specifically, an ensemble forecast adjustment technique is explored that uses the ensemble Kalman filter to assimilate observations as they become available and adjust not only the current analysis, but also subsequent forecast fields based on covariances between the ensemble estimate of the observation and future forecast states. This approach allows rapid adjustment of forecast fields, or functions of those fields, "offline" without the expense of running the full dynamical model. Furthermore, by utilizing ensemble techniques, short-term forecast uncertainty from the ensemble is also adjusted. The technique is tested using ECMWF and CMCE operational ensemble systems and is found to be effective at reducing forecast errors in surface pressure for at least 18-24 hours after the observation time.

Keywords: nowcasting, ensemble Kalman filter
Parallel Session

SCI-PS136.01 - Measurement of atmospheric constituents from space: history and state-of-art

Pawan Bhartia\textsuperscript{1}, Omar Torres\textsuperscript{1}, Nickolay Krotkov\textsuperscript{1}, Richard McPeters\textsuperscript{1}

\textsuperscript{1}NASA Goddard Space Flight Center, Greenbelt, USA

In this talk we will discuss measurement of atmospheric constituents from satellite instruments that operate in the UV and blue wavelengths of the solar spectrum. This field essentially got started in April 1970 with the launch of the Backscatter UV (BUV) instrument on NASA's Nimbus-4 satellite. Since then more than a dozen instruments of increasing sophistication have been launched by NASA, NOAA, ESA and other space agencies around the world. Initially, the focus of these measurements was to study stratospheric ozone. Though the measurement program got started as curiosity driven research, it turned into a public policy imperative after the discovery of ozone depleting substances in the stratosphere, and took on urgency after the discovery of the Antarctic ozone hole. With international agreements now in place to phase out the offending chemicals, the program has now settled on long-term monitoring of the recovery of the ozone layer. The UV instruments designed to measure ozone have also turned to be very sensitive for tracking sulfur-dioxide produced by volcanoes, and they have unique capability to detect volcanic ash, desert dust and smoke over clouds and snow/ice covered surfaces. More recently the focus of this research has moved to the study of boundary layer traces gases including SO\textsubscript{2}, NO\textsubscript{2}, HCHO, BrO, and CHOCHO. However, measurement of tropospheric ozone from space remains a challenge though some progress has been made in this area, and several new techniques for measuring boundary layer O\textsubscript{3} are currently under investigation.

\textbf{Keywords:} Atmospheric Ozone, Air Quality, Satellite Remote Sensing, Atmospheric Chemistry
Parallel Session

SCI-PS136.02 - International study group on the added value of chemical data assimilation in the stratosphere

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¹Environment Canada, Dorval, Canada; ²Belgium Institute for Space Aeronomy, Brussels, Belgium

An international study group under the auspices of the International Space Science Institute has been created to examine how chemical data assimilation can provide science information that goes beyond analysis and short-term forecasting. Several themes will be approached; 1 – Development of a multi-year analysis of the stratosphere. The objective is to examine the scientific knowledge gained by the assimilation of short-lived species in addition to long-lived species in the stratosphere, 2 – Estimation of the impact of high energy particles in the upper stratosphere, 3- the development of simplified chemistry schemes for its use in GCMs, 3- Extended-range predictability of stratospheric ozone and its dependence on assimilation of other species, 4- Learning about satellite observation based on data assimilation diagnostics. Following on the SPARC Data Initiative, the idea is to study satellite observation from a data assimilation perspective. 5- The UTLS using re-analysis.

Keywords: chemical data assimilation, stratosphere
Parallel Session

SCI-PS136.03 - Transport and dispersion patterns of aerosols over the East African region using AOD data

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This study used AOD from MODIS observations at 550nm in 1º X 1º grid resolution to investigate the transport and dispersion patterns of aerosols over the East African (EA) region. The specific objectives of the study were to perform spatial analysis using monthly means of MODIS Terra AOD, evaluate monthly means for a five year MODIS Terra AOD, examine diurnal patterns between MODIS Terra and MODIS Aqua AOD, and simulate transport and dispersion of the AOD during the NE Trade winds and the SE Trade winds to identify the possible sources and sinks of the aerosols. Analyses performed were time series analysis, hovmöller analysis and backward air trajectory analysis. Through backward air trajectory analysis, the possible sources of aerosols in the NH were found to be the Middle East, Sahara and Arabian deserts during February, whereas in the SH, the possible sources were found to be the Congo rain forest, Kalahari and Namibian deserts, Southern Atlantic Ocean, South west Indian Ocean, Madagascar Island and South African region during July. Also, computed was the forward air trajectory analysis over the same locations. The findings of this study established that long distance transport of aerosols and their dispersion through low level winds is responsible for the aerosols affecting the EA region. This greatly depends on the season of the year together with the prevailing atmospheric conditions.


Keywords: AOD - Aerosol Optical Depth, MODIS - Moderate Resolution Imaging Spectroradiometer, HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory, MOVAS - MODIS Online Visualization and Analysis System
SCI-PS136.04 - Variability in aerosol optical depth and its relationship with meteorological parameters over mega-city Lahore (Pakistan)

Salman Tariq¹

¹University of the Punjab, Lahore, Pakistan

Aerosols affect the global climate and can cause cooling as well as warming of the planet. A ground based remote sensing instrument Aerosol Robotic Network (AERONET) is used to analyze the all the available data of aerosol optical depth (AOD) and Angstrom exponent (AE) during 2006 – 2012 over Lahore. AOD and AE from Moderate Resolution Imaging Spectro-radiometer (MODIS) are also validated with AERONET observations. The meteorological parameters like temperature, rainfall and humidity are also analyzed in order to understand their relationship with aerosol properties. During the study period highest monthly averaged value of AOD is observed in July (0.96 ±0.35) with the corresponding monthly averaged AE value of 0.83±0.28 while lowest value is found in February (0.39±0.21) with the corresponding monthly averaged AE value of 1.06±0.25. The monthly averaged AE value is found to be highest in January (1.36±0.15) indicating the dominance of fine mode aerosol particles due to biomass burning. Lowest value of AE is observed in June (0.49±0.23) pointing towards the dominance of coarse mode aerosol particles such as desert/soil dust over Lahore.

Keywords: Aerosol optical depth, Lahore, AERONET, MODIS
Parallel Session

SCI-PS137.01 - Recent activities on “Big Data Assimilation” in Japan

Takemasa Miyoshi\textsuperscript{1}, Masaru Kunii\textsuperscript{2}, Juan Ruiz\textsuperscript{1,3}, Hiromu Seko\textsuperscript{2}, Shinsuke Satoh\textsuperscript{4}, Tomoo Ushio\textsuperscript{5}, Yutaka Ishikawa\textsuperscript{6}, Hirofumi Tomita\textsuperscript{1}, Kotaro Bessho\textsuperscript{7}

\textsuperscript{1}RIKEN Advanced Institute for Computational Science, Kobe, Japan,
\textsuperscript{2}Meteorological Research Institute, Tsukuba, Japan, \textsuperscript{3}University of Buenos Aires, Buenos Aires, Argentina,
\textsuperscript{4}National Institute of Information and Communications Technology, Tokyo, Japan,
\textsuperscript{5}Osaka University, Osaka, Japan,
\textsuperscript{6}University of Tokyo, Tokyo, Japan, \textsuperscript{7}Meteorological Satellite Center, Tokyo, Japan

In 2013, the Japanese government started a strategic funding program for the Big Data science, specifically fundamental technological developments and big data applications. One of the two proposals awarded in the field of big data application was “Big Data Assimilation” for super-rapid 30-second cycle of an ensemble Kalman filter aiming at local severe weather forecasting at a 100-m resolution with 30-minute lead time. This presentation will discuss the concept and recent progress using the Japanese 10-Peta-Flops K computer and Phased Array Weather Radar.

Keywords: numerical weather prediction, data assimilation, convective scale, phased array radar
Parallel Session

SCI-PS137.02 - How temporally representative are synoptic observations?

Marion Mittermaier\textsuperscript{1}
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This work aims to quantify the sub-hourly variability of synoptic observations such as temperature, cloud, visibility, wind, using 1-minute observations. A range of sites around the United Kingdom with varying geographical locations (coastal, inland, upland) were selected to analyse sub-hourly variability as a function of time of day, on daily, monthly and seasonal time scales. Conditional relationships affecting variability are also explored. The aim is to understand to what extent results from these different locations can be generalised in a quasi-climatological sense. The idea is to "dress" hourly synoptic observations with an estimated total observations error for a variety of applications, including data assimilation and verification, particularly for deterministic and ensemble km-scale NWP forecasts where observations error is becoming increasingly important.

Keywords: sub-hourly variability, representativeness error, conditional variability
Parallel Session

SCI-PS137.03 - AROME-WMED, a real-time mesoscale model designed for the HyMeX Special Observation Periods

Nadia Fourrie\textsuperscript{1}, Emilie Bresson\textsuperscript{1}, Mathieu Nuret\textsuperscript{1}, Cassandre Jany\textsuperscript{1}, Pierre Brousseau\textsuperscript{1}, Alexis Doerenbecher\textsuperscript{1}, Michael Kreitz\textsuperscript{2}, Hervé Benichou\textsuperscript{2}, Marielle Amodei\textsuperscript{2}, Francis Pouponneau\textsuperscript{2}

\textsuperscript{1}CNRM-GAME, Meteo-France and CNRS, Toulouse, France, \textsuperscript{2}Meteo-France, Toulouse, France

During autumn 2012 and winter 2013, two special observation periods of the Hydrological cycle in the Mediterranean Experiment (HyMeX) took place. Developed at CNRM-GAME, AROME-WMED is a dedicated version of the mesoscale AROME-France model, which covers the western Mediterranean basin. It provides real time analyses and forecasts sent daily to the HyMeX operational centre for decision making on the observation deployment. These data are also available on the HyMeX database. This presentation highlights the main features of this numerical weather prediction system in terms of data assimilation and forecast. The forecast skill of the AROME-WMED is assessed with objective scores and case studies and compared to the operational AROME-France model, for both Autumn 2012 (5 September to 6 November 2012) and Winter 2013 (1 February to 15 March 2013) Special Observation Periods. The overall performances of AROME-WMED are good and similar to those of AROME-France for the 0 to 30 hours forecast range. The 24-h to 48-h forecast range is of course less accurate but remains useful for scheduling observations deployment. Indeed the quality of parameters such as precipitation, temperature or humidity, is illustrated by a heavy precipitation case study over South of Spain. Finally, the future developments for the reanalysis of the SOP1, which will should be available by 2015, will be presented.

Keywords: HyMeX, convective scale model, real-time run
Parallel Session

SCI-PS137.04 - Improving vortex scale hurricane prediction using the hybrid EnKF-Var data assimilation method

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A hybrid ensemble Kalman filter-variational data assimilation (DA) system has been developed based on the US NCEP operational DA system, GSI and became operational for the US Global Forecast System (GFS). The new hybrid DA system has significantly improved many aspects of the operational global forecasts (e.g. Wang et al. 2013). Recently the hybrid system has been extended to 4D, denoted as 4D-ensemble-variational (4DEnsVar, e.g. Wang and Lei 2014) method, which avoids the tangent linear and adjoint of the forecast model. Studies of 4DEnsVar using GFS have demonstrated this 4D extension significantly improved the hurricane track forecasts. In addition, efforts have been made to further develop and test the same hybrid system with the US operational regional Hurricane Weather Research and Forecast (HWRF) modeling system to improve vortex-scale tropical cyclone prediction. The performance of the HWRF hybrid DA system ingesting HWRF’s own EnKF ensemble (denoted as “hybrid”) was compared with that ingesting GFS ensemble (denoted as “hybrid-GFSENS”). Studies with hurricane cases from previous hurricane seasons (e.g., 2012-2013), assimilating the airborne Doppler radar data from NOAA P3 aircraft were conducted. Verification against independent in situ flight level data and remotely sensed observations such as SFMR wind speed and HRD radar wind composite showed that the analyses provided by the “hybrid” captures the hurricane structure much better than the hybrid-GFSENS and GSI 3DVar. Forecasts initialized from the analysis of the “hybrid” produced smaller track errors and better MSLP and max wind relationship than that initialized from hybrid-GFSENS and GSI 3DVar.


Keywords: Hurricane, vortex scale, hybrid ensemble-variational data assimilation, ensemble Kalman filter
Parallel Session

SCI-PS138.01 - Predictability study using the Environment Canada Chemical Data Assimilation (EC CDA) system

Jean de Grandpre\textsuperscript{1}, Yves J. Rochon\textsuperscript{2}, Richard Menard\textsuperscript{1}

\textsuperscript{1}Environment Canada, Dorval, Canada, \textsuperscript{2}Environment Canada, Downsview, Canada

Chemical Data Assimilation (CDA) observation databases are mainly based on integrated measurements such as species column amount obtained from operational nadir viewing instruments such as GOME-2, SBUV/2 and IASI. For the assimilation of such quantities it is necessary to make assumptions regarding the vertical projection of species analysis increment which can have an impact on the chemical analysis system. The impact of species vertical distribution on species predictability can be significant which makes the chemical forecasting system a useful tool for assessing the quality of the analysis system. In this study the EC CDA system is used for evaluating the ozone predictability at the medium range time scale throughout the upper troposphere and lower stratosphere region. Ozone forecasts have been evaluated against analyses and independent measurements over summertime and wintertime periods. Results indicate that column ozone predictability can exceed several weeks and has a significant sensitivity to analyse errors of the initial conditions. The study shows that the assimilation of observations from nadir viewing instruments for ozone and other air quality precursors such as NO2 and CO can be used for assessing the overall performance of CDA systems.

**Keywords:** Ozone, chemistry, assimilation
SCI-PS138.02 - Model evaluation of meteorological processes important for North African dust emission

Stephanie Fiedler¹, Kerstin Schepanski², Peter Knippertz³, Bernd Heinold², Nicolas Bellouin⁴, Ina Tegen², Stephanie Woodward⁵

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Mineral dust is the dominant aerosol type by mass and plays a role in weather and climate. Our understanding of the atmospheric dust cycle is, however, incomplete due to the lack of good observations in desert regions and simplifications of relevant processes by physical parameterizations in state-of-the-art atmospheric models. A crucial issue is the uncertainty related to near-surface winds controlling the dust emission non-linearly. A range of different atmospheric processes has been suggested to produce such winds, but their relative importance is unknown. The present work addresses this problem by (1) developing new and applying existing identification algorithms for key meteorological phenomena such as nocturnal low-level jets (NLLJs) and atmospheric depressions, (2) producing climatologies for these based on re-analysis and an Earth system model, (3) estimating the dust emission amount associated with these processes using an offline dust emission model, (4) intercomparing the climatologies from models and observations. The most important findings from this work are: (1) atmospheric depressions are abundant over North Africa and associated with a large fraction of the dust emission; (2) migrating and long-lived cyclones are rare but their dust emission intensity is particularly large; (3) NLLJs form frequently and cause a large fraction of the emission amount in the southeastern Sahara and adjacent Sahel during winter; (4) the Earth system model HadGEM2-ES reproduces the mean statistic of the NLLJ occurrence from ERA-Interim, but shows considerable spatial shifts associated with the summertime heat low and the Azores High as well as differences in the diurnal cycle.


Keywords: mineral dust, low-level jets, cyclones, model evaluation
Parallel Session

SCI-PS138.03 - Physiochemical and optical characteristics of aerosols observed in South Korea

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This study aims to analyze the physicochemical and optical properties of aerosols observed in South Korea during the year of 2013. First, the mass size aerosols was monitored by Atmospheric Particle Spectrometer(APS). It revealed that the PM2.5/PM10 mass ratio in Asian dust cases decreased almost 3 times in comparison to that in haze cases. Secondly, the size-resolved chemical composition of aerosols was analyzed using Micro-Orifice Uniform Deposit Impactor(MOUDI) as well as semi-real time monitoring with Particle Into Liquid Sampler(PILS). The results showed that higher nitrate and sulfate contents in the aerosol from the haze events, while calcium content was much higher in Asian dust cases. In addition, optical properties of aerosols(aerosol optical depth, angstrom exponent, and aerosol direct forcing) were analyzed using skyradiometers. The data showed that aerosol radiative forcing at the surface was always negative and the maximum negative cooling effect was observed in June of 2013.

Keywords: Physicochemical property, Optical property, aerosols, aerosol model
We present a comprehensive study of tropospheric ozone based upon an uniquely extensive dataset of electrochemical cell (ECC) ozone soundings over the tropical Atlantic Ocean, acquired from shipborne intensive observation periods (IOP) during eight separate NOAA Aerosols and Ocean Science Expedition (AEROSE) campaigns (2006-2011, 2013a,b) and the 1999 AEROSOL99 campaign. A composite of well-resolved and accurate (5%) tropospheric profiles retrieved from daily ozonesondes, launched along latitudes between 33N to 34S, are used to describe the Atlantic Ocean ozone geographical and vertical distribution and seasonality. Laminae obtained applying the Pierce-Teitelbaum (PT) method are coupled to GW and RW, exploiting their relationship with vertical displacement and quasi-horizontal transport respectively. We apply optical depth measurements, ship-borne tracers, Lagrangian backtrajectory modeling and reanalysis data and others with the following objectives: (1) Characterize the different atmospheric conditions and processes that are believed to ignite the formation of these layers. (2) Quantify the contribution of each to the total ozone tropospheric budget due to stratospheric-tropospheric interactions, boundary layer processes, advection of pollutants and regional convection and lightning. (3) Estimate frequency of stratospheric events over the North Atlantic. (4) Analyze the possible role of upper-level dynamics, Saharan dust storm cyclogenesis and STE in triggering an anomalous, localized mid and upper tropospheric ozone enhancement (of up to 37% over the column 1-10 km) observed on multiple occasions near the east coast of Africa.


Keywords: laminar analysis, stratospheric-tropospheric interactions, tropospheric ozone budget, transport of precursors
Parallel Session

SCI-PS139.01 - Dynamics of Rossby Wave Trains in a quantitative PV-Θ framework

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Rossby wave trains (RWTs) are a fundamental ingredient of mid-latitude dynamics and may constitute precursors to high-impact weather events. RWTs may be assumed to be highly predictable flow features because of their large scale. Recent work, however, has shown that for medium-range forecasts there may be severe limitations to RWT predictability. As a contribution to an improved understanding of these inherent uncertainties, we employ a framework to quantify different processes governing RWT evolution. Based on the classic Eady model, RWTs are considered as interacting waves at upper and lower tropospheric levels. Recent work has shown that cloud diabatic processes may have also a considerable impact. A primary goal of this study is to quantify the relative importance of these processes for real atmospheric RWTs. RWTs are investigated as potential vorticity (PV) waves on isentropes. The amplification of this wave pattern is governed by advective tendencies from the upper-level wave itself, from baroclinic feedback of the low-level temperature wave and interior PV anomalies, from divergent outflow, and from diabatic tendencies. Piecewise PV inversion is applied to separate the impact from the upper- and low-level waves. The diabatic tendencies are derived from the Year-of-tropical-convection data. Analysis will be presented for two RWTs, connected to Alpine flooding and a sudden stratospheric warming event, respectively. In both cases divergent outflow and diabatic processes play a prominent role in ridge amplification, in contrast to the classic picture of barotropic or baroclinically-coupled Rossby wave propagation. Potential implications for the predictability of RWTs will be discussed briefly.

Keywords: Rossby wave train, mid-latitude dynamics, piecewise PV inversion
Severe weather over Europe is known to be occasionally associated with long-lived Rossby wave-trains. This suggests potential predictability on the time-scale of a week and even longer — a potential which is far from being exploited today. As a prerequisite for improved forecasts we aim to diagnose deficiencies in current weather forecast systems regarding the generation, propagation, and decay of such long-lived wave trains. As a prerequisite to reach this goal we aim to gain a deeper understanding of Rossby wave-train behavior in general. Assuming that Rossby wave-trains are almost plane waves, we define wave-train objects based on the longitudinal envelope of the meridional wind. From this we produced a climatology of Rossby wave-train objects, thus providing us with a general overview of wave-train behavior. An alternative way to define Rossby wave-train objects is based on the wave activity flux, which arguably is a dynamically more meaningful quantity than the meridional wind. Using this new method provides us with a „sharper image“ of wave-train propagation: what appears to be one single long-lived Rossby wave-train on a conventional Hovmoeller diagram of the meridional wind, may sometimes split into two separate Rossby wave trains when using the wave activity flux diagnostic. The latter behavior is, in particular, true for composites which have recently been computed in order to characterize wave-train precursors to strong cyclones over Europe.

**Keywords:** wave activity flux, Rossby wave-trains, wavepacket, climatology
SCI-PS139.03 - Triggering mechanisms of Rossby Wave Trains terminating in Western Europe and the sensible weather impact

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A Rossby wave train (RWT) can be described as a coherent envelope or packet of baroclinic waves that develop in the mean zonal flow (Lee and Held 1993). A frequently highlighted aspect of the RWT is that its energy travels with a group velocity greater than its phase velocity (Lee and Held 1993) resulting in so-called downstream development that can impact sensible weather far from the point of RWT initiation. A number of atmospheric phenomena have been shown to trigger RWTs (e.g. warm conveyor belts associated with extratropical cyclones, extratropical transition of recurving tropical cyclones, tropospheric potential vorticity anomalies, and diabatic Rossby vortices). Using the RWT climatology prepared by Glatt and Wirth (2013), the present study examines a subset of RWTs that terminate over Western Europe during the months of September and October from 2004-2010. The primary goal is diagnose the relative frequency of RWT initiation associated with the above phenomena. In addition to providing a statistical analysis, specific examples will be presented. The focus will be on RWTs that result in high impact weather over the Western European region.


Keywords: Rossby Wave Trains, Downstream Development, High Impact Weather
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The significance of upper level Rossby wave trains (RWTs) for weather forecasting has long been recognized. More recently Langland et al. (2002) found that RWTs originating over Western Pacific may play an important role for the middle and long range predictability of high impact weather events over North America and beyond. Dirren et al. (2003) analyzed forecast errors from PV perspective and they found that errors are concentrated along the wave guide of RWTs due to amplitude or phase errors of RWTs. However, our knowledge of the factors limiting the predictability of RWTs and the forecast skill of numerical weather prediction systems with respect to RWTs is still limited. Our research is focused on the forecast errors of spatially localized areas of high PV gradients which act as waveguides for the RWTs. An object based spatial forecast verification tool has been developed which compares form, amplitude and location characteristics of waveguide objects in the analysis and in the forecast. As input ECMWF analysis and deterministic forecast data of ECMWF’s Integrated Forecast System (http://www.ecmwf.int/research/ifsdocs/) was used. A short climatology of forecast errors is presented for the period 01/2008-12/2010 for short and medium range forecast lead times (1 day-10 days). This climatology is used to derive error statistics as a function of season and location and to identify time periods where large errors occur.


Keywords: object based forecast verification, errors of Rossby waveguides
Parallel Session

SCI-PS140.01 - Predictability and data assimilation of tropical cyclones

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Despite rapid advances in numerical weather prediction (NWP) models and ever increasing computational capability, our ability to accurately predict various severe weather phenomena including tropical cyclones in the short range and at the mesoscales remains limited. This talk will present an overview of recent progress in our understanding of the predictability of tropical cyclones using both real-data studies and idealized simulations. Although the predictability of tropical cyclones across different temporal and spatial scales may be inherently limited, there is still significant room for improving the practical predictability of tropical cyclones through advanced data assimilation techniques, better use of existing or future observations, and improved forecast models. Inter-comparison and coupling of various variational and ensemble based techniques for both severe weather and tropical cyclones will also be presented.


Keywords: Tropical cyclones, Atmospheric predictability, Data assimilation, Hurricane prediction
Sensitivity analysis of the Weather Research and Forecasting (WRF - ARW) model was performed over the Philippines for typhoon Haiyan event. Combinations of four microphysics and three cumulus physics schemes were tested in a reanalysis downscaled at 12-km spatial grid and hourly temporal resolution. Model results of meteorological parameters such as wind speed, pressure, amount of precipitation that are of high importance during a typhoon event were evaluated using available synoptic and automated weather stations. Typhoon track and intensity were evaluated based on the best track provided by the Japan Meteorological Agency. In general, the investigated model configurations showed acceptable behavior although differences were observed in the performance of each meteorological parameter. The use of Grell-Divenyi cumulus physics scheme provided the best rainfall forecast while the WSM 6-class microphysics scheme provided the best forecast for pressure and wind speed. In addition, the WSM 6-class microphysics produced the least error on the Haiyan’s central pressure and maximum wind speed but it is the Grell-Devenyi cumulus physics scheme that predicted the best track. Based on the meteorological parameters evaluated, it is difficult to unambiguously establish which of the model configurations performs best. However, this study provides a general overview of WRF sensitivity and can constitute a reference for future meteorological modeling exercises.

**Keywords:** WRF-ARW, Haiyan, Philippines, Sensitivity studies
The lack of consistency between the premier tropical cyclone intensity forecast models and large fluctuations in model performance decreases the value of tropical cyclone forecasts. One approach to creating more reliable tropical cyclone intensity forecasts with the resources currently available is to create real-time skill predictions that help forecasters and end users know whether a particular model forecast will be more or less skillful than average. This a priori expectation of forecast performance combats the adverse effects of the substantial day-to-day, model-to-model, and storm-to-storm fluctuations in forecast quality. As a first step towards providing real-time error predictions to accompany each tropical cyclone intensity forecast, Bhatia and Nolan (2013) studied the relationship between synoptic parameters, TC attributes, and forecast error. Their results indicate that certain storm environments are inherently more or less difficult for individual models to forecast. In this study, we build on previous results by using storm-specific characteristics as well as parameters representing initial condition error and atmospheric stability to predict forecast error. Error predictions will be applied to 24-120 hour intensity forecasts for the Logistic Growth Equation Model (LGEM), Decay Statistical Hurricane Intensity Prediction Scheme (DSHP), Hurricane Weather Research and Forecasting Interpolated Model (HWFI), and Geophysical Fluid Dynamics Laboratory Interpolated Hurricane Model (GHMI). The ability of different regression techniques will be compared to evaluate which method will provide the most utility in an operational setting.


Keywords: Hurricanes, Predictability
Although tropical cyclone (TC) intensity change under idealized conditions is fairly well understood, accurate forecasts of intensity change for real TCs remain elusive. The goal of this study is to determine the processes responsible for different TC intensification rates using a large set of equally likely forecasts. A five-day, 96-member ensemble forecast for Hurricane Katia (2011) was produced using the Advanced Hurricane Weather Research and Forecasting (AHW) model. Hurricane Katia posed great challenges for numerical forecasts during its early development, with some operational models predicting a weak storm versus other models predicting a major hurricane. Ensemble forecasts from the AHW model were no exception, with some members predicting that Katia would remain a 35-knot tropical storm, with others predicting a category-2 hurricane. In order to understand what processes lead these different forecast scenarios, two distinct subgroups were identified: 1) 10 members that predicted the lowest time-averaged minimum sea level pressure (strongest members) and 2) 10 members that predicted a weak storm (weakest members). Results indicate that all members were initialized with a moderately strong environmental vertical wind shear, but the weakest members had a drier environment than the strongest members. In turn, this moisture difference subsequently affected the development and maintenance of the convection near the inner-core, which could have led to differences in intensity forecasts. This hypothesis is evaluated by comparing shear-relative forecast fields, and moisture budget terms within the strongest and weakest members. The implications of those results on TC intensity predictability and observation strategies will be discussed.

Keywords: hurricanes, ensembles, predictability, dynamics
SCI-PS141.01 - The Antarctic Mesoscale Prediction System (AMPS)

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The Antarctic Mesoscale Prediction System (AMPS) is an experimental, real-time numerical weather prediction capability that provides support for the United States Antarctic Program (USAP, especially the aircraft operations), Antarctic science, and international Antarctic efforts. It is a collaboration of NCAR and the Byrd Polar Research Center. Aircraft in support of USAP routinely transport personnel and cargo from Christchurch, New Zealand across the Southern Ocean to McMurdo station in the Ross Sea sector. As alternates to the primary landing strip at McMurdo are problematic, the terminal aerodrome forecasts assume greater importance than for most other locations. If the weather suddenly deteriorates below flight minima, aircraft turn back to New Zealand prior to or at the point of safe return, a costly event that reliable forecasts prevent. In addition to intercontinental operations, there are a large number of flights within Antarctica from McMurdo to many locations, especially to South Pole station. AMPS produces numerical guidance from the polar-optimized Weather Research and Forecasting model with twice-daily forecasts covering Antarctica. Within the parent grid that includes Christchurch, there are 4 nested domains with the finest resolution grid (1.1 km) focused on McMurdo that is surrounded by rugged, complex terrain. Initial model conditions come from the National Centers for Environmental Prediction’s Global Forecast System that are enhanced by regional data assimilation of conventional and satellite data using the three-dimensional data assimilation option in WRFDA. An overview is presented of AMPS, its forecast performance, and its active participation in the Polar Prediction Project.


Keywords: Numerical Weather Prediction, Antarctica, United States Antarctic Program, Polar Prediction Project
Parallel Session

SCI-PS141.02 - Weather service in the Dronning Maud Land and beyond

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For more than a decade meteorologists at the German Antarctic research station Neumayer (70°S, 008°W) offer detailed and individual summer weather forecasts for all activities in the Dronning Maud Land. Especially the intercontinental air link with Cape Town made the establishment of this service mandatory. The work is performed in close cooperation between the Alfred Wegener Institute for Polar and Marine Research (AWI) and the German Weather Service (DWD). The forecasts base mainly on in situ data including automatic weather stations (AWS), on near real time satellite pictures and on a variety of model products mainly from the Antarctic Mesoscale Prediction System (AMPS) and the European Centre for Medium-Range Weather Forecasts (ECMWF). To optimize this service the errors of a typical AWS had been quantified by running an unmaintained AWS one year side by side of the maintained instruments from the meteorological observatory from Neumayer. In a second year the same AWS was placed 11 km north of Neumayer to judge the spatial footprint of the observatory data. By comparing model products with the measurements of the observatory systematic errors in the forecast products have been observed. Also the ERA-Interim reanalysis differs significantly from the temperature time series observed at Neumayer despite the fact that the data is fed into the Global Telecommunication System GTS for more than 30 years. From these findings some guidance on optimizing the Antarctic observing and prediction systems could be developed.

Keywords: Neumayer, AWS, AMPS, ECMWF
Parallel Session

SCI-PS141.03 - Concordiasi Dropsondes: Improved characterization of errors in the Antarctic Mesoscale Prediction System

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The Antarctic Mesoscale Prediction System (AMPS) is a real-time, limited-area numerical weather prediction model with domains covering the Antarctic continent and its surrounding regions. AMPS simulations provide logistical support to the United States Antarctic Program and numerous other international interests in Antarctica. Extreme conditions in the region are associated with unique challenges to modelling efforts including the implementation of accurate physical parameterizations. Efforts to evaluate and improve AMPS have been hampered by the limited spatial coverage of observations. During the fall of 2010, special dropsonde observations were obtained in an intensive observation period during the Concordiasi field program, providing a unique opportunity to evaluate both upper- and lower-level model performance in an otherwise data-sparse region of the globe. In this study, we discuss differences between AMPS forecasts and Concordiasi dropsondes. Results indicate that model bias characteristics largely fall into two subsets: those over the Antarctic continent land areas and those over ocean areas. Over land, the analysed surface inversion is much weaker in AMPS, resulting in an upper-boundary-layer bias of approximately -3 K. Also over land, forecast boundary-layer temperature, relative humidity, and wind speed biases are 4 K, 20\%, and -2 m/s, respectively. Over ocean, warm and dry biases are centered below the 700-hPa level. It is hypothesized that the latter biases are a result of under-predictions of clouds, and we explore them using the Rapid Radiative Transfer Model. We also compare AMPS with the Global Forecast System and the European Centre for Medium Range Weather Forecasting model.

Keywords: Antarctic Mesoscale Prediction System, Concordiasi, Model evaluation, Polar Weather Research and Forecasting Model
SCI-PS141.04 - Ensemble Data Assimilation in a mesoscale model during CONCORDIASI (2010)

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The Antarctic and Southern Ocean are extremely difficult regions for numerical weather prediction (NWP) models in part due to the limited quantity and quality of observations for this remote region. From this a greater degree of uncertainty exists in accuracy of the analyses utilized for the model initialization, which will cause confidence in the forecast to be low. The Antarctic Mesoscale Prediction System (AMPS), which is a modified version of the Advanced Research Weather and Research Forecasting (ARW-WRF), is currently the only operational mesoscale NWP model used in the southern polar region. In this study, we evaluate the impact of using ensemble-based data assimilation in the AMPS model by utilizing an Ensemble Adjustment Kalman Filter (EAKF) found in the frameworks of the Data Assimilation and Research Testbed (DART) for an observation period during the CONCORDIASI Project. We refer to this experimental data assimilation as Antarctic-DART. The focus of our results will start by evaluating the differences between between AMPS model (initialized using 3DVAR) and Antarctic-DART. While both configurations utilize a subset of quality-controlled observations from CONCORDIASI, Antarctic-DART assimilates substantially fewer observations, with the assimilation of surface (METAR), radiosondes (wind, temperature and relative humidity), aircraft (ACARS), cloud satellite wind, ship, and GPS (COSMIC) observations. A comparison of model initialization and forecast skill will be evaluated with the addition of MODIS satellite winds and special observation types unique to CONCORDIASI.

Keywords: Ensemble Data Assimilation, Antarctic Mesoscale Prediction System, CONCORDIASI
Parallel Session

SCI-PS142.01 - Stationary wave driving as a potential mechanism to exploit for extratropical S2S prediction

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This talk will present ideas on how stationary wave driving of planetary wave Eliassen-Palm (EP) flux anomalies might provide a dynamical mechanism to exploit in order to improve extratropical subseasonal to seasonal prediction. Recent work has shown that a key control on wintertime Northern Annular Mode (NAM) variability on seasonal timescales involves constructive and destructive interference between planetary scale wave anomalies and the climatological stationary wave. It is shown how in observations and in GCM simulations the anomalous vertical EP flux from the troposphere to the stratosphere, which is a reliable precursor to tropospheric NAM anomalies, often involves linear interference between the planetary wave anomaly and the climatological stationary wave field. It will be argued that this work suggests several practical directions for improving S2S prediction: 1) The work suggests that if a planetary-scale wave anomaly that is in or out of alignment with the climatological stationary wave is forecast, negative or positive NAM phases will be more likely to follow in subsequent weeks. 2) Since the zonal phase of wave anomalies in the lower stratosphere is persistent and is a good predictor of the linear interference effect, accurate initialization of the planetary wave structure in the stratosphere might improve intraseasonal NAM forecasts. 3) Since linear interference is sensitive to representation of the climatological stationary wave, it is important for prediction systems to ensure that the stationary wave is well represented.


Keywords: stationary wave, subseasonal to seasonal prediction, Northern Annular Mode, stratosphere-troposphere interactions
Parallel Session

SCI-PS142.02 - Towards a U.S. National Earth System Prediction Capability

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The U.S. National Earth System Prediction Capability (ESPC) inter-agency program was established in 2010 as a coordinating effort to improve collaboration across the environmental research and operational prediction communities for the development and implementation of improved physical earth system prediction across timescales. Many of the sources of predictability beyond synoptic timescales rely on coupled ocean-atmosphere and other earth system dynamical interactions, as has been indicated by observational correlations in the historical record and numerical reforecast experiments. Specific earth system conditions at these longer timescales exceed the limits of explicit predictability due to the chaotic nature of the dynamical system, resulting in a reliance on ensemble methods to create probabilistic forecasts; however, representing low order modes in the coupled earth system more accurately may improve those ensemble-based, conditional probabilities. The scope of this challenge necessitates broad participation from the meteorological, oceanographic, and climate science communities, so the National ESPC project was expanded in 2012 to include both research mission agencies such as NASA and NSF as well as the original operational prediction agencies such as NOAA and the Department of Defense. This effort seeks to reduce technology barriers to collaboration among U.S. federally sponsored environmental science research activities through a common modeling architecture and community component models, and to reduce organizational barriers to improve the transition of research advancements into operational prediction capability.

Keywords: subseasonal-to-seasonal predictability, research-to-operations, interagency coordination
Parallel Session

SCI-PS142.03 - Predictability of the Sudden Stratospheric Warming of 2012-2013 and associated skill for the surface forecast

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The Stratospheric Sudden Warming (SSW) is characterized by a rapid deceleration in circumpolar westerly winds resulting into easterly and a large increase in the temperature of the colder polar cap region called the polar vortex on the time scale of a few days. The predictability of these extreme stratospheric events are crucial for their impact on the tropospheric forecast on a timescale of one to two weeks. The Stratospheric Network on Assessment of Predictability (SNAP), a network of major operational forecasting centres, aims to understand the stratosphere-troposphere link and quantify how far in advance SSWs can be predicted and add skill to tropospheric forecasts. During the 2012-2013 winter anomalous upward propagating planetary wave activity was observed during the second and third week of December followed by a rapid deceleration of westerly circulation around January 2, and within 3-4 days the circulation reversed on January 7, 2013. This stratospheric dynamical activity was followed by an equatorward shift of the tropospheric jet stream and a high pressure anomaly over North Atlantic, resulting in severe cold conditions in the UK and Northern Europe. Our current skill in predicting SSWs and therefore its consequential impact on tropospheric weather forecast is very limited due to the gap in proper understanding of stratosphere-troposphere coupling. In this presentation we will show how far in advance the current forecasting systems are able to predict this event and consequently added skill in surface forecast. We will also investigate the limitations of different models in correctly simulate the event.

Keywords: Stratospheric Sudden Warming, Predictability, Surface forecast skill
Parallel Session

SCI-PS142.04 - Influence of large-scale climate modes on atmospheric rivers that drive regional precipitation extremes

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The anomalously snowy winter season of 2010/2011 in the Sierra Nevada is analyzed in terms of snow water equivalent (SWE) anomalies and the role of atmospheric rivers (ARs)—narrow channels of enhanced meridional water vapor transport between the tropics and extratropics. Mean April 1 SWE was 0.44 m (56%) above normal averaged over 100 snow sensors. AR occurrence was anomalously high during the period, with 20 AR dates during the season and 14 in the month of December 2010, compared to the mean occurrence of 9 dates per season. Fifteen out of the 20 AR dates were associated with negative phases of the Arctic Oscillation (AO) and the Pacific-North American (PNA) teleconnection pattern. Analysis of all winter ARs in California during water years 1998–2011 indicates more ARs occur during the negative phase of AO and PNA, with the increase between positive and negative phases being \~90\% for AO, and \~50\% for PNA. The circulation pattern associated with concurrent negative phases of AO and PNA, characterized by cyclonic anomalies centered northwest of California, provides a favorable dynamical condition for ARs. The analysis suggests that the massive Sierra Nevada snowpack during the 2010/2011 winter season is primarily related to anomalously high frequency of ARs favored by the joint phasing of \~AO and \~PNA, and that a secondary contribution is from increased snow accumulation during these ARs favored by colder air temperatures associated with \~AO, \~PNA and La Niña. The results have implications for subseasonal-to-seasonal predictability of AR activities and related precipitation extremes.


Keywords: atmospheric rivers, large-scale modes, precipitation extremes
Parallel Session

SCI-PS143.01 - Statistical Interpretation of Model Output – An essential link between model and user

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Statistical interpretation of model output, or statistical adaptation, essentially means the statistical processing of the output of an NWP model, and is one of many forms of model output postprocessing. The goal is generally to transform the raw forecast output from models into a form which is more “user-friendly” while at the same time debiasing the raw model forecasts. Historically the most popular form of statistical interpretation was “Model Output Statistics” (MOS), first introduced in the US in the early 1970s. Through the 70s and 80s many national centers implemented their own MOS systems, while from the 1990s onward adaptive or “dynamic” statistical post-processing methods were developed to cope with the high frequency of changes to operational models. The focus of all these systems was the enhancement of the output of deterministic models, and these systems produced both probabilistic and deterministic forecasts. Is MOS-type statistical post-processing still needed with the accuracy levels of current operational models? As models become more accurate in an absolute sense, the room for improvement using statistical post-processing decreases, or so the argument goes. This question is explored in this paper. It is argued that statistical post-processing is as important as it always was, but that the role and purposes need to change, or at least be broadened. The presentation will include a survey of statistical post-processing methods, both older and newer, along with an exploration of their current role as intermediaries between the raw model output and users, including forecasters and end-users of forecasts.

Keywords: statistical post processing, model output statistics
Parallel Session

SCI-PS143.02 - The future role of statistical postprocessing in weather forecasting

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Statistical postprocessing techniques, especially MOS (Model Output Statistics) are capable of reducing about 50% of the error variance of standard weather element forecasts of numerical models - no matter what their horizontal or vertical resolution is. This 50% seems to be a 'natural constant' over decades: The models are getting better, the MOS techniques are getting more sophisticated, and the improvement remains the same: 50% - which makes the difference between model forecasts which can be improved by the forecaster easily and MOS forecasts which cannot be improved by the forecaster on the average. In this paper, a wide range of MOS applications ranging from nowcasting (aviation, insurance and general warnings), to energy (wind and sun), to water level forecasts is presented. Verification results for MOS vs. human forecasts are shown, based on official verification of the German National Weather Service (DWD), and based on weather forecasting tournaments like wetterturnier.de (Germany) or AMOS weather tipping (Australia). The following questions are addressed by verification: What is the impact of higher model resolution or of mixing two different numerical models on the quality of the final MOS forecast? Consequences for the design of future customer oriented weather forecasting systems are suggested. It is shown that neither the ever increasing resolution of the models nor the presence of ensemble forecasts can substitute the benefits of MOS which generates bias-free forecasts of any observed element in probabilistic and non-probabilistic form.

Keywords: postprocessing, MOS, verification, probabilities
Parallel Session

SCI-PS143.03 - Post-processing methods for probabilistic convection forecasts based on the limited-area ensemble COSMO-DE-EPS of DWD

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Mainly in summer strong convective events can occur in Germany. These cases are often associated with severe and high-impact weather. Hence, probabilistic forecasts of such events are of increased interest in weather warnings in general and in aviation forecasts and air traffic management in particular. The main goal of the project is to develop a post-processing probabilistic convection forecast in order to support the air traffic management in decision making processes. The probabilistic forecasts are based on the convection-permitting ensemble prediction system COSMO-DE-EPS, running in operations at DWD (German Meteorological Service) since May 2012. We develop post-processing products in the form of threshold-exceedance probabilistic products from direct model output (DMO) variables or so called indirect model output (IMO, e.g. thunderstorms), which are determined by a regression of DMO variables. An essential part of the development of regression methods is the use of observational data for training and verification. Pairs of observations of events (as predictands) and DMO EPS forecasts (as predictors) are used to quantify the underlying relation, which is then used as forecast directive for IMO parameters. The predictor selection is done here with the LASSO (least absolute shrinkage and selection operator) method. Logistic regression shows a gainful performance for extreme events, such as heavy precipitation in former studies and is therefore taken into account here, too.

\textbf{Keywords:} Post Processing, Ensemble Prediction System, Convection, Regression Methods
Parallel Session

SCI-PS143.04 - ModelMIX – optimal combination of NWP Model Forecasts for AutoWARN

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AutoWARN is developed by the German Weather Service (DWD) with the aim of providing an automated decision support for the weather warning service and enabling its stepwise centralisation. All relevant meteorological data including observations, nowcasting products and NWP model forecasts are processed to create automated warning proposals, which are used, after possible modification by forecasters, to create the warning status. Based on that, warning products are finally generated for customers. In order to use all available information as input for this process, forecasts of several different ensemble based NWP systems should be taken into account. However, to avoid a huge number of automated warning proposals from different model forecasts, these must be combined into a single forecast product. This is done by ModelMIX based on DWD’s operational Model Output Statistics System (MOS) applied to weather warnings (WarnMOS) and its newly developed extension to ensemble forecasts (EnsembleMOS). In a first step, different model forecasts are separately post-processed, thereby reducing their systematic forecast error and generating required probabilistic forecasts for warning events. In a next step, by applying the MOS approach again, all these forecasts are combined into a single statistically best probability forecast product for each DWD warning event on a 1 km grid. The presentation provides an overview on recent developments, including the use of DWD’s new global model (ICON), regional models with high spatial resolution for a better description of small-scale processes, ensemble models (COSMO-DE-EPS, ECMWF-EPS) to take into account meteorological uncertainties, some promising verification results and future plans.

Keywords: weather warnings, model post-processing, probabilistic forecasts, model output statistics
Parallel Session

UAS-PS313.01 - Communicating scientific forecasting techniques to end users for WMO Coastal Inundation Forecasting Demonstration Project

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Coastal inundations are an increasing threat to the people living in low-lying, highly populated coastal areas. The management of such risk represents a great challenge to scientists and policy-makers in the areas of meteorology, hydrology, oceanography, emergency management and coastal planning. To improve safety-related services for the community, as a fundamental priority of the World Meteorological Organization (WMO), the Coastal Inundation Forecasting Demonstration Project (CIFDP) is implemented in order to meet the challenges of coastal communities’ safety and socio-economic sustainability. The main focus of the CIFDP is to facilitate an efficient forecasting and warning systems for coastal inundation based on robust science and observations, responding to the national user requirements. A User Requirement Plan (URP) is the main channel within the CIFDP framework to compile a high level inventory of the institutional users’ information, and to communicate scientific information to the end users. Bangladesh is one of the countries where the project (CIFDP-B) has started since 2011. The URP for CIFDP-B, to regularly review and update through continuous user consultation, was developed through an analysis of surveys for the institutional users of forecasting and warning information in Bangladesh. The communication plan, as part of the URP for CIFDP-B, shows the processes of information dissemination from central to local government level within the emergency response system of Bangladesh. This paper shows how information dissemination system could decrease the loss of human and property in the 780km-long dangerous coast line in Bangladesh, from coastal inundation in Bangladesh.

Keywords: CIFDP, WMO, Coastal Inundation, Bangladesh
UAS-PS313.02 - From research to end-users services at Meteo-France

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In order to meet the needs of weather-sensitive users for integrated applications or high-value products using advances from the latest research, Meteo-France has created a dedicated end-users services department covering general studies & consultancy, agrometeorology and environment & health activities. Three outstanding contributions will be detailed in our presentation: - Our ISOP system provides fodder yield anomaly assessments to public authorities to support their monitoring and decision-making activities. This is made possible through an integrated platform with complex meteorological data handling, downscaling methods and user’s software to produce statistics, indexes or graphical outputs on an operational way. Another equivalent integrated system is currently under discussion in partnership with the Arvalis Institute. - Climate change impact studies tailored to specific users’ needs and objectives are produced. Two examples of these are: the Explore2070 project for which we have provided downscaled scenarios for water resources in France (mainland and overseas) by 2070; the AFClim prospective during which the adaptation of agriculture practices to climate change has been evaluated by an expert group on the basis of long-term time-series, downscaled 2050 climatic projections and agroclimatic indexes. Fact sheets have been provided to public policy-makers as outputs. - Market studies have confirmed the need of modelling and consultancy facilities to support public policies aiming at reducing urban heat in a changing climate. Consequently, a numerical system, Acclimat, developed by Météo-France research services is presently being transferred to build an operational configurable software, available for our internal network of regional consultancy offices.


Keywords: end-users services, agrometeorology, climate change impact, decision making
Parallel Session

UAS-PS313.03 - Flood risk and uncertainty: assessing the national weather service's flood forecast and warning tools

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A significant body of social science research has examined the factors that motivate people to prepare for natural hazards, as well as ways in which people respond to uncertainty and warning messages. As part of a series of projects funded through NOAA's Weather-Ready Nation initiative, an interdisciplinary team of institutions headed by Nurture Nature Center in Easton, Pennsylvania, undertook a study of National Weather Service's (NWS) flood forecast and warning tools to apply some of this understanding in a practical context. The research aimed to 1) understand how people living in the Delaware River Basin already use NWS products and services and 2) determine strategies for NWS to consider in preparing/revising its flood forecast and warning products to better motivate flood preparedness and warning response among rural and urban audiences. The research team, including East Carolina University and NWS weather and river forecast offices, created an extreme storm scenario that served as the focal point for a series of focus-group sessions. These sessions tested public response to various forecast products, including the river hydrograph, flood inundation mapping tools, flood watches and warnings, and ensemble forecast systems showing uncertainty. Project findings are being used to formulate recommendations, including a series of mocked-up revisions to NWS forecast products, based on the information garnered from the focus groups, with the aim of improving public understanding of uncertainty and flood risk. The project includes an outreach component (http://socialscience.focusonfloods.org) to educate the public about uncertainty in forecasts and to share findings with the weather community.

Keywords: floods, communication, social science, uncertainty
Weather predictions have improved significantly in recent decades. At the same time, advances in information and communication technology are dramatically changing how people access, combine, and share information when hazardous weather threatens. To reduce the negative impacts of hazardous weather events, it is important to understand how weather forecast and warning information is communicated and used in today’s world. We will discuss a project that aims to improve this understanding by integrating knowledge and methods from atmospheric and related sciences, computer and information science, and social and behavioral sciences. The project focuses around investigating how interactions among different actors and types of information influence risk interpretations and behavioral responses as a hurricane approaches and arrives, in the context of evolving meteorological predictions and the modern information environment. The research combines study of the real-world hazard information system with computational physical and social modeling. To understand the real-world system, we are collecting and analyzing data about how people communicate, perceive, and respond to hurricane threats from social media streams, complemented by interviews and focus groups. This is combined with computational modeling research that includes high-resolution ensemble hurricane and storm-surge modeling and agent-based modeling of social actors who pursue, process, and transmit information. The project will advance fundamental knowledge in each area and build new connections across disciplines to help learn how to reduce harm from tropical cyclones and other hazards. We will present the project paradigm along with initial results from the research.

Keywords: tropical cyclones, communication, information use, social media
Parallel Session

UAS-PS314.01 – WITHDRAWN - Driving economic development through Innovation technology in weather information application

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Business risk associated with extreme weather events in the APEC region such as typhoons, floods and heavy rains is likely to be exacerbated by environmental changes, with enterprises facing increasing financial and organizational costs. This proposed project will organize a symposium that aims to enhance economic development in APEC in terms of Innovation Technology on precipitation prediction (e.g., cooperative precipitation ensemble forecast), which can provide more accurate and timely weather information to industries and business. Themed “Driving Economic Development through Innovation Technology in Weather Information Application,” the symposium will facilitate dialogue among Meteorological and Hydrological Services (NMHSs), business enterprises (weather information users) and relevant research institutes. The Innovation Technology of weather information application will assist business sectors to make better decisions when encountering short-period weather changes, and also help them devise a better Business Continuity Plan (BCP). More details of the proposal will be discussed in the presentation.

Keywords: economic development, weather information application, innovation technology
Parallel Session

UAS-PS314.01 - Understanding the need of decision makers: an approach to develop better products and services

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Progress in the science of Meteorology during the coming years offers the promise of improved forecast accuracy at all spatial and temporal scales and within various components of the Earth System (eg, atmosphere, hydrosphere, cryosphere). However, with the increasing variety and volume of data available, we must face the challenges of how to communicate with users in order to understand their decision making processes and ascertain their data requirements and present this data in formats that are relevant and useful to them. This presentation will focus on the importance of developing “applied science bridge-units” between Research and Services. The emphasis of the presentation will be on the importance of these units to developing more specific products and services for clients through collaboration in order to facilitate the effective use of weather and environmental information in their decision making.

Keywords: decision makers, client oriented approach, Research and Services Bridge
Parallel Session

UAS-PS314.02 - Crowd-sourcing for obtaining data on an extreme tornado: A new model informing meteorological research

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Strategic utilization of new social media can greatly increase data collection on meteorological phenomena. We present the case of the El Reno, Oklahoma supercell of 31 May 2013, which produced one of the largest (~4.3 km diameter) and most intense (>130 ms\(^{-1}\)) tornadoes ever recorded, resulting in the first known storm chaser mortality. The storm was sampled extensively by remote sensing (mobile research and operational radars; lightning detection networks), while post-storm surveys documented the tornado track and associated damage. At least 250 chase groups directly observed the El Reno Storm, documenting it with high-resolution still and video imagery, though without field coordination or subsequent consolidation of these visual data resources. In a modern analog to T.T. Fujita’s pioneering effort to analyze multi-perspective imagery of the 1957 Fargo tornadoes, our team has begun the El Reno Survey (http://el-reno-survey.net/), a project to crowd-source storm data from chasers and compile submitted materials in a quality controlled, open-access research database. Response to solicitations for inputs has been very strong: within 3 months of project launch, 64 groups had contributed to our database. We will present multi-perspective analysis results utilizing these resources on the genesis, intensification and expansion of the tornado and of the storm’s highly anomalous lightning activity. Methods developed to precisely fix time and location characteristics of storm chaser imagery, rendering it usable for scientific purposes will also be described.

**Keywords:** New social media, Crowd-sourcing, El Reno tornado, extreme event
Parallel Session

UAS-PS314.03 - Communicating weather and impacts in remote Alaska in a new age of social media

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Coastal storms have tremendous impact on the indigenous communities of the Bering and Chukchi Seas. Impact and timing from swell, sea ice and other sensible weather elements vary immensely by each community. Combined with limited communication infrastructure, conveying impacts to those in harm’s way proves challenging. Yet, communication infrastructure in rural western Alaska has modernized considerably over recent years. While not on par with urban areas, this modernization does open new avenues to communicate weather and impacts. Through assessment of services provided during two recent coastal storm events, and with information gathered by indigenous outreach organizations, we investigated the use of various forms of media by Bering and Chukchi Sea coastal residents. The role of social media exists and is rising. We will discuss our findings, the unique ways weather and impact information is shared, and what we see as the future of critical weather dissemination for these rural areas.

Keywords: social media, rural, coast, Alaska
**Parallel Session**

**SCI-PS144.01 - Using a novel coupled-modelling framework to reduce tropical precipitation biases**

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Most atmospheric general circulation models (AGCMs) used for numerical weather prediction and climate simulations suffer from large systematic errors in tropical precipitation, including too much rainfall over warm tropical oceans, too little rainfall over land and a poor representation of intra-seasonal variability (e.g., the Madden-Julian oscillation and monsoon “active” and “break” events). Coupling these AGCMs to dynamical ocean models reduces these biases, but does so at the expense of considerable systematic errors in sea-surface temperatures (SSTs). We use a novel coupled-modelling framework of the Met Office AGCM coupled to many columns of a mixed-layer ocean model, with prescribed ocean temperature and salinity corrections to maintain the observed seasonal cycle of SST. We show that this framework reduces many long-standing tropical precipitation errors in the AGCM. Specifically, coupling improves the severe AGCM dry biases over India during the summer monsoon, reduces erroneously heavy rainfall in the tropical northwest Pacific in spring and summer and improves the eastward propagation of the Madden-Julian oscillation. Drawing on the strength of our modelling framework, we use regional coupling experiments to show that coupling in both the tropics and extra-tropics are required to achieve these improvements in tropical precipitation. Atmosphere-only simulations with prescribed coupled-model SSTs fail to reproduce these improvements, indicating a substantial role for air-sea coupling, under accurate mean-state SSTs, for accurately simulating the mean seasonal cycle and intra-seasonal variability of tropical precipitation in this model.

**Keywords:** Coupling, Tropics, Rainfall, Monsoon
Parallel Session

SCI-PS144.02 - Sensitivity study of a Heavy Precipitating Event to the sea state using convection-permitting model simulations

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This study focuses on a Heavy Precipitating Event (HPE) which took place on South-East French coast the 26th of October 2012 during the first Special Observation Period (SOP1) of HyMeX (Hydrological Mediterranean eXperiment). Three simulations of this HPE were ran using the mesoscale non-hydrostatic atmospheric model MesoNH. Each simulation lasted 24 hours starting on 26/10/2012 at 00UTC. The simulations used a 2.5km horizontal-resolution domain encompassing the area of the western Mediterranean sea where the main exchanges of heat and momentum just prior to the event occurred. Each simulation used a different configuration of the bulk parametrization COARE3.0 (Coupled-Ocean Atmosphere Response Experiment, Fairall et al. 2003) to compute the turbulent fluxes. The first did not take into account the waves, the second introduced the wave age inferred from an empirical formulation whereas the third computed the wave age from the output of a 2D wave model WAM (WAMDI Group 1988). The simulations displayed clear differences in the air-sea turbulent fluxes especially for the heat fluxes with local differences of several tens of W/m². Such discrepancies in the sensible and latent heat fluxes had direct effects on the low-level air temperature and specific humidity. These changes in the low-level thermodynamics combined with smaller but persistent differences of the 10m wind field, induced modifications in the life cycle of the simulated convective systems, resulting in significant differences in terms of location and amount of precipitation.


Keywords: heavy precipitating event, turbulent fluxes, sea state, high resolution modelling
Parallel Session

SCI-PS144.03 - Working towards a first-ever operational coupled lake-ice-atmosphere forecasting system in Canada

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As we strive to improve our understanding and forecasting of the natural world through higher resolution models we need to take into account more processes and components. This includes, only in part, a better representation of large-scale lakes and the ice that covers them in winter. We will show some promising modeling results and general set-up details of our experimental Great Lakes Forecasting System which was developed based on our next generation operational Gulf of St Lawrence Coupled Ice-Ocean-Atmosphere forecasting system. It includes two main parts: A 3D pseudo-analysis of the Great Lakes and a 48 hour coupled ice-lake-atmosphere forecast. The analysis component provides the most significant improvement in forecast skill. It provides a constraint on both ice concentration and thickness through the assimilation of Radarsat images. It is used to initialize the coupled run as well as to provide initial water temperature and ice conditions for various research and experimental systems under development at Environment Canada (ie a High Resolution National Forecast System, Very High resolution PanAm Games Forecast System). The coupled part of the system is a 48 hour regional forecast using the operational RDPS (Regional Deterministic Prediction System) as forcing fields for the atmosphere and the analysis for the lake and ice models. This model proves most useful during high impact events such as strong winds or extreme cold. The system uses NEMO as the ocean model, CICE for the ice component and the Atmospheric model is a standard configuration of GEM.

\textbf{Keywords}: coupled, lake, operational, atmosphere
Parallel Session

SCI-PS144.04 - Impact of sea ice on global coupled medium-range atmosphere-ice-ocean forecasts

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As numerical weather prediction (NWP) systems become further refined, the interactions across the Air-Ice-Ocean (AIO) interface are becoming increasingly important. This is giving rise to the development of a new generation of fully-integrated environmental prediction systems composed of atmosphere, ice, ocean, and wave modeling and analysis systems. Such systems are in increasing demand as the utility of marine information products (e.g. for emergency response) becomes more widely recognized. A fully-coupled AIO forecasting system for the Gulf of St. Lawrence (GSL) has been developed and has been running operationally at the Canadian Meteorological Centre since June 2011. This system demonstrated the strong impact that a dynamic sea ice cover can have on 48hr atmospheric forecasts. The success of this system has motivated the creation of the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS), an initiative between Environmental Canada, Fisheries and Ocean Canada and National Defense to develop new and enhanced environmental products and services. Within CONCEPTS two main systems are under development: a global coupled prediction system for medium-to-monthly range applications and a short-range regional coupled prediction system. In this presentation we show results from the global coupled AIO system highlighting the role of sea ice in coupled forecasting skill and its importance for polar environmental prediction. In particular, several case studies are used to demonstrate the various impacts sea ice can have, along with sources of error and skill. We also provide a discussion of key challenges and future directions.

Keywords: coupled, atmosphere, ice, ocean
Parallel Session

SCI-PS146.01 - Ensemble Kalman Filter Assimilation of MOPITT CO Retrieval Profiles with WRF/Chem-DART

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This research incorporates WRF/Chem, a version of the Weather Research and Forecasting Model (WRF) with online chemistry, into the Data Assimilation Research Testbed (DART) for studying the assimilation of trace gas retrieval profiles into a regional model with an ensemble adjustment Kalman filter. It presents results from a 30-day assimilation study with 6-hr cycling over the continental United States. There are two experiments: (i) assimilation of meteorology only (MET DA) and (ii) assimilation of meteorology and chemistry (MET/CHEM DA). For MET DA, it assimilates NOAA conventional PREPBUFR observations, and for MET/CHEM DA it assimilates PREPBUFR observations and Measurement of Pollution in the Troposphere (MOPITT) v5 CO retrieval profiles. The results show that assimilation of MOPITT CO retrievals (MET/CHEM DA) improves: (i) the fit of the DART posterior (WRF/Chem initial conditions) to the MOPITT CO observations and (ii) the WRF/Chem CO forecast skill compared to the control experiment (MET DA).

Keywords: EnKF, MOPITT, WRF/Chem, DART
Parallel Session

SCI-PS146.02 – WITHDRAWN - The joint Canadian-Swedish Atmospheric Limb Sounding Satellite (ALiSS) Mission

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The Atmospheric Limb Sounding Satellite (ALiSS) is a joint Canadian-Swedish concept currently under study by agencies, industrial partners and academic institutions within both countries. Onboard ALiSS are four atmospheric limb remote sensing instruments. Three have space heritage and are: the Canadian designed Atmospheric Tomography System (CATS) that is a derivative of the highly successful Optical Spectrograph and InfraRed Imaging System (OSIRIS) instrument; the Swedish designed STEAMR is a follow on instrument to the Sub-millimeter, Millimeter Radiometer (SMR) that currently operates with OSIRIS on Odin and a GPS Radio Occultation instrument. The fourth instrument, also Canadian, is the Spatial Heterodyne Observations of Water (SHOW). SHOW is novel technology that will measure water vapour profiles. Among other things the ALiSS package will deliver very high spatial resolution atmospheric composition (O$_3$, H$_2$O, NO$_2$, HNO$_3$, aerosol, others...) measurements within the extremely important UTLS region for chemistry and climate studies. One application would be using these within data assimilation systems in order to better monitor and predict these quantities. Also, the heritage of these instruments implies the ALiSS measurements will be extremely valuable in the continuation of climate quality, satellite based time series of important constituents such as stratospheric aerosols, nitrogen dioxide, bromine monoxide and ozone. This talk will outline the ALiSS concept and the utility of the measurements for quantifying stratospheric levels in order to obtain measurements of tropospheric pollutants such as surface ozone and NO$_2$ from nadir viewing sensors such as Sentinel 5 precursor, TEMPO (Tropospheric Emissions: Monitoring of Pollution) and others.

Keywords: atmospheric remote sensing, assimilation, air quality, UTLS
SCI-PS146.03 - BASCOE ensemble data assimilation stratospheric chemistry system

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The local ensemble Kalman filter assimilation method is applied to the BASCOE (Belgian Assimilation System for Chemical ObsErvations) stratospheric chemistry model. We use a stochastic version of the EnKF, i.e. with perturbed observations. The EnKF developed in BASCOE accounts for two adjustable parameters: a parameter controlling the model error term and a parameter controlling the observational error. The EnKF system is shown to be markedly sensitive to these two parameters, which are adjusted based on the monitoring of a chi2-test measuring the misfit between the control variable and the observations. The model includes 57 chemical species with a full description of stratospheric chemistry. The application of the EnKF to the full-chemistry model requires a careful tuning procedure of the error covariances for each chemical species. The performance of the EnKF method was estimated through the assimilation of Aura-MLS and MIPAS observations.


Keywords: data assimilation, EnKF, stratosphere, CTM
Parallel Session

SCI-PS146.04 - Assimilation of water vapour measurements by a Chemistry Transport Model in the tropical UTLS

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This study deals with one of the most debated aspect of the Upper Troposphere/Lower Stratosphere (UTLS), namely the budget of the water vapour (H2O). It aims to be a baseline for further studies in relation with the TROPICO project linked to deep overshooting convection, and relies on field campaigns held in Bauru, Sao Paulo state, Brazil, involving a combination of balloon-borne measurements, ground-based and space-borne observations and modelling. UTLS H2O is known to play an important role in many aspects of meteorology, including radiation, dynamics, chemistry and climate change. Modelling of H2O, especially in the UTLS, is very difficult because it varies in space, time, and phase. In UTLS and Stratosphere, H2O is considered as a chemical species in MOCAGE CTM. To constrain the model, we use the Chemical transport model (CTM) MOCAGE of Météo-France coupled with the 3D-FGAT (3D First Guess at Appropriate Time) assimilation scheme in order to assimilate the Aura Microwave Limb Sounder (MLS) version 3.3 H2O measurements within the 261–46 hPa range. Some diagnostics are developed to assess the quality of the assimilated H2O fields depending on several parameters: model error, horizontal and vertical diffusions, observation minus analysis and observation minus forecast. Comparisons with an independant source of H2O in the UTLS will be shown: radiosondes, meteorological analyses, balloon- and space-borne measurements. The influence of H2O assimilation in the tropical UTLS is presented and discussed.

Keywords: Water Vapor, UTLS, Assimilation, Chemistry Transport Model
Parallel Session

SCI-PS147.01 - Efficient radar forward operator for operational data assimilation within the COSMO-model

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The new weather radar network of DWD comprises 17 C-Band Doppler radars, evenly distributed throughout Germany. They provide unique 3-dimensional information about dynamical and microphysical characteristics of precipitating clouds in high resolutions. Our applications are planned to take advantage of radar data within an upcoming new 4D-LETKF data assimilation system. It is assumed that the assimilation of radar data is a promising means for improvements of short-term precipitation forecasts, especially in convective situations. However, the observed quantities are not directly comparable to variables of the numerical model. In order to, on one hand, enable radar data assimilation in the framework of the above-mentioned assimilation system and, on the other hand, to facilitate comparisons of numerical simulations with radar observations in the context of cloud microphysics verification, a comprehensive modular radar forward operator has been developed. This operator simulates the measurement process of radar observables from the model variables and allows for direct comparison in terms of radar observables. The operator consists of several modules, each of which handles a special physical process. Each of these modules offers different formulations associated with different complexity in simulations, which can be flexibly chosen according to user’s needs. In order to assess the performance of the operator, a series of sensitive experiments have been conducted. The main goal is to find an optimal configuration of the operator in the sense of balance between accuracy and computational expense. Finally, we have exemplary performed assimilation experiments with radar data and the preliminary results are presented.

Keywords: radar, data assimilation, superobservation, LETKF
Parallel Session

SCI-PS147.02 - Enhancing information transfer from observations to unobserved state variables for mesoscale radar data assimilation

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Analysis produced from mesoscale radar data assimilation always has a short-lived impact on numerical forecast (maximum 2~3 hours). A plausible explanation is that assimilation of only reflectivity and radial velocity has difficulty in correcting other unobserved state variables in analysis. According to the statistical data analysis theory, correction of unobserved variables requires significant and reliable cross-correlation of background errors between observed and unobserved variables. However, such cross-correlation is not always significant, as shown in this exercise. The purposes of this study are to increase the error cross-correlation and to enhance the information transfer from observation to unobserved variables. In this study, radial velocity and vertical motion are considered as the observed and unobserved variables respectively. The later, although not completely observed by radar, is important for storm initiation in mesoscale. In order to correct vertical motion, simulated observations about radial velocity are assimilated by Ensemble Kalman Filter based on background error cross-correlation computed from ensemble forecasts. After assimilation, reduction of uncertainty in vertical motion suggests observation information transferred to the unobserved variable. The results show that background error cross-correlation is crucial for information transfer, which can be increased in two ways. The first method converts radial velocity data into observations about convergence, which is more related to vertical motion in theory. The second method is to directly collect observations at the locations where error cross-correlation is significant. The analyses resulting from those methods contain smaller error variance of vertical motion, compared to the results of traditional radar data assimilation method.

Keywords: Radar, Data assimilation, Observation
Parallel Session

SCI-PS147.03 - Assimilation of 3D radar reflectivity with an Ensemble Kalman Filter on a convection-permitting scale

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The prediction of convective events is a difficult task due to the non-linear and chaotic behavior of the atmosphere on this scale. Therefore, data assimilation is crucial to enhance numerical weather prediction (NWP). Radar observations represent an ideal data base due to their capability to capture the 3D spatial and temporal evolution of convective systems. However, the assimilation of radar data is not straightforward because reflectivity is not a prognostic model variable. Thus, an appropriate radar forward operator is necessary in order to derive synthetic radar volume scans based on the NWP model output. The obtained pseudo-reflectivities enable the comparison of the model forecast with the actual observation. Ensemble Kalman Filters are able to directly gain information from this comparison in the observation space. Related to linear regression, they transfer the information back onto the model states. At the German Weather Service (DWD), a Local Ensemble Transform Kalman Filter (LETKF) is currently under development. This LETKF setup, combined with a radar forward operator, is applied to assimilate reflectivity measurements from the DWD C-band radar network into the convection-permitting NWP model COSMO-DE. We will use rapid update cycles to catch small-scale convective events. Based on case studies, the benefit of radar data assimilation is assessed by comparing both the analysis and a subsequent free forecast with a control ensemble without assimilation of radar measurements.

Keywords: Data assimilation, Remote sensing, Convective scale, Ensemble Kalman Filter
Parallel Session

SCI-PS147.04 - Testing convective scale data assimilation in severe storm cases using variational LAPS

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The Experimental Warning Program is part of NOAA’s Hazardous Weather Testbed and held annually at spring time at the National Weather Center. In Spring 2013, several tornadoes touched down, including the deadly EF5 Moore tornado that killed 24 people and caused millions of dollars damage on 20 May 2013. In this paper, we will introduce the variational version of the Local Analysis and Prediction System (vLAPS). vLAPS is a fine scale numerical data assimilation and forecast system. We will select several cases of supercell storms and tornadoes to highlight the real-time performance of variational LAPS including some feedback from forecasters who used variational LAPS together with other available numerical guidance to provide experimental warnings.

Keywords: Convective Scale Data Assimilation, High impact storms, Variational Data Assimilation
Parallel Session

SCI-PS148.01 - Eddy kinetic-energy redistribution within real and idealized extratropical storms

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The formation of lower-tropospheric wind speed maxima (i.e. low-level jets) within extratropical cyclones is analyzed by performing eddy kinetic-energy (EKE) budgets. The focus is on surface cyclones crossing the slowly-varying large-scale jet from its warm-air to its cold-air side which is one recurrent feature of European storms. An analysis of the windstorms Klaus (22-24 January 2009) and Friedhelm (07-09 December 2011) is made using ERA-interim reanalysis datasets. The formation of the various low-level jets inside each storm is shown to strongly depend on the position of the storm relative to the large-scale jet axis. As long as the storms evolved south of the large-scale jet, the most intense EKE maxima as well as the total kinetic-energy maxima formed and intensified on the southeastern side of the surface cyclones in the warm sector. As soon as the surface cyclones moved to the north of the large-scale jet, cyclonic redistribution of EKE took place in the lower troposphere. During this stage, EKE was generated in the mid-troposphere by baroclinic conversion, then downward redistributed by the vertical ageostrophic geopotential fluxes toward the lower troposphere before being cyclonically redistributed by the ageostrophic geopotential fluxes along the bent-back warm front. This EKE redistribution led to the formation of a low-level jet to the south of each cyclone center. These results are finally explained at the light of idealized simulations performed with the two-layer quasi-geostrophic model and by underlying the key role played by the lateral shears of the large-scale jet in the evolution of EKE.

Keywords: eddy kinetic energy, low-level jet, jet crossing, mid-latitude storms
Parallel Session

SCI-PS148.02 - Historical research perspective of the lifecycle of extratropical cyclones: observations and high-resolution numerical simulations

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This lecture opens with an overview of the emergence of modern conceptualizations and the dynamical prediction of the structure and life cycles of extratropical cyclones and their internal frontal and associated precipitation systems at Vilhelm Bjerknes' Leipzig Geophysical Institute (1913-1917) and the Bergen Geophysical Institute (1918-1922). We present: i) the recently discovered unpublished analyses that formed the basis for the Bergen School conceptual models of extratropical cyclones by J.Bjerknes, H.Solberg and T. Bergeron; ii) the Leipzig school contribution to development of quasi-geostrophic theory and its application to graphical numerical diagnosis and numerical prediction by T. Hesselberg and H. Sverdrup. We next revisit the 1989 ERICA IOP-4 extratropical cyclone life cycle through a high-resolution (3-km) simulation with the NCAR/WRF-ARW regional prediction system. This simulation illustrates the Thor Bergeron, and Shapiro-Keyser extratropical warm-core seclusion process.

Keyword: Extratropical Cyclones
Parallel Session

SCI-PS148.03 - Microphysical heating rates in a warm conveyor belt: Comparison of a COSMO and IFS simulation

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Warm conveyor belts (WCB) are strongly ascending airstreams in extratropical cyclones, associated with the formation of elongated cloud bands. During cloud formation, various microphysical processes lead to the release of latent heat which subsequently modify the potential vorticity (PV). A wrong representation of microphysical processes associated with the WCB can therefore influence the large and mesoscale flow evolution and lead to erroneous forecasts. In order to investigate how the different microphysical processes and the associated heating influence the PV and hence the large and mesoscale flow, we investigate the representation of these diabatic heating rates (DHRs) and their associated diabatic PV rates (DPVR) in the NWP models COSMO and IFS. The DHR are calculated within both models and the associated DPVRs are calculated. The differences in the DHR and DPVR are analyzed for a case study of a WCB in the North Atlantic. Based on the model output, WCB trajectories are calculated and the DHR and DPVR associated with the WCB are analyzed. It can be seen that the overall heating along the WCB trajectories and the upper level PV pattern is similar for both models. However, differences occur in the partitioning between the different simulated hydrometeor species cloud liquid, rain, ice and snow and in the DHR associated with the formation of these clouds. The height as well as the amount of the maximum latent heat release differs between both models, which also has implications for the mesoscale dynamics.

Keywords: warm conveyor belts, microphysical heating rates, large scale dynamics
The conceptual model of extratropical cyclones (ETCs) includes a cyclone and warm and cold fronts, with associated patterns of clouds and precipitation. In this study, the focus is on post-cold frontal (PCF) cumulus clouds. PCF clouds transport moisture from the boundary layer into the free troposphere, which could limit available moisture to other regions of the ETC as suggested by recent studies. Studies of PCF cumulus clouds are needed in order to quantify not only their moisture transport, but also their precipitation and radiative roles. This study makes use of a cloud-resolving model with advanced cloud microphysics to examine PCF cumulus clouds observed during an ETC case study. Using the Regional Atmospheric Modeling System (RAMS), an ETC is simulated at high resolution and with bin-emulating two-moment bulk microphysics, in order to examine PCF cumulus cloud microphysical and dynamical characteristics, frequency, and moisture transport. The role of environmental properties on their development is also examined by altering environmental parameters, such as the concentration of aerosol and sea surface temperature. Assessment of the relative role of these environmental parameters in PCF cumulus cloud development provides valuable knowledge of the controls on these clouds' contribution to the ETC radiative and moisture budget. This study provides links between the cloud micro- and mesoscale structure to the ETC larger scale cloud and precipitation patterns. A case study of PCF cumulus clouds aids in determining the role of a yet un-quantified portion of the ETC moisture and radiation budget, including under varying environmental parameters.

Keywords: Cumulus Cloud, Post-Cold Frontal, Cloud-Resolving Model
Parallel Session

SCI-PS149.01 - Global climatology of vertical wind shear near tropical disturbances

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Recent climatology and idealized studies have explored tropical cyclone (TC) genesis in varying types of vertical wind shear. The climatology studies have shown that TC genesis is most favorable in environment deep-layer easterly shear \( \leq 5.0 \text{ m s}^{-1} \). The idealized studies have shown that given a favorable thermodynamic environment, TC genesis occurs more readily in westerly shear. It has been argued that westerly shear is more favorable for TC genesis than easterly shear because it allows for the favorable superposition of enhanced surface latent heat fluxes with organized convection on the downshear-left flank (when the low-level flow is easterly). Westerly shear was also shown to be more favorable if dry air lies to the north of the nascent cyclone, as is often the case. The apparent disagreement between the climatology and idealized studies has been linked to the strong correlation between easterly shear and increased maximum potential intensity (MPI). The aim of this presentation is to examine a global climatology of vertical shear and MPI for candidate disturbances identified in the ERA-Interim dataset by a vortex-tracking algorithm. Disturbance tracks that coincide with named TCs in the Best Track (IBTrACS) database are classified as developing TCs and all other systems as nondeveloping disturbances. By examining a large sample of shear, surface wind and moisture configurations of developing and nondeveloping systems, we will test the assertion that westerly shear can be more conducive to genesis than easterly shear, and that modest, non-zero shear is more favorable than nearly zero shear.

Keywords: tropical, hurricanes, climatology, shear
Parallel Session

SCI-PS149.02 - Tropical cyclones in vertical shear: Impact on the inflow layer of storms in idealized experiments

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Intensity changes of tropical cyclones (TCs) remain a significant forecast challenge. One roadblock to improved forecasts is our incomplete understanding of the governing processes. Arguably, the most important environmental contribution to intensity change is vertical shear of the environmental winds. This presentation summarizes recent advances in our understanding of vertical shear – TC interaction based on idealized numerical experiments. While previous work focused on processes in the mid- to upper troposphere, our work emphasizes the important modification of the TC’s inflow layer by environmental vertical wind shear. Vertical wind shear is prone to excite a persistent downdraft pattern tied to the tilt of the TC vortex. These downdrafts flush the inflow layer with low-entropy air diluting the TC’s heat engine. Surface fluxes apparently do not compensate for this entropy decrease completely and air within the inner-core updrafts rises with reduces entropy values. A simple quasi-steady, two-dimensional framework reveals that the downdraft region is fed by environmental, low-entropy air, arguably allowing for the persistence of the downdrafts. A Lagrangian analysis supports this notion and emphasizes that a much-increased amount of air from above the (frictional) axisymmetric inflow layer is drawn into TCs affected by vertical shear, as compared to TCs in quiescent environment. It is these air masses that dilute the TC’s heat engine and thus provide a thermodynamic reason for intensity decrease.

Keywords: tropical cyclone - environment interaction, tropical cyclone intensity change, tropical cyclone heat engine, flow boundaries
Parallel Session

SCI-PS149.03 - Upper-tropospheric precursors associated with subtropical cyclone formation in the North Atlantic Basin

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Oceanic cyclones exhibiting properties of both tropical and extratropical systems have been categorized as subtropical cyclones (STCs) since the early 1950s. The opportunity to investigate the roles of baroclinic and diabatic processes during the evolution of STCs from a potential vorticity (PV) perspective motivates this study. We will investigate the roles of baroclinic and diabatic processes during the evolution of STCs by calculating three PV metrics from the NCEP Climate Forecast System Reanalysis 0.5° gridded dataset. The three PV metrics quantify the relative contributions of: 1) lower-tropospheric baroclinic processes, 2) midtropospheric diabatic heating, and 3) upper-tropospheric dynamical processes during the evolution of individual cyclones. Quantification of these three contributions reveals the changing PV structure of an individual cyclone, indicates fluctuations in the dominant energy source of the cyclone, and aids in categorizing the cyclone. A cyclone-relative composite analysis performed on subjectively constructed clusters of North Atlantic STCs identified from a 1979–2010 climatology will be presented to document the structure, motion, and evolution of upper-tropospheric features linked to STC formation. This analysis highlights the frequent occurrence of precursor midlatitude anticyclonic wave breaking events that inject relatively cold upper-tropospheric air into the subtropics prior to STC formation. An evaluation of the relative contributions of lower-tropospheric baroclinic processes, midtropospheric diabatic heating, and upper-tropospheric dynamical processes during the evolution of STCs included in the composite analysis reveals the enhancement of upper-tropospheric PV prior to STC formation, and the reduction of upper-tropospheric PV and enhancement of midtropospheric PV during STC formation.

Keywords: subtropical, cyclone, anticyclonic wave breaking, tropical
Parallel Session

SCI-PS149.04 - A large number of tropical cyclone intensity forecasts using a high-resolution atmosphere-ocean coupled model

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This work quantifies the benefit of using high-resolution atmosphere-ocean coupled model on the tropical cyclone (TC) intensity forecast around Japan. To do so, a large number of calculations are conducted by running the JMA non-hydrostatic atmospheric model (AMSM) and the AMSM coupled to a simple upper ocean model (CMSM). In total, we compile the two-hundred eighty-one 3-day forecasts for 34 TCs from April 2009 to September 2012 on each model. Their performance is compared with the JMA global atmospheric model (GSM), which is used for the operational TC intensity guidance. The intense TCs are weakly reproduced at the initial time in GSM and they become too intense in the non-coupled models with increasing the forecast time. The TC intensity are better reproduced in CMSM owing to the smaller initial intensity error and the decrease of sea surface temperature, which is closer to observations. The improvement rates of minimum sea level pressure in CMSM relative to GSM (AMSM) is 10.9\% (3.4\%) for FT=24 h, 27.4\% (21.3\%) for FT=48 h and 40.5\% (28.9\%) for 72 h. As for the maximum wind speed, CMSM is better than GSM (AMSM) by 6.2\% (8.1\%) for FT=24 h, 12.8\% (19.5\%) for FT=48 h and 18.9\% (27.9\%) for 72 h. This study confirms that the sea surface cooling induced by the passage of TC is indispensable to suppress the erroneous TC intensification around Japan. In contrast, the coupling to an upper ocean model yields only a negligible difference in TC track forecast.

**Keywords:** tropical cyclone intensity forecasts, atmosphere-ocean coupled model, K-computer, tropical cyclone track forecasts
Global numerical weather prediction skill over polar areas is assessed for the recent past, mostly based on the ECMWF system but also taking into account Met Office, JMA, Env. Canada and NCEP data. Forecast verification with analyses shows a similar trend of forecast improvement over the past 12 years as at lower latitude originating from changes applied to model, e.g. model resolution, data assimilation and observational data coverage and quality. Adding forecasts from reanalyses helps delineating system improvement and weather variability. Ensemble skill equally evolved over time and, again, consistently across latitudes. The quality of analyses serving for forecast verification and initialization has been further investigated. Analyses from selected TIGGE models reveal substantial differences for surface parameters but also at lower levels in the troposphere where most of the physical processes relevant to weather in the short-to-medium range take place over the poles. Comparing analysis differences between centres with single-model ensemble analysis also shows inconsistencies. This suggests that multi-model analysis difference does not easily approximate analysis uncertainty recognizing that the chosen ensemble analysis reveals unrealistically low spread in polar regions for most parameters at lower tropospheric levels. This also has an impact on ensemble forecast spread and is particularly visible at the surface, also when compared to station observations.

**Keywords:** polar prediction, global weather forecasting, ensembles
Parallel Session

SCI-PS150.02 - Sea ice forecast verification in the Canadian Global Ice Ocean Prediction System

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Recent increases in marine traffic in the Arctic have amplified the demand for reliable ice and marine environmental predictions. This paper presents the verification of ice forecast skill from a new system implemented recently at the Canadian Meteorological Centre called the Global Ice Ocean Prediction System (GIOPS). GIOPS provides daily global ice and ocean analyses and 10 day forecasts at 00GMT on a 1/4° resolution grid. GIOPS includes a full multivariate ocean data assimilation system that combines satellite observations of sea level anomaly and sea surface temperature (SST) together with in situ observations of temperature and salinity. Ice analyses are produced using a 3DVar method that assimilates satellite observations from SSM/I and SSMIS together with manual analyses from the Canadian Ice Service. Analyses of total ice concentration are projected onto the partial thickness categories used in the ice model using spatially and temporally varying weighting functions derived from ice model tendencies. This method is shown to reduce deleterious impacts on the ice thickness distribution when assimilating ice concentration. An objective verification of sea ice forecasts is made using two methods: analysis-based error assessment focusing on the marginal ice zone and a contingency table approach to evaluate ice extent as compared to an independent analysis. Together the methods demonstrate a consistent picture of skilful medium-range forecasts in both Northern and Southern Hemispheres as compared to persistence. Particular skill is found in both hemispheres during melt periods, whereas larger errors are present during the period of rapid ice formation in fall.

Keywords: sea ice, forecast, verification, ocean
Parallel Session

SCI-PS150.03 - High-resolution atmospheric NWP modelling over Australian Antarctic bases

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The Bureau of Meteorology (BoM) provides forecasting support for the Australian Antarctic program (AAp). Here we present an introduction to and initial results from the Australian Community Climate and Earth-System Simulator – City Polar model (ACCESS-CP) which is being developed to provide high resolution limited area Numerical Weather Prediction (NWP) outputs for use by forecasters who provide weather services over Antarctica and the surrounding Southern Ocean. ACCESS-CP is a 4km atmosphere only regional model that nests within the ACCESS-P (12km Antarctic domain) and ACCESS-G (25km Global domain) models. It provides forecast guidance on a twice daily basis out to three days and covers the AAp regions of Mawson and Davis and of Casey and surrounds. ACCESS-CP replaces the original polar-specific ACCESS model of ACCESS-P which had a resolution of ~27km. There are no polar-specific modifications made to ACCESS-CP at this stage. Early results from ACCESS-CP show improvements in model performance over the original version of ACCESS-P, although there remains a diurnal bias in low-level temperatures. Surface pressure shows generally a positive error, with a larger bias in areas of low pressure. This version of the model provides a baseline in order to obtain a stable runtime environment for winter and summer periods. Once this has been established, work can commence on including polar-specific physical parameterisation schemes, including those for the boundary layer scheme, radiation, clouds and gravity wave processes in order to ensure that high latitude processes are properly modelled. Ongoing verification will quantify improvements made to the model.

Keywords: Antarctic, Modelling, Forecasting, ACCESS
Parallel Session

SCI-PS150.04 - Assimilating SMOS sea ice thickness into a coupled ice-ocean model using a local SEIK filter

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The impact of assimilating sea ice thickness data derived from ESA’s Soil Moisture and Ocean salinity (SMOS) satellite together with Special Sensor Microwave Imager/Sounder (SSMIS) sea ice concentration data of the National Snow and Ice Data Center (NSIDC) in a coupled ice-ocean model is examined. A period of three months from November, 1st, 2011 to January, 31st, 2012 is selected to assess the forecast skill of the assimilation system. 24h-forecasts and longer forecasts are based on the Massachusetts Institute of Technology general circulation model (MITgcm), and the assimilation is performed by a localized Singular Evolutive Interpolated Kalman (LSEIK) filter. For comparison, the assimilation is repeated only with the SSMIS sea ice concentrations. By running two different assimilation experiments, and comparing with the unassimilated model, independent satellite derived data, and in-situ observation, it is shown that the SMOS ice thickness assimilation leads to much better thickness forecasts. With SMOS thickness data, the sea ice concentration forecasts also agree better with observations, although this improvement is smaller.

Keywords: assimilation, sea ice thickness, sea ice concentration, SMOS
Parallel Session

SCI-PS151.01 - Diagnosing subseasonal predictability of tropical anomalies

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An empirical modeling approach that can be used to make tropical forecasts and evaluate the processes contributing to and detracting from their predictability on subseasonal time scales is discussed. The model used, a "coupled" linear inverse model (CLIM) derived from observed simultaneous and time-lag correlation statistics of 5-day running mean anomalous SST, OLR, and 200 and 850 mb winds, has been run in near-realtime for the last few years, with forecasts available at http://www.cdc.noaa.gov/forecasts/clim. Its forecasts have skill that is comparable to CFS2. In general, geographical and temporal variations of forecast skill are quite similar between the LIM and CGCMs, making the much simpler CLIM a potentially useful forecast benchmark and also an attractive tool for assessing and diagnosing overall predictability the CFS2 and potentially other CGCMs. It is shown that certain initial conditions, derived from a singular vector analysis of the CLIM system propagator, result in both maximum anomaly amplification and greater realized forecast skill in both the CLIM and CFS2. Additionally, the eigenvectors of the system's dynamical evolution operator separate into two distinct, but nonorthogonal, subspaces: one governing the nearly uncoupled daily-to-subseasonal dynamics, and the other governing the strongly air-sea coupled longer-term dynamics. These subspaces arise naturally from the CLIM analysis; no bandpass frequency filtering is applied. A further analysis of which processes drive predictability on different time scales shows that maximum forecast skill occurs when initially destructive interference of anomalies from these two subspaces evolves to yield constructive interference.

Keywords: predictability, subseasonal prediction, tropics
Parallel Session

SCI-PS151.02 - Highlights from Project Minerva: Towards seamless high-resolution climate prediction

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We present here an introduction to and highlights from Project Minerva, an international collaboration between the Center for Ocean-Land-Atmosphere Studies (COLA) and the European Centre for Medium-Range Weather Forecasts (ECMWF) and a continuation of the highly successful Project Athena. Project Minerva represents an extensive series of integrations made using the ECMWF coupled Ensemble Prediction System in support of both centers’ ongoing efforts to understand and quantify predictability in the climate system from daily to interannual time scales. Building upon the results of Project Athena, we explore the impact of increased atmospheric resolution on model fidelity and prediction skill in a coupled, seamless framework as part of the NCAR Advanced Scientific Discovery program. Highlights to be presented include impact of resolution and ensemble size on skill in seasonal forecasts of tropical cyclone frequency and intensity, the NAO, the monsoon circulations, as well as the effect of resolution on ensemble mean bias and spread.

\textbf{Keywords:} Climate, High-resolution, Seamless, Coupled
Parallel Session

SCI-PS151.03 - Feasibility study of sub-seasonal prediction with an atmosphere-land-ocean-sea ice coupled model

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Many studies demonstrated that atmosphere-ocean coupled models have better ability in representing atmospheric features such as precipitation and winds in the tropics, monsoons and tropical intraseasonal oscillations. Meanwhile uncoupled (atmosphere-only) models are adopted for sub-seasonal prediction at some operational weather services including the Japan Meteorological Agency (JMA). This is because current coupled models are subject to model biases even in a short lead time. The problem of biases is a major stumbling block for introduction of coupled sub-seasonal prediction models. Introduction of ocean coupling is our challenge in development of a seamless operational prediction system. In this study, the feasibility of coupled sub-seasonal prediction is investigated with a new version of the JMA seasonal prediction system. Twin hindcast experiments with coupled and uncoupled models are carried out for over 30 years. Verification of the coupled model experiment shows some improvements of prediction skills mainly in the tropics (i.e., 850-hPa temperature, upper-tropospheric zonal winds) as well as some degradations in a short lead time compared to uncoupled model experiment. A model climate for precipitation and winds in the tropics is significantly improved with the ocean coupling. As a pragmatic approach, flux adjustments could alleviate model drifts to some extent, and reduce degradations related to the model drifts. Results of coupled predictions with the flux adjustments will be also discussed in the context of sub-seasonal forecasting.

\textbf{Keywords:} sub-seasonal prediction, coupled model
The NCEP GEFS has been setup to produce ensemble-based probabilistic forecasts beyond two weeks. A set of retrospective control forecasts has been generated for skill benchmark along with sets of forecasts from improved ensemble generation approaches. The control forecasts are based on the current operational GEFS, which has been optimized to represent both initial and model-related uncertainties but lacks both perturbations of the surface variables and coupling with the ocean. These two aspects have been reported to be important sources of prediction skill beyond two weeks. Despite these limitations, the skill of probabilistic prediction skill of the MJO signal in the control forecasts during the first two weeks is comparable or higher than that from coupled models. Furthermore, the skill of extratropical circulation correlates well with the MJO variability, suggesting that teleconnection responses to forcing in the tropical Pacific is to some degree adequately modeled. Forecast skill of time and space average atmospheric variables, particularly in the tropics tends to decay slowly beyond two weeks but systematic errors prevent useful predictions at medium and extended ranges. An approach to utilize available retrospective forecasts is implemented to reduce the systematic error. To enhance further the GEFS skill over the control, additional experiments were carried out such as increasing the ensemble membership by lagged ensemble combination, providing initial perturbations of the surface variables and experimenting with realistically evolving SSTs.


Keywords: Ensemble methods, Madden Julian oscillation, Systematic error correction, Probabilistic forecast evaluation
Parallel Session

SCI-PS152.01 - Met Office post-processing of operational NWP forecasts

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The Met Office Unified Model operationally produces a variety of deterministic and ensemble NWP products across a range of timescales, spatial domains, resolutions and ensemble sizes. A key issue is how we can best use these myriad NWP outputs in downstream products. In the Met Office, post-processing provides a key role in bridging the gap between upstream NWP model outputs and downstream customer-focused products. For several years this has been achieved by providing a single optimally blended forecast for 5,000 sites in the UK and another 5,000 over the globe, seamless over time to 15 days ahead and independent of underlying NWP model resolution and ensemble size. This serves to improve the model skill through statistical downscaling, bias correction and multi-model techniques utilising ensemble and deterministic NWP products from the Met Office and other forecasting centres. Additionally, upgrades to upstream models are decoupled from downstream products. We present the current and future outlook for post-processing in the Met Office, including the extension of these techniques to gridded diagnostics, seamless over time as well as space. These developments significantly simplify the implementation of downstream products and impacts-based models which can tap into this single source of optimally blended forecast data. Therefore complexity is reduced and efficiency increased for the production of quality automated forecasts.

\textbf{Keywords:} post-processing, downscaling, bias correction, blending
An operational prognostic system for forecasting of turbulence in the vicinity 20 airports in Norway has been developed by the Norwegian Meteorological Institute and SINTEF (Norwegian research foundation). The system is based on a multiscale nesting starting from forecasts by ECMWF (0.125 degrees resolution) as boundary conditions for the 2.5 km resolution operational NWP model Arome-Norway (a version of the non-hydrostatic HARMONIE model with AROME physics). The CFD model SIMRA is used in the inner nest and the forecast length is 18 hours 2 times per day. This model is based on Reynolds averaging techniques using a k-epsilon closure for the turbulence and has an average resolution of 100 m horizontally and a vertical resolution increasing gradually from 1 m close to the ground to about 200 m for the upper layer of the model. The forecasts are validated by traditional wind measurements supplemented by wind data derived from AMDAR observations from commercial aircraft. During 2013 high-frequency (8 Hz) measurements from flight data recorders (FDR) for selected time periods have been analyzed to estimate the turbulence using power spectra techniques. The forecasts of wind and turbulence are presented to the end users as 2D maps where the wind and turbulence intensity are interpolated onto a funnel shaped surface around the runway and the centerlines as used in the instrument landing system. Pilot reports are gathered and more than 80% of them say the forecasts are useful under turbulent conditions. The model setup, validation and general experience will be discussed.

Keywords: turbulence, forecasting, validation, CFD
Parallel Session

SCI-PS152.03 - Predictability of winter storm damages

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Classical meteorological warnings often suffer from the fact, that the relevance for users is not directly apparent, especially if users have limited experience with respect to the implications of severe weather on their enterprises. Impact based warnings might help improve the perception of weather warnings, offering information closer to a users decision and thus narrowing the gap between meteorological forecasts and the users information needs. However, when addressing the forecast of weather related impacts, uncertainties beyond meteorological forecast uncertainties arise from the impact modeling procedure itself, which is usually based on the statistical relation between certain meteorological predictors and historical impact records. In this contribution a probabilistic approach to model winter storm impacts on county scale is presented, which can serve as a basis for impact based warnings. The model is based on historical loss records on residential buildings provided by the German insurance association (Gesamtverband der Deutschen Versicherungswirtschaft e.V., GDV) and highly resolved meteorological reanalysis data. Logistic regression analysis is performed to derive a probabilistic relation between meteorological conditions and resulting impacts, which can in a second step be applied to derive probabilities for the occurrence of wind induced damages from meteorological forecast products. Special focus is given to the assessment of potential predictability, given a perfect meteorological forecast which is represented by the meteorological reanalysis at high spatial and temporal resolution. Furthermore the model is applied to re-forecasts of historical winter storm events using different lead times to assess the forecast skill dependent on forecast lead times.

Keywords: Impact, Predictability, Storm
SCI-PS152.04 - A forecasting system for snow and ice accretion on cable stay bridges and power lines

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Cable stay bridges are architecturally compelling and solve problems that traditionally designed bridges face. However cable stay bridges face challenges with snow and ice accretion on the cable stays in regions that are susceptible to freezing conditions. Snow and ice accretion has the potential to shed snow and ice in large cohesive pieces that pose a risk to vehicle and pedestrian traffic and ultimately may force closure of a bridge during an event. During Arctic outbreak events in the Vancouver area, warm westerly flows override a cold pool associated with low level easterly winds, creating wet snow precipitation, which can accumulate on power lines and cable stay bridges. High resolution forecasts with the Weather Research and Forecasting (WRF) model allow one to resolve the low level vertical wind shear, precipitation, and temperature profiles associated with these events at the bridge level and pylon heights, and also provide wet snow fraction data for snow accretion models. This paper summarizes an automatic forecasting system that uses an NWP ensemble approach to predict the type and rate of precipitation coupled with a cable stay accretion model to provide advanced notification of cable stay accretion and shedding events for cable stay bridges in northern climates. Similar models are applied to snow accretion on power lines as well. Technical, scientific and operational characteristics of the system as well as the results of preliminary model verification studies will be presented.

Keywords: WRF, Forecast, Snow, Accretion
Parallel Session

SCI-PS153.01 - What makes a good ensemble forecast?

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An ensemble forecast (a collection of point forecasts) can be put to use in several different ways. For example, it might be transformed into a single point forecast, it might be used to define a probability forecast, or it might be interpreted as a set of possible futures. An ensemble may perform well when used in one way but not when used in other ways and so our assessment of the performance of an ensemble prediction system should account for the different ways in which the forecasts will be used. With this in mind, we shall review some methods for assessing ensemble forecasts and consider the implications of failing to tailor our assessments appropriately. We shall pay special attention to assessing ensemble forecasts that are interpreted as sets of possible futures, the case for which recently introduced ‘fair’ performance measures are designed.

Keywords: ensembles, forecasting, verification
Ensemble forecasts are verified against observations as well as analyses with the aim to obtain new or additional views regarding the assessment of ensemble forecasts. Observations used here include radiosondes and satellite data such as the Advanced TIROS Sounding Unit (AMSU)-A, the Microwave Humidity Sounder (MHS), and the Advanced Scatterometer (ASCAT). Using ensemble predictions from the European Centre for Medium-Range Weather Forecasts (ECMWF), the spread-error relationship, or reliability, is diagnosed. The observation-based verifications are found to give contrary evaluation results to the analysis-based verifications. For example, in the verification of temperature at 700 hPa over the Northern Hemisphere, the over-dispersiveness seen in the verification against analyses is not seen in the verification against equivalent radiosonde and AMSU-A observations at short lead times (e.g. 1 day). Rather the ensemble is under-dispersive especially when the spread is large. In contrast, for 5-day forecasts, the relationship looks similar for the analysis- and observation-based verifications. This new observation-based assessment of ensemble reliability provides different views from those of the more traditional, analysis-based evaluations. It should become part of routine evaluation suites since analysis-based verification only may lead to wrong decision-making on future upgrades of ensemble systems.

**Keywords:** Ensemble Prediction System, Verification, Reliability, Observation
Parallel Session

SCI-PS153.03 - Verifying modelled currents using a threshold exceedance approach

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Categorical metrics are based on pre-defined thresholds, and measure the skill of a forecast system in predicting when given thresholds will be exceeded. This approach monitors the quality of operational products, giving increased quantitative information about these exceedance events and could be used to summarise the accuracy of some operational products in a convenient form. We focus our assessment on ocean currents, a parameter for which verification is generally less mature within the scientific community. We assess a number of European operational models which are made publically available through the European MyOcean² project. The routine verification performed by relatively simple metrics (e.g. bias or RMS errors), does not describe many important aspects of ocean current verification, such as the spatial accuracy of tidal flow, or the timing and intensity of strong current events. As a first attempt to address the simpler description given by biases or RMS errors, we apply a set of categorical metrics to explore what the model products tell us beyond the routine application of simpler metrics. We examine the validity and shortcomings of following categorical metrics for current verification: categorical bias; probability of detection (POD); false alarm rate (FAR); probability of false detection (PoFD); critical success index (CSI); equitable threat score (ETS); and extreme dependency score (EDS). We also apply the more sophisticated technique of multi-categorical thresholds and its value for ocean current verification.

Keywords: Categorical Metrics, Ocean Currents, Verification, Multi-category
Parallel Session

SCI-PS153.04 - Verification of the linguistic uncertainty of warning uncertainty

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Although operational severe weather warnings are still mainly issued as deterministic forecasts, we have knowledge about their uncertainty from forecasters experience as well as dynamical and statistical models. Here verification results for three uncertainty estimates will be compared: probability forecasts from global Model Output Statistics, numerical estimates by human forecasters and finally also their verbal description of uncertainty in regional warning reports. They reveal positive skill in the estimation of uncertainty of severe weather forecasts. Warnings are often not given as point and time specific forecasts. They are rather issued for an area and a time interval. Then the uncertainty of the warning at a particular point and time also includes spatial and temporal components. The plethora of terms used for the verbal description of the uncertainty of warnings in the warning reports can be divided into four groups: deterministic, "purely" probabilistic, spatial and temporal confinements. It turns out that the usage of the terms is different for different weather situations, e.g. rather deterministic for large scale events and probabilistic for smaller scale events. Furthermore, for each event there is an almost bimodal distribution of the numerical uncertainty estimates with a high usage of low and high probabilities but little use of medium values. These results are distinctively different from the results of a survey asking professional emergency respondents for the numerical interpretation of the terms “possible, likely and very likely”, which showed a wide spread of interpretations with a broad overlap in the middle range of 30-70%.

Keywords: verification, uncertainty, language
Parallel Session

UAS-PS315.01 - Social and behavioral influences on decision-making by emergency managers

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Decision-making under the stress of impending severe weather is complex, uncertain and often results in unpredictable outcomes. The ability to characterize and synthesize risk into emergency management (EM) processes is dependent on the knowledge of science experts successfully communicating with a dynamic community of emergency managers. It is an objective of the Weather Ready Nation to understand the human dynamics and not just the weather science, and a focus of this project is to integrate the social and physical sciences. Our team from Arizona State University, East Carolina University, the University of North Carolina, and the University of Oklahoma has been exploring the major influences on EM decisions in complex social networks. Through interviews, focus groups, and surveys, the team has identified numerous influences that can manifest themselves as a disruption of the risk connections. In addition, we were able to identify the most critical influences on the weather related decisions of EMs. Among the most important of those influences is confidence, which is manifested in various ways. We are particularly interested in the influences on the confidence of EMs to make decisions. This is built, in part, on the confidence exuded by the forecasters, but that is not the only factor. The importance of and influences on confidence were tested through surveys and interviews, the results of which led to the development of prototypes of both processes and products that were, in turn, tested with respect to potential effectiveness from the perspective of both EMs and forecasters.

Keywords: emergency managers, severe weather, influences on decisions, confidence
Parallel Session

UAS-PS315.02 - Psychological dimensions of risk perception and disaster preparedness for natural disasters in Canada

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The Canadian population is at an increased risk of significant loss due to extreme natural events, thus disaster preparedness is important to mitigate the impacts of natural disasters. This study showcases findings from a larger research program that aims to understand risk perception as a way to improve risk communication to enhance individual and collective preparedness through planning behaviours, sense of mastery, and community resilience. The present study examined the structure of psychological dimensions for natural disasters, risk perceptions, and preparedness actions. Data from a nationally representative survey of Canadians (n = 3,263) were analyzed. Responses to a series of statements regarding natural disaster risks and issues were subjected to exploratory and confirmatory factor analysis. The relationships amongst psychological dimensions, risk perceptions and preparedness actions were examined. Results showed that Canadians’ psychological dimensions for natural disasters could be explained by a 3-factor solution: a) Self-preparedness, b) Illusiveness of preparedness, and c) External responsibility for disaster management. Mean scores for psychological dimensions differed by socio-demographics. Each psychological dimension was associated with different perceived risk for environmental events – for instance, only external responsibility for disaster management positively related to perceived risk for major flooding. Each psychological dimension predicted different preparedness actions – notably, self-preparedness was the best predictor of preparedness response such as having an emergency supply kit. Findings highlight the importance of understanding psychological dimensions of risk perception so that interventions can aim to foster a sense of self-preparedness and actual behavioural response. Theoretical and practical implications will be discussed.

Keywords: Risk Perception, Psychological dimensions, Disaster preparedness, Natural disasters
Parallel Session

UAS-PS315.03 - Developing a valid scale of past experiences for tornado risks

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Hazardous weather, such as tornadoes, is common enough that it offers people opportunities to build reservoirs of experiences about the conditions and impacts of the event. Such experiences can be acquired directly by one’s personal participation in an event, or indirectly by learning about others’ experiences. People’s past experiences are important to understand because they can influence how people perceive and respond to future risks. Although past experience has been examined in many risk research studies, researchers have measured it in wide-ranging, inconsistent, and simple ways. Thus, key dimensions of past hazard experiences are not known nor is how they relate to one’s assessment of future risks. This presentation will discuss an effort to develop a valid scale of past experiences in the context of tornado risks. Initial items were developed to measure past tornado experience, and they were evaluated through a mixed-mode survey of the public who live in the tornado-prone central U.S. Open-ended survey questions elicited additional aspects of people’s past tornado experiences in their own words. This presentation will present the results from (a) the initial close-ended items, subjected to exploratory factor analysis to ascertain the latent factors, and (b) the qualitative data analysis, which will be used to develop and test additional experience items on a subsequent public survey. The relationship between past tornado experience and people’s tornado risk perceptions also will be discussed. Findings from this research have the potential to inform tornado risk communication, which could enhance people’s future decision-making and protective responses.

Keywords: past experience, risk perceptions, tornadoes
Parallel Session

UAS-PS315.04 - Perception and use of weather information in decision-making by members of the Canadian public

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Much of the existing research on the production and communication of weather information focuses on the way(s) that end-users obtain, interpret, and respond to severe weather alerts. In contrast, there has been much less research published on the way(s) that end-users perceive, comprehend, and utilize daily weather information. This paper presents the results of an exploratory study that examines Canadian residents’ preferences, perceptions, and usage of weather information. As part of this research project, semi-structured interviews (n=32) and close-ended questionnaires (n=268) were conducted to examine issues relating to general weather knowledge, weather salience, and trust in authority. In terms of general weather knowledge, it was found that most respondents were able to generally differentiate between a weather watch and a weather warning. Individuals who were unable to differentiate between these two products often attributed their misunderstanding to the similarity between the two terms—both in terms of linguistics and in context. It was also found that individuals obtain weather information both actively (i.e., when individuals seek information out themselves) and passively (i.e., when information is delivered to them). When asked how individuals would prefer to obtain weather information, a strong consensus emerged for automatically delivered information, particularly for weather watches and warnings. The results of this study suggest that many respondents were generally weather salient. This salience influenced whether and how individuals accessed weather information, as well as individuals’ general weather knowledge.

Keywords: Perception, Weather and society, Forecast preferences, Ontario
Parallel Session

UAS-PS316.01 - Dimensions of risk and uncertainty perception in severe weather forecasts and warnings

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This paper presents results of an online questionnaire study that involved a representative sample of the Berlin population (n=1500). The study aimed at ascertaining the cognitive, conative, and affective dimensions of dealing with risk and uncertainty in weather warnings in a large European metropolitan area. The study deals with the perception of risk and uncertainty in weather warnings, the way people make use of this information, and how values, emotions and prior experience influence the perception process. In addition, the influences of socio-economic and socio-demographic attributes are addressed. The topics discussed in the questionnaire are peoples' understanding and interpretation of probabilistic (numeric, verbal and graphical) information, their knowledge of and dealing with atmospheric hazards, their confidence in weather forecasts and their trust in public authorities. The questionnaire study is embedded in a broader interdisciplinary research project of the Hans-Ertel-Centre for Weather Research of Deutscher Wetterdienst at Freie Universität Berlin, Germany. Weather forecast communication in Germany is analyzed from two different user sides. In addition to the Berlin population survey, a study among the national emergency service community (Kox et al., submitted to Atmos. Res.) took place. Comparison of these two studies provides examples of experts versus laypersons discrepancy in perception of and dealing with atmospheric hazards and their predictive uncertainty.

Keywords: Uncertainty, Risk, Perception, Communication
Parallel Session

UAS-PS316.02 - Why forecasts fail: ensemble prediction, early warnings and the challenges of emergency management

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This paper explores why and how ensemble predictions used in the development of medium-term (4-15 days) weather forecasts and early warning systems might not necessarily deliver the promises of better adaptation strategies in the face of weather-related extreme events. Drawing on political sciences and francophone geography, the paper adopts an institutionalist framework within which the concept of distance serves to demonstrate why operational forecasters and emergency responders fail to engage with probabilistic forecasts and perhaps more importantly, to act upon them. The paper argues that while the emphasis put on the technical development of modelling capacities has been central to adaptation discourse and practices, this same technical appeal has hidden the wider practical and political dimensions involved in producing sets of institutional obstacles to the use of ensemble predictions for civil protection agencies. Finally, the paper concludes that while the general discourse of adaptation has favored investments in forecasting science aiming to support disaster risk reduction, it is argued that paying attention to the political factors underlying break-downs in the communication of probabilistic warnings should be acknowledged and known if promises of adaptation to extreme weather are meant to be realized.

Keywords: Europe, disaster risk reduction, ensemble predictions, civil protection
The United States has not experienced the landfall of a major hurricane, defined as category 3 or stronger on the Saffir-Simpson Hurricane Wind Scale, since 2005. Nevertheless, several other hurricanes and tropical storms have come ashore and resulted in major impacts in this country. Many of those impacts have been due to water, with storm surge causing extensive damages in coastal areas and freshwater floods extending well inland. Storm surge poses a greater threat for large loss of life in a single day than any other weather-related hazard, and prior to recent storm surge events including Ike 2008 and even Sandy 2012, the National Hurricane Center has been working toward new storm surge products and warnings. Following several years of effort, the National Weather Service is planning to introduce new products and warnings for storm surge during the next couple of years, in order to increase public understanding of, planning for, and response to the storm surge hazard. Such changes also present opportunities for existing tropical storm and hurricane watches and warnings to focus more clearly on the wind hazard.

**Keywords:** hurricane, storm surge, communication
Parallel Session

UAS-PS316.04 - Forecasting surface water flooding from intense summer convective storms using a convection-permitting ensemble

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Recent advances in convective-scale numerical weather prediction have enabled direct coupling of numerical weather forecasts with hazard impact models, especially flood models, offering the potential for a revolution in local hazard prediction. However, many obstacles need to be overcome if these new capabilities are to deliver the improved resilience that is needed by society. During the London Olympic and Paralympic Games in 2012 the Met Office trialled new capabilities that addressed three of these challenges: initialising convective scale weather features, predicting the uncertainty of the convective-scale weather, and post-processing ensemble forecasts to communicate the likelihood of intense precipitation likely to produce flooding. The presentation will briefly review the trial and its results and will identify areas that require further work.

Keywords: Ensemble, NWP, Convection, Flood
The drift of targets in search and rescue events can be simulated numerically using winds from numerical prediction models (NWPs) as forcings. While NWP forecasts have improved dramatically they are still subject to error, which is estimated by generating forecast ensembles depicting uncertainties due to observational error and model imperfections. Feeding these wind ensembles to drift models in turn produces ensembles of drift trajectories. Through the North American Ensemble Forecast System, ensembles of winds from the Canadian Meteorological Centre (CMC), the U. S. National Centers for Environmental Prediction, and the U. S. Navy's Fleet Numerical Meteorology and Oceanographic Center (FNMOC), are used as forcings to an implementation of the Canadian Search and Rescue Planning tool (a drift model) to produce ensembles of drift trajectories. These trajectories were assessed against the tracks of drifting buoys, with an initial focus on Canadian Arctic waters. Comparisons were made amongst trajectories forced by the winds of the global ensembles produced by the three centers, revealing some stark differences, particularly for the FNMOC winds. Experiments were also conducted comparing the trajectories obtained using winds from CMC's regional and global ensembles (the former available at higher spatial resolution and both available at higher temporal resolutions than winds from the other two centers) revealing much less dispersion in the regional forecasts. Currents can also play a significant role in the drift trajectories, and development underway to incorporate them into the drift model will be also be discussed, as well as potential future applications of this work.

**Keywords:** SAR, ensembles, NAEFS
Parallel Session

UAS-PS319.02 - Forecast-based Disaster Risk Management: A financial mechanism for climate-informed humanitarian action

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The IPCC Special Report on Extremes (SREX) recently confirmed that disaster risk is rising rapidly. For some disasters climate change is becoming an increasingly important factor. However, for near-term decisions on disaster risk management, information about long-term trends in extremes is non-specific and often not actionable. This talk discusses a pilot financing mechanism within the Red Cross Red Crescent Movement to disburse funding based on thresholds of climate and weather forecasts that are linked to disaster risk. This will enable humanitarian actors to systematically take action before a potential disaster, saving lives and livelihoods. Such a forecast-based system reduces the need for certainty in long-term climate projections, by enabling disaster managers to respond to a changing climate as it evolves. We will discuss the techniques used to link forecasts with disasters on timescales of hours to seasons, and the resulting operating procedures that are financed by this pilot mechanism.

Keywords: humanitarian, forecast, disaster risk, triggers
Parallel Session

UAS-PS319.03 - High resolution wildfires simulation, forecasting tools to estimate front evolution, fire induced weather and pollution

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Wildfire and meteorology are evolution tightly coupled. In areas where the risk is present, firefighters and goods in the forest/urban interface are exposed to immediate impact by the flames and fire induced weather with a larger number affected by smoke with adverse health effects. Uncertainties in the fuel(vegetal) description (distribution and composition), fire emissions and fire plume dynamics are important factors which substantially limit the capability of current models to predict these effects. The proposed approach focus on simulating the whole coupled/fire system at high resolution to help forecasting its impact (smoke plume and fire behavior) and assess risk of an on-going incident. It is decomposed into two tools that can be run coupled. A surface wildfire code that can simulate front dynamics in a very short simulation time (<60s for 1000Ha) and at a very high resolution (to take into account roads and fuel breaks). And a micro meteorological code (MesoNH) run with nested domains up to fire resolution (50m) at which the wildfire code injects heat and smoke tracers through sub-grid models, and receives surface wind that modifies the front dynamics. Currently tested as a reanalysis tool on specific cases, results shows qualitatively good agreement compared to large wildfire observations, and quantitatively good agreement with experimental instrumented field burn data. On-going and future work required to generalize the approach are the development of high resolution (100m), dynamical, fuel model that will leverage the advances made in surface models to estimate fuel moisture, load and composition.


Keywords: simulation, wildfire, coupled model, combustion
Parallel Session

UAS-PS319.04 - Providing meteorological services to the Canadian Armed Forces through network-based services

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Meteorological services are provided to the Canadian Armed Forces by the Canadian Forces Weather and Oceanographic Service (CFWOS), an organization that includes uniformed Meteorological Technicians and Meteorological Service of Canada (MSC) meteorologists and IT specialists. As society migrates to new means to access information, an internal support organization such as the CFWOS must also change how services are delivered, to remain relevant to military clients and to optimize the use of resources. There are two key thrusts being undertaken to modernize the use of intranet-based weather services to support the Canadian Armed Forces. The first is the use of network-based technologies to deliver verbal information, via videoconference, web cams, webinars, teleconference, VOIP and chat. Under a $26M capital project, the CFWOS organization has relocated its weather briefing and forecasting personnel to three main centres, and is making use of network-based technologies on existing departmental networks to enable verbal delivery of required weather support to command teams and tactical users. This project is to be complete in summer 2014. The second thrust revolves around improvements to self-serve intranet-based web services and data services. New initiatives in this area include improved flight planning tools for aircrew, OCG-compliant services (Open Geospatial Consortium standards), and numerical weather prediction datasets transferred directly to user decision support systems. This presentation will give an overview of the recent and planned activities in these two service areas.

Keywords: military, defense, internet, communication
As the international THORPEX program draws to a close at the end of 2014, three international legacy projects have been established: Polar Prediction Project (PPP), Subseasonal-to-Seasonal prediction (S2S), and High-Impact Weather (HIWeather). There will be several presentations on each of these legacy projects during the WWOSC. In the United States, a first planning meeting was held in Silver Spring, Maryland on June 5-6 2014 to introduce the legacy projects, and for participants to identify critical gaps, common scientific challenges and priorities in the context of these projects. The next stage in the US is to develop a coordinated community project plan that is linked with the three international projects. The purpose of this Town Hall is to engage the US community in a new program, to seek feedback on the path forward, and to welcome contributions from the community to the drafting of the project plan.

**Chair:** Sharanya Majumdar

**SCI-SPL03.01 – Panel Participant**

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WW-JPL04.01 - Science-practice interface: interrogating climate vulnerability, disaster reduction and urban resilience

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Keeping a balance between sound scientific analyses and producing socially relevant outcomes remains a key challenge in achieving efficient, effective science-practice interface. Based on the recent experiences of disaster management and climate risk management in Asian cities, this paper interrogates the relevant links between climate vulnerability, adaptation and urban resilience. More specifically, this paper explores how three components of climate science-practice interface, namely, salience, credibility and legitimacy, played out in the flood disasters of Metro Manila (2009, 2012, and 2013) and Bangkok (2011). The study suggests that climate risk management demands comprehensive and integrated solutions that emerged from trans-disciplinary, participatory, user-application oriented research and contextually-driven institutional needs/practices.

Keywords: Science Practice, Climate Vulnerability, Disaster Reduction, Urban Resilience

WW-JPL04.02 - Directions in mesoscale and convective scale prediction

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Please refer to the WMO website for presentations (if available) related to this panel
Parallel Session

SCI-PS154.01 - Representing inland water bodies and coastal areas in global numerical weather prediction: sensitivity and impact

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A representation of inland water bodies and coastal areas in NWP models is essential to simulate the large contrasts in albedo, roughness and heat storage associated with those surfaces and consequently the turbulent heat fluxes towards the atmosphere. A lake and shallow coastal waters parametrization scheme has been introduced in the ECMWF Integrated Forecasting System and its sensitivity and impact from regional to global scale are analysed. Results from fully coupled runs suggest that inland water bodies can (i) effectively regulate the amplitude of temperature diurnal cycle, (ii) produce a shift in the seasonal temperature evolution, and (iii) introduce an important source of tropospheric moisture. Those effects are shown to improve significantly the medium-range forecasts of near surface temperature and humidity.


Keywords: lakes, NWP
High-resolution analysis of land-surface fields, such as soil moisture, soil temperature and snow conditions has wide range of applications in environmental, agricultural, and hydrological studies, as well as in atmospheric modelling. The high-resolution Surface Prediction System (SPS), developed at Environment Canada (EC), has been employed to generate hourly surface analysis over a Canada-wide domain with a grid spacing of 2 km, for a five-year period 2008-2012. SPS is a two-layer offline surface model that uses a detailed representation of surface characteristics. It requires updates of atmospheric forcing at regular intervals. In this work, hourly atmospheric forcing is obtained from EC’s operational weather forecasts, whereas the six-hourly precipitation accumulations are readjusted to the Canadian Precipitation Analysis. Furthermore, optimal interpolation is employed to assimilate 2-m temperature and humidity observed hourly at land-based stations across Canada into the forcing fields. These fields are then used to drive a continuous SPS integration over the five-year period. In order to prevent potential accumulation of errors, a scale-selective relaxation of simulated soil moisture towards the operational regional analysis is implemented. For this purpose, a smoothing filter is applied on the difference between the regional analysis and SPS soil moisture. The filtered difference is then used to readjust the SPS fields. In this way large-scale SPS soil-moisture components are controlled by regional analysis, while allowing free development of fine-scale features. Based on the proposed approach, the outputs of SPS have higher resolution and outperform analysis in terms of bias and standard error, particularly for surface temperature.

**Keywords:** soil moisture, surface modelling, surface analysis
SCI-PS154.03 - Ensemble data assimilation to characterize surface-layer errors in numerical weather prediction models

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Experiments with the single-column implementation of the Weather Research and Forecasting Model provide a basis for deducing land–atmosphere coupling errors in the model. Coupling occurs both through heat and moisture fluxes through the land–atmosphere interface and roughness sublayer, and turbulent heat, moisture, and momentum fluxes through the atmospheric surface layer. This work primarily addresses the turbulent fluxes, which are parameterized following the Monin–Obukhov similarity theory applied to the atmospheric surface layer. By combining ensemble data assimilation and parameter estimation, the model error can be characterized. Ensemble data assimilation of 2-m temperature and water vapor mixing ratio, and 10-m wind components, forces the model to follow observations during a month-long simulation for a column over the Atmospheric Radiation Measurement (ARM) Central Facility near Lamont, Oklahoma. One-hour errors in predicted observations are systematically small but nonzero. Analysis increments for state elements nearby (15 m AGL) can be too small or have the wrong sign, indicating biased covariances and model error. Experiments using the ensemble filter to objectively estimate a parameter controlling the thermal land–atmosphere coupling show that the parameter adapts to offset the model errors, but that the errors cannot be eliminated. Results suggest either structural errors or further parametric errors that may be difficult to estimate. Experiments omitting atypical observations such as soil and flux measurements lead to qualitatively similar deductions, showing the potential for assimilating common observations as an inexpensive framework for deducing and isolating model errors.


Keywords: Land-atmosphere coupling, Ensemble data assimilation, Model error, Surface layer
Parallel Session

SCI-PS154.04 - A parameterization for land surface physical characteristics of burning areas for weather and climate models

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In weather and climate models, land surface models represent the land surface interactions with the atmosphere. The surface-atmosphere interactions have important impacts on atmospheric boundary layer dynamics and weather and climate variability. Therefore, accurately and timely presenting land surface physical characteristics in land surface models is essential. Wild fires can cause significant and rapid changes of land surface physical characteristics. This study proposes a parameterization for land surface physical characteristics of burning areas in land surface models. In this scheme, the changes of vegetation cover, the surface albedo and the surface roughness length caused by wild fires are considered. The parameterization was tested with the Wallow fire case. The preliminary results show that the parameterization can improve model performance.

Keywords: Parameterization, physical characteristics, burning area, model
Parallel Session

SCI-PS155.01 - The role of waves in air-sea interaction

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Ocean surface waves play a fundamentally important role in the transfer of energy and momentum between the ocean and the atmosphere. In the early 1990s, Janssen (1991) introduced the wave-age dependent surface stress for the lower atmospheric boundary condition by modifying the traditional Charnock relation (1955) by introducing the fraction of the wave stress to the total momentum flux from the atmosphere and introduce coupled atmosphere-wave models. Ocean circulation models are traditionally forced by either using the total surface calculated stress from the Charnock relation, or alternatively by calculating the surface stress from an empirical expression for the drag coefficient. Either way, all the momentum extracted from the atmosphere is then used to force the Eulerian ocean models locally. However, a significant fraction of the momentum flux is taken up by the ocean as wave momentum. Waves carry momentum as Stokes drift, a fundamentally Lagrangian property that cannot be correctly represented in an Eulerian frame of reference (Weber et al. 2006). Accordingly, the part of the momentum extracted from the atmosphere needs to be kept separate wave model. First when waves are breaking will the wave momentum become available for mean ocean currents (Saetra et al. 2007). In this way, the ocean waves may redistribute the momentum and energy in space and time before it can be used to force the ocean model. The presentation will present results from the EU-funded project MyWave, where a fully coupled atmosphere-wave-ocean model has been developed.


Keywords: Waves, Ocean, Atmosphere, Interaction
Parallel Session

SCI-PS155.02 – WITHDRAWN - Stochastic parametrization of wave breaking in wave-current interactions

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We propose a stochastic parametrization for wave breaking, introduced in a Lagrangian frame, to model the momentum, mass, and energy exchanges due to wave breaking on the large-scale spatio-temporal scales of waves and currents in the Eulerian frame. Moreover, we introduce a dynamic for white-capping events, consistent with their observed statistical distribution and energy. Consequences on the dispersion of passive oceanic tracers are also discussed.

Keywords: stochastic, wave breaking, currents, waves
Parallel Session

SCI-PS155.03 - Western Mediterranean Sea air-sea exchanges from the AROME-WMED model during the HyMeX campaign

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Intense air-sea exchanges play an important role during intense weather events in the Mediterranean Sea, especially in supplying heat and moisture for heavy precipitation that often affect the area. Observations collected during the first HyMeX Special Observation Period (SOP1) over the Western Mediterranean area in autumn 2012 provide a unique dataset for assessing the capabilities of numerical weather prediction systems in representing the air-sea interface and marine boundary layer before and during heavy precipitation events. A HyMeX-dedicated version of AROME covering the western Mediterranean Sea, named AROME-WMED, was evaluated through comparisons against moored and drifting buoys and ship measurements deployed for the HyMeX campaign. A generally good agreement is found for near-surface meteorological parameters. However, during strong air-sea exchanges, significant errors occur for air and sea temperatures. Main reasons are (i) SST which does not evolve during the forecast run; (ii) overestimation of heat fluxes in strong wind regimes with the AROME turbulent flux parametrization. Then, air-sea exchanges during the SOP1 were characterized thanks to the AROME-WMED short-range (0-24h) forecasts. The analyses show some spots of strong air-sea fluxes in the Gulf of Lion, and the Balearic, Ligurian and Tyrrhenian seas. The detailed study of the IOP13 heavy precipitation event shows that dynamic (wind) and thermodynamic (static stability) both contributed to intense air-sea fluxes. The role of wind in triggering and sustenance of these fluxes is described.

Keywords: air-sea exchanges, AROME-WMED, Western Mediterranean Sea, HyMeX
Parallel Session

SCI-PS155.04 - Regional coupled atmosphere ocean modelling in the North Sea region

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The validation and evolution of climate projections in the North Sea is one of the research tasks of the research programme KLIWAS of the German Federal Ministry of Transport, Building and Urban Development (BMVBS). Simulations of three coupled regional atmosphere-ocean models were made in co-operation with the Swedish Meteorological and Hydrological Institute, the Climate Service Centre and the Max Planck-Institute for Meteorology for both the North Sea and the Baltic for the time period of 1950 to 2100. The regional coupling results for present-day climate are compared to a new North Sea climatology. The KLIWAS projects adds coupled ocean simulations to the band-width of possible future climate conditions in the atmosphere as given by the ENSEMBLES project. While air and water temperature will rise to the year 2100, the mean wind speed does not show a significant trend, but large decadal variability. The frequency of wind directions from the western sector increases in the majority of the simulations and results in an increase of significant wave height in the eastern parts of the North Sea.

Keywords: coupled ocean atmosphere, regional climate modelling, North Sea, changed climate
Parallel Session

SCI-PS156.01 - Subseasonal to seasonal prediction: CPC operational outlooks and other applications

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The demand for subseasonal to seasonal (S2S) climate related information is growing exponentially with the need spanning many disciplines and sectoral lines from the energy, agriculture, water resource management and financial industries and for outlooks from Week-2 through the seasonal forecast time horizon. The suite of CPC operational outlooks spanning these time scales is presented and includes forecast launch schedules, product description, forecast process and available tools. Description of U.S. temperature and precipitation, hazards and drought outlooks are presented. A discussion of other S2S applications, perhaps not so obvious, is also presented along with CPC upcoming goals and plans to address gaps in the NWS operational product suite.

Keywords: Subseasonal, outlooks
Parallel Session

SCI-PS156.02 - Toward seamless prediction of severe weather activity

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Severe weather indices are functions of atmospheric parameters chosen to identify environments favorable to phenomena such as severe thunderstorms, hail and tornadoes. Typical ingredients in such indices include convective available potential energy and vertical wind shear. These indices are routinely applied to short-range weather forecasts to gauge the potential for severe weather events. Recently we have shown that a tornado index computed from observation-based monthly-averaged parameters from the North American Regional Reanalysis is able to capture aspects of monthly climatological and interannual variability present in the US tornado report database. Additionally we have found that when the index is computed with monthly-averaged forecast environmental parameters from the CFSv2, the index presents some predictive skill on continental and regional scales up to one month in advance. Our previous work has been limited to calendar month averaged quantities and was not able to address intermediate (a few days to a few weeks) lead-times and averaging-windows. In particular, the predictability of severe weather activity versus that of particular events has not been investigated. Here we examine those questions as well as verification issues using 6-hourly CFSv2 forecasts with lead-times of 0-45 days, focusing on forecasts and reports of severe weather during 2013

**Keywords:** tornado, hail, subseasonal
Parallel Session

SCI-PS156.03 - Monthly probabilistic drought forecasting in Europe and Africa using the ECMWF Ensemble system

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The Joint Research Centre's Climate Risk Management Unit is developing methods and tools for monitoring and forecasting extreme events (e.g., droughts & floods) and their impacts from regional to global scales. This work is embedded in the European Drought Observatory for drought monitoring and forecasting in Europe and in the development of similar methods and tools for Africa, Latin America and at the global level using the ensemble forecasting system from the ECMWF ensemble system. First, forecasted precipitation is used to predict meteorological drought using medium to long-range probabilistic forecasting (pentad to monthly) products. A set of forecasted standardized precipitation indices, based on more than 18 years of hindcasts, has been computed for the period 2008 to 2013. Then, these probabilistic products (hindcast and forecast) have been analysed to extract additional and useful information to predict meteorological drought, such as the exceedance probability of thresholds, quartile distribution, and ensemble spread. These results have been validated with the precipitation observed using ensemble scores. For specific areas, especially in Africa, associated with a strong sensitivity to drought and where models show difficulties to predict precipitation variability, atmospheric predictors have been identified and used to early detect meteorological droughts. These predictors based on temperature, geopotential height and humidity fields in the free troposphere, are generally related to the atmospheric synoptic components. These products have the advantage to be better represented in the model. This talk will present the methods, the implementations and the validation of forecasting methodologies for selected areas.

Keywords: probabilistic forecast systems, drought, precipitation forecasting, synoptic forcings
Sub-seasonal to Seasonal Predictability over Indonesia resulting from ENSO and the MJO provides an opportunity to inform cropping calendars in a dynamic way, conditional on the forecast. The maritime continent monsoon enables rice growers in west Java to plant and harvest two crops of rice, planting the first after monsoon onset in October–November, and the second in March–April. However the first crop is susceptible to flooding damage during the peak of the monsoon season in January–February, while the second crop is at serious risk of drought at the tail end of the rainy season in May–July. In particular, a delayed monsoon onset shifts the whole cropping sequence backward which increases the risk of drought in the second planting. Rainfall forecast information at sub-monthly to seasonal timescales has the potential to help farmers plan ahead, for example by anticipating a delayed onset, preparations can be made to accelerate planting. A statistical forecasting methodology for sub-seasonal to seasonal monsoon rainfall prediction is developed that combines together ENSO predictors based on antecedent Pacific SSTs, together with updates derived from the observed state of the MJO, using a cross-validated hindcast canonical correlation analysis approach. Verifications of hindcast skill suggest that the seasonal ENSO component provides the largest contribution to the anomaly correlation skill, although the MJO-based updates are found to add value in some areas. This forecast model is then tested in conjunction with cropping calendars for double-cropped rice in west Java, and maize in western Timor.

Keywords: sub-seasonal prediction, applications
Parallel Session

SCI-PS157.01 - Numerical Environmental Prediction, on the way towards more integrated forecasting of the Earth System

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Often considered as separate, individual components of the Earth system have achieved varying levels of maturity in terms of analysis, modeling, and forecasting. Including the atmosphere, land, oceans, cryosphere, as well as hydrology, urban modeling, and air quality, a complete and interdependent representation of the Earth system is still in its early phase, in spite of the considerable progress achieved in the last decade or so. Numerical Environment Prediction (NEP), as it is called, is getting closer to Numerical Weather Prediction (NWP) – its counterpart and predecessor, in terms of accuracy and operationalization. But running together a number of modeling and assimilation systems for the Earth system’s different elements is quite complex and challenging, especially when interactions between these elements are beyond quasi-independent one-way coupling, i.e., closer to full coupling between several or all of the sub models. Results from several studies emphasizing this type of models and systems integration will be presented at the conference. Focus will be placed on systems developed for implementation at Environment Canada with special attention given to land surface modeling and assimilation systems including the representation of urban areas. Examples of more complex coupling will be presented (e.g., between the land and atmospheric modeling / assimilation systems, in deterministic and ensemble modes). Other aspects will be touched upon, i.e., hydrology, lakes, sea-ice, in order to shed light on the overall positive and more challenging aspects of NEP, and to provide an outlook on the near future for this new generation of forecasting systems.

Keywords: Numerical Environmental Prediction, Earth system modeling, Coupled systems, Operational
Parallel Session

SCI-PS157.02 - UK Environmental Prediction – integration and evaluation at the convective scale

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It has long been understood that accurate prediction and warning of the impacts of severe weather requires an integrated approach to forecasting. This was well demonstrated in the UK throughout winter 2013/14 when an exceptional run of severe winter storms, often with damaging high winds and intense rainfall led to significant damage from the large waves and storm surge along coastlines, and from saturated soils, high river flows and significant flooding inland. The substantial impacts on individuals, businesses and infrastructure indicate a pressing need to understand better the value that might be delivered through more integrated environmental prediction. To address this need, the Met Office, NERC Centre for Ecology & Hydrology and NERC National Oceanography Centre have begun to develop the foundations of a coupled high resolution probabilistic forecast system for the UK at km-scale. This links together existing model components of the atmosphere, coastal ocean, land surface and hydrology. Our initial focus on a 2-year Prototype project will demonstrate the UK coupled prediction concept in research mode, including an analysis of the winter 2013/14 storms and its impacts. By linking science development to operational collaborations such as the UK Natural Hazards Partnership, we can ensure that science priorities are rooted in user requirements. This presentation will provide an overview of UK environmental prediction activities, in the context of the 2013/14 storms. We will present initial progress towards closer model integration and discuss the challenges to realise the potential of integrated regional coupled forecasting for improving predictions and applications.

Keywords: environmental prediction, regional coupled modelling, UK winter storms 2013/14
SCI-PS157.03 - The High-Resolution Rapid Refresh (HRRR): A maturation of frequently updating convection-allowing numerical weather prediction

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The High-Resolution Rapid Refresh (HRRR) is a 3-km convection-allowing weather forecast model designed to produce hourly-updated forecasts over the conterminous United States. The HRRR has evolved from a real-time experimental forecast product for aviation applications to a 2014 operational model implementation as part of the National Centers for Environmental Prediction (NCEP) production suite. In this presentation we will highlight recent developments in the HRRR data assimilation capabilities as well as improvements in the model physics and numerics. The HRRR assimilates observations using Gridpoint Statistical Interpolation (GSI) on several scales in space and time from sub-hourly storm-scale radar reflectivity observations to hourly satellite observations of clouds and other meso-to-synoptic scale data such as METARs, AMDARs and rawinsondes. The HRRR produces sub-hourly output out to 15 forecast hours using a recent version of the Advanced Research WRF model (WRF-ARW) with Thompson microphysics, Mellor-Yamada-Nakanishi-Niino boundary layer parameterization scheme and a nine-layer RUC-Smirnova Land Surface Model. Observed radar reflectivities are used as a proxy for model latent heating specification during a cycled pre-forecast hour with an emphasis on forcing observed convective structures from higher reflectivity regions for an accurate storm-scale analysis. The assimilation of surface observations are enhanced through special analysis features that promote retention of surface observations through the model boundary layer and reduce near-surface forecast biases through adjustments to the soil temperature and moisture. HRRR forecast improvements in 2014 will be documented for short-term forecast applications in the aviation, severe weather and renewable energy communities including both verification statistics and case-study examples.

Keywords: HRRR, Storm, Convection, Radar
The Japan Meteorological Agency (JMA) has been operating a convection-permitting regional NWP model (called the Local Forecast Model; LFM) to provide information on aviation operation and disaster risk reduction. The LFM covers Japan and its surrounding areas with a 2km horizontal grid spacing, and provides 9-hour forecasts. In order to update forecasts with the latest observations assimilated, hourly operations of the LFM are conducted, that requires high-speed computation, while the LFM has very large number of grid points (1581x1301x60). Some physical processes were modified from those of the coarser operational regional model with a 5 km horizontal grid spacing (called the Meso-Scale Model; MSM) in consideration of their dependency on resolutions. As examples, no convective parameterization is employed and the smaller PDF width of the fluctuation of the total water amount is adopted. Currently a new dynamical core named “ASUCA” has been developed to replace the present dynamical core of the LFM with. ASUCA is aiming at achieving higher forecast accuracy, improved computational stability and exact mass conservation. Flux-form fully compressible governing equations are adopted and discretized using the finite volume method to secure mass conservation. The flux limiter function proposed by Koren (1993) is employed to satisfy monotonicity and avoid numerical oscillations. The Runge-Kutta scheme suggested by Wicker and Skamarock (2002) is adopted for the time integration of the system. ASUCA and its program code are designed to be efficient on massive parallel scalar computing. We will present the details of the LFM and ASUCA.


Keywords: convective-permitting, operational model, dynamics, high resolution
Parallel Session

SCI-PS158.01 - Atmospheric data assimilation and predictability: a three-dimensional modal view

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Eigensolutions of the linearized primitive equations, known as normal modes, have been in use for almost forty years for the nonlinear normal-mode initialization for NWP and for identifying large-scale structure of the leading balanced and inertio-gravity (IG) modes in the atmosphere, especially in the Tropics. Over the past few years, the application of three-dimensionally orthogonal normal modes was developed for diagnostics of data assimilation systems and analysis datasets. The methodology allows a more complete physical interpretation of the balance which is particularly suitable for the tropics where the IG circulation dominates on all scales and where the short-range forecast errors are largest. This contribution would present results from operational NWP and idealized data assimilation and ensemble forecasting experiments to show some important characteristics of the global forecast errors. In particular, the ECMWF 4D-Var ensemble is characterized by around 50% of the global forecast-error variance in short range being unbalanced. Furthermore, the forecast-error variance growth between in short range range is substantially different in the balanced, eastward-propagating and westward-propagating IG modes. Results from the 4D-Var ensemble data assimilation are further complemented with the modal analysis of the ECMWF operational 50-member ensemble based on model-level data over 7-day range. Finally, results from the ECMWF system are contrasted with the outputs from a perfect-model ensemble data assimilation experiment which assimilated globally homogeneous observations of dynamical variables by using the ensemble adjustment Kalman filter in the Community Atmosphere Model (DART/CAM).


Keywords: three-dimensional normal modes, ensemble forecasting, inertio-gravity circulation, balance and predictability
 SCI-POS1050 - Use of ensembles to renew and improve adjoint-based adaptive observation strategies.

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Adaptive observation seeks to build an optimal frame for an observation network that accounts for the dynamical aspect of the atmosphere and for the data assimilation system. Most advanced techniques account for the dynamical aspects of the atmosphere and the data assimilation system. A forecast score variance is used to identify the sensitive areas at the assimilation time through an adjoint-based method. The adaptive observation method implemented at Météo-France is called the Kalman Filter Sensitivity (KFS). The first part of this study aims to assess the robustness of the method regarding trajectory errors and proposes a practical solution to deal with the trajectory uncertainties (Oger et al. 2011). To avoid high computational costs, a simplified framework is used. The experiments are performed with a two layer Quasi-Geostrophic model in an incremental 4D-var system. Numerical experiments show that the impact of additional observations depends equally on the suboptimal formulation of the DAS components and the trajectory errors. Then a new statistical tool for observation targeting called Variance Reduction Field (VRF) is introduced. The forecast score variance reduction is linked to a test probe assimilated for each model grid point. The VRF allows to compute the forecast score variance reduction that this probe would generate once assimilated. This method is implemented in a Lorenz 96 model. To compute these two fields, two approaches are proposed. The first one is based on a deterministic simulation. The second approach consists of using an ensemble data assimilation and prediction system.


Keywords: adaptative observation, ensemble, data assimilation, adjoint method
Parallel Session

SCI-PS158.03 - Ensemble estimation of background-error covariances using stochastic wind forcing: a coastal data assimilative twin experiment

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In this study, a Data Assimilative (DA) twin experiment is implemented with the aim to provide the “best” estimate of the coastal ocean state via ensemble methods. The work uses a coastal configuration of NEMO in the Bay of Biscay, following the activities of LEGOS/CNRS and Mercator Ocean teams within the European MyOcean2 project. In a first step, an ensemble of coastal ocean simulations in response to an ensemble of wind perturbations is carried out in order to represent ocean model uncertainties. Ensemble results and covariances are analyzed and interpreted as proxy errors in shelf, shelf break, and abyssal plain areas. Sensitivity experiments with several temporal sampling schemes are performed to enrich the model error directions for assimilation. The convergence of covariances is investigated as a function of the ensemble size. A second ensemble is generated, following the same stochastic protocol, with the aim to investigate the role of the age of errors. In a second step, an existing DA platform at Mercator Ocean is modified so that the background error covariances are estimated from the ensemble statistics. In the setup of the ensemble twin experiment, SST and SSH observations are simulated from a member later excluded from the ensemble used to derive covariances, with the help of a Talagrand diagram. With that protocol, we explore EnOI approaches and attempt to identify their limits with respect to a full EnKF implementation.

Keywords: ensemble, stochastic, assimilation, coastal
Parallel Session

SCI-PS158.04 - The consequences of neglecting the correlation of errors in radar data assimilation

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In radar data assimilation, optimal analyses are sought by minimizing a cost function in which the variance and correlation of background and observation errors are correctly represented. Radar observations are particular in that they are often available at spatial resolution comparable to that of background estimates. Because of computational constraints and lack of information on the nature of errors, misrepresenting the correlation of errors is unavoidable. In this study, we characterize the impact of such misrepresentations in an idealized framework where the spatial correlations of background and observation errors are both set to homogeneous exponential decay. We then compare analyses obtained with perfect representation of correlations to others obtained by neglecting correlations altogether. These two sets of analyses are examined from a theoretical and a computational perspective. We show that if the spatial correlations of background and observation errors are similar, then the errors made by neglecting correlations may be small. We suggest that the sampling noise, related to the accuracy with which analysis errors may be estimated on a given domain, be used as a criterion for determining when the correlations of errors may be neglected with little impact on the quality of analyses. These results suggest that the computational costs of radar data assimilation could be reduced by neglecting the correlations of errors in areas where dense radar observations are available.

Keywords: Data assimilation, Error correlations, exponential correlations, error misrepresentation
Parallel Session

SCI-PS159.01 - Assimilation of atmospheric constituents: highlights from MACC-II/Copernicus

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While the first papers on assimilation of atmospheric constituents’ data appeared about two decades ago, the topic is still in its infancy compared to the situation in Numerical Weather Prediction (NWP). This situation arises from a number of causes, among which: the relative paucity of the Global Observing System for atmospheric composition; the complexity and computational burden associated with “chemical” assimilation and modelling tools; specific challenges with atmospheric composition processes, models and observations... Another element compared to NWP was the essential lack of operational applications, which very effectively stimulate research. With the Copernicus programme in Europe, significant progress has been made over recent years through a series of projects leading to the current MACC-II (Monitoring Atmospheric Composition and Climate – Interim Implementation) one. MACC-II combines state-of-the-art atmospheric modelling with observations to provide pre-operational information services covering air quality, global tropospheric and stratospheric atmospheric composition, climate forcings, and UV and solar energy. MACC-II uses a wide array of satellite and in-situ data, observing both meteorological and atmospheric composition variables, to provide a best estimate of the state of the atmosphere on a daily basis. These analyses used as initial conditions for 5-day global forecasts of atmospheric composition and 4-day European air quality forecasts. This presentation will present highlights from the experience gained with the assimilation of satellite and in-situ (surface and profile) data, covering greenhouse gases, aerosol and reactive gases, at the global and the regional scale. Current challenges in atmospheric composition data assimilation will be illustrated.


Keywords: data assimilation, atmospheric composition, Copernicus
SCI-PS159.02 - Data assimilation of trace gases in a chemical transport model: the impact on model forecasts.

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Chemical Transport Models (CTMs) provide 3D fields of trace gases concentration and are commonly used for air-quality forecasting. The model uncertainty depends on the chemical species and its lifetime. Short-lived tracers, like NO2, are highly dependent on the quality of emissions inventories, whereas longer-lived gases, such as CO, are also sensitive to uncertainties in the model initial condition and to transport errors. Data assimilation permits to account for the overall model uncertainty, but its impact on the forecast skills still depends on the lifetime of the species and on the frequency of assimilated observations. We present results from VALENTINA, a variational data assimilation suite for the Météo France CTM MOCAGE. The system allows the assimilation of satellite and surface observations on global or regional domains and is currently employed for the MACC-II European air-quality analyses. We consider the assimilation of satellite and in-situ observations of principal gaseous pollutants such as ozone (O3), carbon monoxide (CO) and nitrogen dioxide (NO2) over Europe. Satellite tropospheric products are issued from IASI and OMI sensors on-board MetOp and Aura satellites and surface data are obtained from the European AIRBASE air-quality network. The variable controlled by data assimilation is the 3D concentration of gases. A summer/winter case in 2010/2012 is examined and validation with independent datasets is discussed. The results provide insights about the capabilities of chemical data assimilation to improve air-quality fields and forecasts in an operational context, using multiple sets of observations and for species with large differences in lifetime.

Keywords: chemical data assimilation, air-quality, troposphere, forecast skills
SCI-PS159.03 - Assimilation of surface chemical species observations into the Canadian GEM-MACH model using optimal interpolation

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Improving air quality short-term forecasts is important to provide better warning to exposed population. In this study, assimilation of surface observations of air quality has been performed into the GEM-MACH Canadian air quality model using a modified interpolation scheme to produce the objective analyses of ozone, nitrogen dioxide and fine particulate matter (PM2.5). Successful assimilation of objective analyses has been achieved and was found to significantly reduce the error of the air quality forecast from the GEM-MACH model (version 3.3.8, i.e. current operational version). Verification with independent observations show that for both summer and winter, longer live species such as ozone and sulfates when they are assimilated has more benefit on the forecast than short live species (such as NO2, nitrates and ammonium particles). Most critical issues related to surface assimilation of air quality including getting the right horizontal and vertical correlation length for data assimilation, determining the most appropriate bias correction scheme for the analysis and estimating the right partitioning in the case of PM2.5 will be also discussed. Some unresolved issue include the chemical shock phenomena when related tracers are assimilated (i.e. when only ozone is assimilated, it puts off balance nitrogen dioxide).


Keywords: assimilation, air quality, chemical species, GEM-MACH
Parallel Session

SCI-PS159.04 - Global CO data assimilation for emissions and trends analysis

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Atmospheric carbon monoxide (CO) is an important trace gas in tropospheric chemistry. As a dominant sink for OH, CO concentrations can modify the oxidizing capacity of the atmosphere. It is also a major precursor of tropospheric ozone in clean environment and thus has an impact on air quality at the hemispheric scale. Sources of CO come from direct emissions from anthropogenic combustion, biomass burning and wildfires or secondary formation from Non Methane Volatile Organic Compounds (NMVOC) oxidation. From 2000, a large suite of satellite observations (MOPITT, AIRS, TES, IASI) allows the monitoring of tropospheric CO concentrations. These measurements show a global decreasing trends and a strong inter-annual variability due to biomass burning emissions, climate, and socioeconomic factors. We will investigate the potential of data assimilation to constrain emissions using an Ensemble Adjustment Kalman Filter coupled to the global Community Atmospheric Model (CAM-Chem). A first step will consists in the evaluation of the MOPITT CO assimilation results regarding the set-up of the data assimilation system. As a second step, the impact of using an ensemble-based emissions flux adjustment from the MOPITT analysis will be examined. Finally, we will check the consistency between the different observations data set for the purpose of their synergistic use in the data assimilation algorithm.

Keywords: Atmospheric chemistry, Data assimilation, Satellite observations, Air quality
Parallel Session

SCI-PS160.01 - Filling gaps in the observation network for thermodynamic profiling by a ground-based microwave radiometer network

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Atmospheric boundary layer processes strongly influence the local weather conditions but are difficult to capture from satellite and in-situ sensors. With numerical weather prediction (NWP) moving towards finer resolution, the more favorable geometry of ground-based remote sensing is well suited to provide the relevant atmospheric quantities with sufficient vertical resolution. Microwave radiometry is particularly suited for continuous thermodynamic profiling, i.e. temperature and humidity, also under cloudy conditions. Temperature profiling based on elevation scanning provides high accuracy profiles with best vertical resolution close to the ground and has shown potential for monitoring of mixing layer height. In addition, cloud liquid water path can be retrieved, which is important for precipitation formation and the radiation budget. Rapid technological development within the last decade brought forward a generation of commercially available microwave radiometers (MWR) that can operate continuously with high temporal resolution under nearly all weather conditions except precipitation. Today, 100+ MWR are operated worldwide by different institutions and several weather services started to setup networks. However, up to now no international standards for operation have been established. In order to connect the various MWR users an International Microwave Radiometer network (MWRnet) was established in 2009 by the EG-CLIMET COST Action. It facilitates the exchange of information to ultimately establish an operational network sharing knowledge, software, procedures, formats, and quality control. New observational modes like spatial mapping of water vapor and clouds are explored. The follow-up COST Action TOPROF also fosters data assimilation into NWP models.

Keywords: thermodynamic profiling, microwave radiometer, observation network
SCI-PS160.02 - Volume scanning microwave radiometry for convection forecasting

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We cannot properly initialize models at the mesoscale with accurate temperature and humidity fields as there exists a gap in our instrumentation suite: no operational instrument can provide measurements or constraints on low-level thermodynamic fields at scales of value to permit accurate 0-3 hr forecasts of severe weather. Furthermore, we show that proposed approaches to use ground-based profiling instruments every 100-150 km cannot meet our accuracy needs. Here, we propose the use of a ground-based volume-scanning microwave radiometer to provide some of those constraints on temperature and humidity. Using an OSSE-based framework, we show how a ground-based narrowbeam scanning microwave radiometer can help diminish the uncertainty on temperature and humidity fields up to mesoscale ranges. Also, some of the characteristics of such an instrument are presented.


Keywords: mesoscale, instrumentation
Parallel Session

SCI-PS160.03 - Next generation airborne polarimetric doppler weather radar

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Understanding climate processes and high impact weather has become one of the top scientific challenges for the atmospheric scientific community. This concern led to extensive research focused on the evolution of kinematic and microphysical structures in storms often located in remote regions over land and/or ocean. One of the key mobile instruments used to sample these systems is airborne Doppler radar to obtain concurrently high temporal and spatial resolution measurements of 3-D winds. Recently, ground-based phased array radar (PAR) demonstrated the high time resolution estimation of accurate Doppler velocity and reflectivity of precipitation and clouds when compared to conventional, mechanically scanning radars. PAR uses electronic scanning (e-scan) to rapidly collect radar measurements which is critical for airborne applications. More importantly, PAR enables the dual-polarization capability not currently available in airborne tail Doppler radars. Hence, a PAR mounted on an airborne platform with dual-polarization capability has the potential for significantly advancing the science of understanding climate processes and high impact weather. This paper presents the proposed configuration of a novel Airborne Phased Array Radar (APAR) to be developed at the NCAR Earth Observing Laboratory and installed on the NSF/NCAR C-130 aircraft. This APAR design can be duplicated for other C-130 aircraft (e.g., US Air Force Hurricane Hunters) and enhance both the climate and weather research in addition to monitoring high impact weather.

Keywords: Airborne, Polarimetric, Doppler, Radar
Parallel Session

SCI-PS160.04 - Strategic importance of FarIR Data for forecasting cold airmass formation in the Polar Vortex

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During Polar night, the establishment of extremely cold airmasses normally takes place over periods of about 2 weeks, well in the range of medium range forecasting. Improving physical processes at that scale is essential for extending weather forecasts and climate simulations. The A-Train satellites and a decade of measurements at PEARL, Eureka, NU, have given us the opportunities to assess the role of polar clouds and aerosols in controlling the atmospheric water budget and the radiation balance. During the Polar night, radiation from extensive thin ice clouds (TIC) in the High Arctic are a very effective diabatic cooling agent thought the whole troposphere. Far IR radiation is controlled by the molecular water vapour rotation modes which collapse rapidly below temperatures around -40°C typical of the Polar and the upper troposphere regions, forming the so-called “dirty-window”. Most of the cooling process takes place in the far IR (15 to 50µm), just beyond the current operationally observed domain of current satellite instruments. To fill this critical observation gap, with INO we are developing a new multispectral radiometer covering most of the thermal and far IR ranges and suitable for monitoring radiation, cloud microphysics of TICs, light precipitation (diamond dust) and water balance in the low concentrations typical of cold airmasses. In this paper, we will review the current status of the Thin Ice Cloud in Far IR Experiment (TICFIRE), a microsatellite mission at CSA dedicated to improve our observation system of the cold Polar vortex and the upper troposphere.


Keywords: Monitoring, Polar vortex, Thin ice clouds, FarIR satellite
Parallel Session

SCI-PS161.01 - Radiative-convective instability and tropical weather and climate prediction

Kerry Emanuel
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We show that above a critical specified sea surface temperature, ordinary radiative-moist-convective equilibrium (RCE) state becomes linearly unstable to large-scale overturning circulations. The instability migrates the RCE state toward one of the two stable equilibria first found by Raymond and Zeng [2000]. It occurs when the clear sky infrared opacity of the lower troposphere becomes so large, owing to high water vapor concentration, that variations of the radiative cooling of the lower troposphere are governed principally by variations in upper tropospheric water vapor. We show that the instability represents a subcritical bifurcation of the ordinary RCE state, leading to either a dry state with large-scale descent, or to a moist state with mean ascent; these states may be accessed by finite amplitude perturbations to ordinary RCE in the subcritical state, or spontaneously in the supercritical state. As first suggested by Raymond [2000] and by Sobel et al. [2007], the latter corresponds to the phenomenon of self-aggregation of moist convection, taking the form of cloud clusters or tropical cyclones. We argue that the non-robustness of self-aggregation in cloud system resolving models may be an artifact of running such models close to the critical temperature for instability. We also show that direct coupling of deep convective downdrafts to enhanced surface fluxes is strongly desirable for numerical simulation and prediction of clustered convection, including the genesis of tropical cyclones, and that cloud-radiation interactions can dominate the physics of mature clusters.

Keywords: Convection, Climate, Self-aggregation, tropical cyclones
Discussions of tropical cyclones (TCs) in relation to climate have typically assumed that TC activity does not feed back upon the climate. However, recent research suggests that TCs may play a significant role in atmospheric meridional heat transport given the strong correlation between aggregate TC activity and meridional heat transport during the following winter. Building upon prior research, the present study seeks to advance our understanding of the potential role of TCs in aggregate transport of atmospheric energy by quantifying whether the upper-tropospheric outflow of TCs is responsible for transporting significant quantities of total energy (i.e., sum of kinetic energy, latent energy, potential energy, and sensible heat) in the upper troposphere from the Northern Hemisphere (NH) tropics into the Southern Hemisphere tropics during the peak of NH TC season. Storm-relative composites of western North Pacific TCs reveal that the upper-tropospheric outflow jet of the TC is responsible for significant southward total energy transport at the equator primarily in the form of dry static energy (i.e., sum of potential energy and sensible heat). Zonal integration of the meridional total energy transport anomalies over a global domain indicates that the contribution of the TC is dominant at the equator, yielding southward energy transport anomalies of $-0.5$ PW. For comparison, climatological meridional energy transport is approximately $-1.0$ to $-2.0$ PW at the equator during the peak of TC season (i.e., late summer and early fall), suggesting that TCs temporarily enhance climatological southward energy transport at the equator.

**Keywords:** tropical cyclones, energy transport, cross-equatorial, climate
Parallel Session

SCI-PS161.03 - The sensitivity of hurricane frequency to ITCZ changes and radiatively forced warming in aquaplanet simulations

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The response of hurricane frequency to climate changes in an aquaplanet configuration of a 50-km resolution atmospheric general circulation model is examined. The lower boundary condition is an energetically consistent slab ocean with a prescribed cross-equatorial ocean heat flux, which breaks the hemispheric symmetry and moves the Intertropical Convergence Zone (ITCZ) off the equator. In this idealized configuration, hurricane frequency increases in response to radiatively forced warming. The ITCZ shifts poleward when the model is warmed with fixed cross-equatorial ocean heat flux, and it is argued that the increase in hurricane frequency results from this poleward shift. Varying the imposed cross-equatorial ocean heat flux amplitude with fixed radiative forcing can isolate the effect of ITCZ shifts. If an increase in radiative forcing is accompanied by a reduction in the ocean heat flux amplitude such that the position of the ITCZ is unchanged, the simulated hurricane frequency decreases under warmed conditions

\textbf{Keywords:} tropical cyclone, climate change
Parallel Session

SCI-PS161.04 - Tropical cyclone intensity probability prediction in a changing climate: A multiple-linear regression modeling approach

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As climate changes, the environmental conditions that influence the formation and evolution of Tropical Cyclones (TCs) are expected to change. Although the potential influence of climate change on TCs has been the subject of number of recent studies, it is still difficult to confidently assess the magnitude of future changes in storm intensity. One of the reason is that the present climate models are too coarse to adequately capture the storm structure and therefore to model the storm intensification. Here we explore this issue with a statistical approach. Although climate models themselves fail to accurately simulate storm intensity, previous studies using the SHIPS have shown that a multiple-linear regression (MLR) model with predictors from the GFS, in addition to those from storm persistence and from climatology, is capable of predicting storm intensity with some skill. Hence, our first step is to develop a MLR with only essential predictors calculated from global reanalysis and NHC best-track data. Monthly and daily NCEP reanalysis data from 1981 to 2012 are used here. Seven predictors are selected which represent storm persistence, potential intensity (PI), vertical shear, etc. The performance of the MLR using varying numbers of predictors is tested. We found that monthly data from global models with only the most essential predictor, the difference between storm intensity and PI, might be sufficient for us to understand the response of hurricane intensity to a changing climate from a statistical perspective. Further, a probabilistic intensity prediction from this simple MLR will also be presented.

Keywords: tropical cyclone intensity probability prediction, climate change, statistical approach
Parallel Session

SCI-PS162.01 - Chemistry in the ECMWF integrated forecast system: Model performance and future perspectives

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In the framework of the Copernicus Atmospheric Service, MACC (Monitoring Atmospheric Composition and Climate) provides routine forecasts of atmospheric composition on a global scale. These are based on chemistry and aerosol modules which are integral parts of the ECMWF Integrated Forecast System, referred to as Composition-IFS (C-IFS). Three different chemical mechanisms are being integrated in C-IFS. The current C-IFS version for tropospheric chemistry is based on a modified version of the Carbon Bond mechanism (CB05). As tropospheric chemistry is an integral part of the IFS, this allows for an optimal application of meteorology in various parameterizations, such as wet scavenging, lightning emissions and boundary layer mixing. The gas-phase chemistry also benefits from the availability of aerosol composition in IFS, through modifications to photolysis rates and heterogeneous reactions. This all implies a good ability of C-IFS to capture many aspects of the variability in tropospheric composition, from diurnal to seasonal time scales. Trace gases such as ozone, hydroxide and aerosol precursors will progressively be used by other IFS subsystems. The modified CB05 tropospheric chemistry is currently expanded with stratospheric chemistry. Interfaces to tools for easy generation of the adjoint code and for exchange of chemical mechanisms will be developed. In this contribution we give an overview of the current status of the model, its performance, and development plans for the near future. We compare C-IFS hindcast simulations to a range of observations and to other state-of-the-art chemistry transport models, which documents the good quality of the new model system.

Keywords: tropospheric Chemistry, MACC, aerosol
Parallel Session

SCI-PS162.03 - Impact of emission schemes on online air quality modelling

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The Met Office carries out a 5-day air quality (AQ) forecast for the UK using the Air Quality in the Unified Model (AQUM) configuration of the MetUM. This modelling system is operated with a 12 km horizontal resolution grid covering much of Western Europe. The representation of chemistry processes in AQUM is done within the United Kingdom Chemistry and Aerosols (UKCA) sub-model of the MetUM. UKCA was initially developed for climate-chemistry studies at the global scale and uses a representation of emissions which lacks the flexibility needed for regional AQ modelling. In the current operational AQ forecast, anthropogenic emissions of each gas-phase species are input to the model as a single 2-dimensional monthly varying field. This set-up includes the use of rather simplistic vertical profiles and temporal emission factors. A more comprehensive system has been developed which can handle emissions from different source sectors independently. This allows the use of realistic vertical and temporal profiles to be applied separately according to the emission sector. In particular, recommendations by EMEP and previous calculations by the SMOKE-EU plume-rise model have been tested for the vertical disaggregation of emissions. Furthermore, temporal emission factors based on calculations by TNO have been implemented to account for hour of the day and day of week. We will present results from this new emission framework. The impact on surface concentrations of pollutants is moderate, but there are improvements in some verification metrics as well as in the model’s ability to simulate diurnal cycles, in particular for ozone.

Keywords: online air quality modelling, emissions
Parallel Session

SCI-PS162.04 - Long-term changes in extreme air pollution meteorology and implications for air quality

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Climate change can significantly affect air pollution meteorology. Of particular concern is the changes in extreme meteorological events (such as heat waves, temperature inversion, atmospheric stagnation and lightning) that have important implications for air quality and public health. We analyze the observed long-term changes in air pollution meteorology based on global datasets for the past decades (ca. 1950-2010) to examine the possible trends in the context of global climate change. Global models are combined with statistical analysis in this study to interpret the identified trends in extreme air pollution meteorology and examine their implications for atmospheric composition and air quality.

Keywords: Air Pollution Meteorology, Climate Change, Extreme Events
The question of predictability arises from the growth of small perturbations within non-linear systems. Atmospheric processes are constantly perturbed by external factors to which they are coupled limiting their intrinsic predictability ("Predictability of Atmospheric State"). NWP forecasts are affected by uncertainties in the representation of atmospheric processes as well as in initial and boundary conditions. Thus, models have their inherent limits to predictability ("Predictability of Model State"). Finally, we evaluate model forecast skill by comparison to observations of the atmospheric state and this defines the "Model Predictability of Atmospheric State". Here we limit ourselves to predictability of precipitation using the US radar mosaic and NWP data generated at Oklahoma University. At the core of our studies is the scale dependence of predictability. Predictability of Atmospheric State can be studied theoretically for very simple systems only. We view precipitation patterns as Deterministic Chaos and we establish that their geometry has the properties of a strange attractor on which predictability can be studied from observations only. This provides a baseline to which models must be compared. Predictability of Model State is studied by determining the scales and the lead times at which the differences between ensemble members become random. Scale dependence of Model Predictability of Atmospheric State is determined by comparison of model prediction and radar data in three different manners: by considering radar observations as an additional member of the ensemble, by using the commonly used skill measurements and by determining the phase distance between model and radar in Fourier space.

**Keywords:** Precipitation, Predictability, Radar data, Numerical models

Isztar Zawadzki\(^1\), Madalina Surcel\(^1\), Aitor Atencia\(^1\)

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Parallel Session

SCI-PS163.02 - Synergetic use of multi-sensor data sets for improved nowcasting of severe convective weather events

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Severe weather associated with deep convection poses a significant threat to life, property and economy. Hence, the detailed knowledge of the occurrence of thunderstorms is important. A better understanding of the underlying thermodynamic process of thunderstorm development may improve forecasting of such events. A synergetic multi-sensor approach is needed to fully observe, understand and hence predict convective weather events. The nowcasting of severe convective events remains a challenging endeavour that suffers from relatively low skill and high false alarm rates. A Lagrangian analysis of precipitation cells combining geostationary satellite, ground-based lightning and radar observations is performed to understand and characterize the mean time evolution of convective systems. This also enables the identification of cell parameters that have predictive skill for nowcasting. Interesting characteristics are seen in the analysis: e.g. decreasing effective radius along with increasing cloud optical thickness is a precursor of further electrification and increasing flash rate; strong trends of lightning rates, so called lightning jumps, are more often followed by high reflectivity and thus an increased chance of hail. The formation of (severe) convective weather events depends on a variety of processes. While fast processes on the mesoscale are generally associated with the impact itself, it is the synoptical situation, associated with slow processes that create the environment for such events. Thus, analyses of the relation of cell characteristics (observation-based) to synoptical conditions (model-based) are performed. These analyses may help to assess the potential of including model data into nowcasting applications as well as improve forecaster’s situational awareness.

Keywords: nowcasting, severe weather, convection
Parallel Session

SCI-PS163.03 - The decorrelation scale: methodology and application for precipitation forecasts

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The methodology of Surcel et al. (2013) is extended to investigate the scale dependence of the predictability of precipitation patterns at the mesoscale. By applying it to two or more precipitation fields, either modeled or observed, a decorrelation scale \( \lambda_0 \) can be defined such that all smaller scales are fully decorrelated. For precipitation forecasts from a radar-data-assimilating Storm-Scale Ensemble Forecasting system, \( \lambda_0 \) is found to increase with lead-time, reaching 300km after 30 hours. That is, for \( \lambda \leq \lambda_0 \) the ensemble members are fully decorrelated, and, hence there is no predictability intrinsic to this ensemble. For \( \lambda > \lambda_0 \), the ensemble members are correlated, indicating some predictability by the ensemble. When applied to characterize the practical predictability by Numerical Weather Prediction (NWP), Lagrangian persistence and Eulerian persistence with respect to radar observations, \( \lambda_0 \) increases with lead-time for most forecasting methods, while it is constant (300 km) for non-radar data assimilating NWP. Comparing the different forecasting models, it is found that they are similar in the 0-6h range, and that none of them exhibit any practical predictability at meso-\( \gamma \) and meso-\( \beta \) scales after the first two hours. On the other hand, the radar-data assimilating ensemble exhibits some intrinsic predictability at these scale, showing that sources of error that impact significantly precipitation predictability at meso-\( \beta \) scales are not accounted for in the construction of this ensemble.


Keywords: precipitation, ensemble forecasting, predictability, radar
Parallel Session

SCI-PS163.04 - Continental Heavy Rainfall Predictability : the THORPEX West Africa case study

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The West African THORPEX case concerns a wet spell that crossed the whole African Sahel during the last decade of August and first decade of September 2009, marked with heavy precipitation leading to floods in many Sahelian countries (Niger, Senegal, Mauritania, Gambia, etc). The event that occurred in Burkina Faso on September 1st has been the most extreme. In ten hours, Ouagadougou, the capital city, recorded 261 mm from a quasi–stationary mesoscale convective system (MCS) leading 150 000 affected people (on 1.5 million people) with 9 death and loss of properties and damaged roads. This extreme event has been analyzed following different complementary approaches. First a forecaster exercise has been replayed using the WASA/F forecasting method and the Synergie forecasting system, to assess the degree of anticipation that forecasters can reach with the present NWP products and their experience. This step allowed a better understanding of this extreme event and to propose a conceptual model. Then we analyzed the skill of NWP (deterministic and probabilistic) global models, showing their ability to predict this event with a two-day lead time. A further modeling study at high resolution (4 km) with the French AROME operational model allowed a better forecast of this event both in term of intensity and location, up to three days in advance. Sensitivity tests and application of different diagnostics (tracking, budgets...) are underway to assess the predictability and to better understand the occurrence of such extreme events over West Africa

Keywords: high-impact weather system, west african easterly waves, precipitable water, precipitability
Parallel Session

SCI-PS164.01 - Cryospheric Observations for Weather Prediction, Atmospheric Reanalyses and Climate Research

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Accurate and consistent cryospheric observations are needed to address problems ranging from local surface heat fluxes to forecasting the evolution of synoptic scale weather systems to understanding impacts of global warming. For example, high-latitude storm development in winter is strongly influenced by sharp temperature gradients along the boundary between sea ice and open ocean waters; information on sea ice conditions is hence critical for operational numerical weather prediction systems and atmospheric reanalyses. Satellite records of ice extent provide for evaluation of hindcasts from global climate models which bear on the veracity of changes projected for the future. The observed downward trend in Arctic sea ice extent and thickness is one of the key drivers of the outsized rise in surface and lower tropospheric temperatures over the Arctic compared to the rest of the globe, and there is evidence, albeit controversial, that this warming is influencing mid-latitudes weather patterns. These are just a few examples pointing to the need to monitor the cryosphere, develop improved observational methodologies, and enhance the quality of and access to existing data. Key challenges include providing temporally consistent records of sea ice extent, concentration and thickness, and reliable estimates of snow depth and its water equivalent across the land surfaces of both hemispheres as well as over sea ice. Station records suffer greatly in being scattered amongst numerous archives and in inconsistent formats. This talk will review some of these cryospheric data needs and challenges.

Keywords: Cryosphere, Observations, Weather Prediction
SCl-PS164.02 - Issues in the dynamical seasonal prediction of the Arctic sea ice

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Arctic sea ice, and its influence on climate variability, has received increasing attention during the last decade. Currently, seasonal prediction of the Arctic sea ice is mostly produced with statistical methods. A few operational centers have recently implemented dynamical sea ice component in the coupled atmosphere-ocean forecast systems for seasonal climate prediction. Yet various issues remain to be resolved for an improved prediction of seasonal sea ice variations. In this study, we discuss issues in the seasonal prediction of the Arctic sea ice from the NCEP Climate Forecast System version 2 (CFSv2), which may also exist in other operational forecast systems. We address factors that affect the prediction of sea ice trend and interannual variability, and its verification. The analysis will be based on retrospective and real-time 9-month forecasts from the CFSv2. We will assess the overall performance of the CFSv2 in capturing the observed sea ice extent climatology, long-term trend, and interannual anomalies. Aspects to be discussed include: (1) the consistency of the initialization of the observed sea ice concentration, (2) impact of surface heat fluxes related to atmospheric model physics, (3) bias in sea surface temperatures, (4) impact of initial sea ice thickness, and (5) dependence of the verification on the observational estimate.

Keywords: Seasonal prediction, Arctic sea ice, Operational, Climate
Parallel Session

SCI-PS164.03 - Will Arctic sea ice thickness initialisation improve the skill of coupled forecasts?

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A number of recent studies have suggested that Arctic sea ice thickness is an important predictor of Arctic sea ice extent. However, coupled initialised forecast systems do not currently assimilate sea ice thickness, both as a result of poor observational coverage and the inability of current data assimilation techniques to deal with the positive definite nature of this variable. As part of the Arctic Predictability and Prediction On Seasonal-to-Inter-annual TimE scales (APPOSITE) project a set of idealised ensemble prediction experiments with the Met Office Hadley Centre’s HadGEM1.2 model have been run. In this setup the initial state of all prognostic variables, including sea ice thickness, is known perfectly and ensembles are generated by adding a small white noise perturbation to the sea surface temperature field. To investigate the importance of sea ice thickness initialisation a second set of ensemble prediction experiments have been run. The initial conditions in this set are identical to the first, except that the sea ice thickness is set to the start day’s model climatology everywhere, but with sea ice concentration and snow cover left unchanged. The forecast set with perturbed sea ice thickness has much larger errors in predicting pan-Arctic sea ice extent for the first year and a half of the forecast. This indicates that sea ice prediction systems will significantly improve with the inclusion of sea ice thickness initialisation. The impact of thickness perturbations on forecast skill in the mid-latitudes will also be discussed.

Keywords: Predictability, sea ice, Arctic
Parallel Session

SCI-PS164.04 - Advances in seasonal forecasting of the Arctic ocean, sea ice and biogeochemistry with CNRM-CM

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¹CNRM-GAME Météo-France CNRS, Toulouse, France, ²IC3, Barcelona, Spain, ³Mercator-Océan, Ramonville-Saint Agne, France, ⁴IPSL-LSCE, Gif-sur-Yvette, France, ⁵IPSL-LOCEAN, Paris, France

The predictive capabilities of CNRM-CM5.1 (Météo-France/Cerfacs) in seasonal forecasting of the Arctic sea ice will be shown with a focus on regional skill during the winter. In spite of a coarse horizontal resolution (~50km), the system exhibits some significant skill in predicting March sea ice anomalies in the different marginal ice zones. The system is especially successful in shaping the sea ice edge in the Barents sea, but provides also useful information in other areas (e.g. the Bering Sea). The skill of these regional hindcasts will be compared to that performed with EC-Earth(v2.3), using a different initialization technique and a different sea ice model. Such predictions not only could be useful for operational needs, but also provide evidences of the role played by coupled air-ice-sea processes and ocean initialization in Arctic sea ice predictability. Future developments planned by Météo-France, CNRM-GAME and partners (including IC3, IPSL and Mercator-Océan) to improve coupled model predictions in the Arctic and perform integrated ocean-sea ice-biogeochemistry seasonal forecasts will also be presented. These developments include increases in horizontal and vertical ocean resolutions, new air-ice and air-sea formulations of turbulent fluxes, a new snow scheme over sea ice, an improved ocean-sea ice initialization and the coupling with the marine biogeochemistry.


Keywords: seasonal forecasting, coupled climate model, Arctic ocean, sea ice
Parallel Session

SCI-PS165.01 - Severe weather prediction and analysis at ECMWF - recent developments and future challenges

Timothy Hewson

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Timely warning of severe weather is a fundamental task for national meteorological services. For this reason ECMWF strives to provide reliable, accurate model guidance, in ensemble and deterministic format, for a wide range of meteorological hazards. Part of the ECMWF strategy is to use 20 years of re-forecasts, always performed with the latest model version, and compare with those in order to assess the rarity of forecast events. The "Extreme Forecast Index" and the "Shift Of Tails" are two related non-dimensional measures provided as products. In many cases event rarity relates directly to impacts, because in all countries the weather resilience of infrastructure is designed, directly or indirectly, around the return period concept, and so these products provide a very useful input to warning systems. Cyclones are also the 'cause' of many severe weather events, and with this in mind ECMWF provides also cyclone tracking products to users. This wide-ranging presentation will look at different aspects of severe weather, such as windstorms, extreme rainfall, summer convection, and freezing rain, using the EFI, SOT, cyclone tracking and direct model output to illustrate. Examples will also show what some of our weaknesses are, and how new developments (relating to CAPE and freezing rain, for example) are addressing those weaknesses. Reference will be made to the difficult area of verification, and also to how severe weather products could be extended to the 1-month timescale. Re-forecast issues will also be discussed, as will plans to expand the re-forecast dataset later this year.

Keywords: Severe weather, Forecast Products, Cyclones, Ensembles
Parallel Session

SCI-PS165.02 - Ensemble storm surge forecasting in the UK during the exceptional 2013/14 winter storm season

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The overtopping of flood defences by coastal storm surges presents a significant threat to life and property. Storm surge forecasting aims to provide advance warning of dangerous events, so that protective action can be taken. Storm surge forecasts are highly sensitive to errors in the meteorological forecast and so are ideally suited to an ensemble forecasting approach. Often the uncertainty in the forecast is particularly high in situations with the potential for a large surge event, so it is important to take account of uncertainty when assessing potential flooding events. The Met Office storm surge ensemble forecasting system uses the CS3X Storm Surge model developed by the National Oceanography Centre, coupled to the Met Office MOGREPS-G and MOGREPS-15 ensemble weather forecast systems. It runs out to 7 days to provide an assessment of surge levels and overtopping risk around the UK coastline. This presentation will focus on the performance of the surge ensemble during the 2013/14 winter, which brought an exceptional run of deep lows across the UK, leading to unprecedented level of surge activity in NW Europe, and significant impacts from several events. The 5th December storm generated a major North Sea storm surge, which threatened the UK’s East coast in a similar manner to the catastrophic 1953 event. The use of the forecasts in the decision-making process by the Flood Forecasting Centre and the Environment Agency will be discussed, including how the guidance provided by the surge ensemble helped to prepare for, and mitigate impacts, in each event.

Keywords: ensemble, storm surge
Parallel Session

SCI-PS165.03 - Towards improving the predictability of atmospheric rivers impacting coastal British Columbia

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³University of British Columbia, Vancouver, Canada, ⁴Environment Canada, Montreal, Canada

Characterised by narrow bands of high water vapour transport from the tropics and subtropics, Atmospheric Rivers (AR) pose significant challenges for forecasters in many parts of the world. Such events can have particularly severe impacts on coastal British Columbia (BC). A brief historical analysis of AR over BC is given to offer context and understanding for the prediction of intensity, timing and location of these events. We investigate predictability at time scales of hours to days to years to illustrate the challenges of forecasting AR events in this region. Beyond predictability, communicating the associated uncertainty to emergency users is hugely important. Recommendations are made to help offer guidance to these users and thus help mitigate the impacts of these heavy rain events.

Keywords: Atmospheric Rivers, Predictability, British Columbia
Parallel Session

SCI-PS165.04 - Nowcasting (with MAPLE) and stationary precipitation patterns associated with large lakes and mountains

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The Weather Network in Canada provides radar-based six hour nowcasts for Canada and the USA on their web site, based on extrapolation of radar imagery using a version of MAPLE (the McGill Algorithm for Precipitation Nowcasting by Lagrangian Extrapolation). Our goal has been to see over what lead time, under various circumstances, nowcasting procedures give reliable results for Canadian locations near the Great Lakes or the Rocky Mountains. In these areas there are often mesoscale features such as lake effect snowsqualls or orographic precipitation in upslope flows which persist in approximately the same location. The current operational version of MAPLE tends to advect them away and forecast reliability is poor. We are evaluating and testing ways in which these nowcasts can be improved through better determination of advection velocities on the meso-scale and by a better understanding of the role of lake and orographic effects. Careful adjustment of some of the adjustable parameters used within MAPLE may improve the performance, and we are attempting to develop methods which can handle such features. Our work so far has focused on winter snowsqualls but we aim to extend this work to summer precipitation events, both in the Great Lakes area and also in areas near the Rocky Mountains where orographic effects can lead to stationary precipitation patterns.

Keywords: Nowcasting, Radar
UAS-PA403 - Panel Discussion

Understanding, reducing and preventing losses from weather-related events: Insurance, finance and disaster risk management perspectives

Against a backdrop of rising economic costs associated with hydrometeorological-related disaster events, members of the insurance and finance sector have been working closely with the risk management, atmospheric science and weather service communities to better understand, reduce and prevent losses. Panelists will discuss current approaches, lessons learned from recent experience, and areas where new or expanded research, development and services are required.

Chair: Rowan Douglas

UAS-PA403.01 - Panel Participant

Jan Eichner¹

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UAS-PA403.02 - Panel Participant – Unable to participate in Panel on site

Rob Wesseling¹

¹ The Soverign General Insurance Company and The Co-operators, Guelph, Canada

UAS-PA403.03 - Assessing alternative rebuilding scenarios in the wake of Superstorm Sandy using GIS and remote sensing

Judd Schechtman¹, Yasser Altayyar², David Bernat³, Adam Davidson⁴

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Hurricane Sandy's massive destruction, as well as the impacts from other recent storms, have shifted public discussion about climate change from the theoretical to the practical. Responses to the storm, including from NY Governor Cuomo, have acknowledged the impacts of climate change and suggested that rebuilding communities in the same vulnerable locations may not be wise policy. This paper develops methods to predict and analyze redevelopment scenarios in coastal flood hazard locations, to provide better information about the long term benefits of policies that support retreat. Based on hypothetical land-use schemes in the wake of Hurricane Sandy, we estimate potential losses from future storms in a number of projected climate change scenarios. We establish potential planning trajectories developed from land use databases (MAPLUTO), and estimate losses under these scenarios by using HAZUS software developed by the US Federal Emergency Management Agency. We then consider how this can be replicated and enhanced with remotely sensed databases such as Ikonos (sub-building scale satellite imagery), and GeoEye to monitor urban footprint and structural details to better assess flooding potential. Furthermore, we use this imagery to provide internal interpolation of HAZUS census blocks. We pilot the rebuilding scenarios for specific New York City coastal neighborhoods on Staten Island. We expect to find that strategic retreat will reduce damage and loss of life in future storms. Results will assist cities and towns worldwide in improving planning to reduce damage and casualties from coastal flooding.

Keywords: Rebuilding, Coastal Flooding, Remote Sensing, Reducing Risk
UAS-PA404 - Panel Discussion

The WWRP - HIWeather Project

The High Impact Weather (HIWeather) project is one of three activities being initiated and managed through the World Weather Research Program (WWRP) to extend and refocus the research and development carried out through the Thorpex Program. WWOSC provides an excellent opportunity to raise awareness and engage a wide range of expertise in the scoping, design and implementation of the project. Panelists will inform participants about the rationale and current status of the project, leading into an open forum and dialogue with the audience to discuss priority research and application areas

Chair: Brian Mills

UAS-PA404.01 – Panel Participant

  Sarah Jones¹

  ¹DWD, Offenbach, Germany

UAS-PA404.02 – Panel Participant

  Brian Golding¹

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Please refer to mywwosc14 conference website and on line APP for updates to abstracts for panel sessions
SCI-PS166.01 - The convection-permitting ensemble COSMO-DE-EPS: From development to applications

Susanne Theis\textsuperscript{1}, Christoph Gebhardt\textsuperscript{1}, Michael Buchhold\textsuperscript{1}

\textsuperscript{1}DWD, Offenbach, Germany

When using limited-area NWP models, operational weather forecasting has reached a model grid length of 1-3 kilometers. These models are convection-permitting, allowing for explicit simulations on the convective scale. On the one hand, this improves the representation of processes which lead to severe weather. On the other hand, it poses a challenge to deterministic predictability, because smaller scales usually possess shorter life cycles and faster error growth. The simulations contain a larger degree of randomness which can offset the benefits due to the finer grid length if uncertainties are not addressed explicitly. So there is a strong motivation to run convection-permitting models in ensemble mode. At Deutscher Wetterdienst (German Weather Service, DWD) the convection-permitting ensemble COSMO-DE-EPS has been operational since 2012. In analogy to the deterministic run of the model COSMO-DE, the ensemble COSMO-DE-EPS has a 3-hourly update cycle with forecasts up to 27 hours on a 2.8 km grid covering Germany and surrounding areas. The ensemble comprises 20 members with variations in initial and boundary conditions and in model physics. COSMO-DE-EPS is now discovered by an increasing number of applications: DWD weather warnings, flood alerts by environmental agencies, storm surge warnings, Frankfurt airport management, renewable energy business (wind and photovoltaic). The step towards applications usually requires communication between users and developers, the design of specific products and visualization tools, and statistical post-processing of the ensemble. This talk will present the setup of COSMO-DE-EPS and illustrate some applications.

Keywords: numerical weather prediction, ensemble prediction, limited-area model, convective scale
Parallel Session

SCI-PS166.02 - Performance of the WWRP project FROST-2014 forecasting systems: Preliminary assessments

Dmitry Kiktev\textsuperscript{1}, Elena Astakhova\textsuperscript{1}, Anatoly Muravyev\textsuperscript{1}, Michael Tsyrulnikov\textsuperscript{1}

\textsuperscript{1}Hydrometcentre of Russia, Moscow, Russia

FROST (Forecast and Research in the Olympic Sochi Testbed) - 2014 is the World Weather Research Program (WWRP) project aimed at development, implementation, and demonstration of capabilities and use of modern short-range numerical weather prediction (NWP) and nowcasting systems in mountainous winter environment. Quite few systematic trials of multiple high-resolution forecasting systems in mountains are known so far due to the lack of appropriate observations and coordinated forecasting activities. In this respect the Olympic Sochi testbed is a valuable opportunity for research of mesoscale predictability and development of forecasting over complex terrain. An extended observational network including about forty automatic meteorological stations, dual polarization Doppler radar, wind and temperature profilers, micro-rain radars and high-resolution upper air sounding was established in the region of Sochi. International mesoscale modeling consortia COSMO and HIRLAM/ALADIN, the Central Institute for Meteorology and Geodynamics (Austria), the Environment Canada, the Finnish Meteorological Institute, the National Oceanic and Atmospheric Administration (USA) and the Korea Meteorological Administration provided forecast input for the project. Model-based, radar tracking and combined nowcasting systems took part in the trial. Several deterministic NWP-models were implemented with spacing of about 1 km and finer. Ensemble project component was presented by six systems including ones with convection permitting ensembles. Data assimilation of local observations was implemented by some participants. A kind of super-ensemble was tried. Preliminary assessments of the FROST-2014 forecasting systems performance are presented. Synergetic effect of the project components and its practical outcomes are considered.

**Keywords:** mesoscale modeling, nowcasting, verification, field campaign
SCI-PS166.03 - The prediction of extratropical storm tracks in East Asia by the NCEP Ensemble Prediction Systems

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Extratropical cyclones are important synoptic disturbances that are related to the day-to-day weather. The accuracy in predicting their tracks can have direct impact on local weather along their paths. An objective feature tracking methodology to identify and track the cyclones has been used to study the prediction of extratropical storm tracks in East Asia by the National Center for Environmental Prediction (NCEP) Global Ensemble Forecast System (GEFS), with storm tracks data provided by NCEP. Only the cyclones generated from inland are taken into account. This research discusses the control forecasts, ensemble mean forecasts and ensemble spread from aspects of cyclones' position and intensity errors. The statistical results show that the along-track error contributes more to the position error than the cross-track error. The intensity of cyclones is over predicted. The predictive skills of the best ensemble members are significantly higher than that of the control forecast. The ensemble mean forecasts demonstrate a higher level of skills than the control forecasts as well, especially for the intensity of the cyclones from day 3 and on. The difference between the ensemble mean error and spread is small for the position of the cyclones. For the intensity, the ensemble spread is less than the ensemble mean error, which may indicate the members are under dispersive.


Keywords: mid latitude regions, extratropical storm tracks, ensemble prediction, verification
Parallel Session

SCI-PS166.04 - Overview of the marine environmental observation, prediction and response network

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The Canadian Network of Centers of Excellence programme recently funded the Marine Environmental Observation Prediction and Response (MEOPAR) network to improve Canada’s ability to manage and respond to risk in the marine environment. MEOPAR is funded for five years and brings together researchers from across Canada. One of MEOPAR’s research themes is working to improve the ability of government agencies and the private sector to respond to existing and emerging marine hazards on time scales of hours to seasons. Integrated observation and prediction systems are being developed to monitor and forecast extreme events such as strong winter storms and associated storm surges, wave activity, and the movement of marine pollutants. This presentation will overview the ongoing and planned development of a relocatable coupled atmosphere-ocean forecast system and illustrate with results for the east coast of Canada. Particular attention will be paid to the development of downscaling capabilities and the assimilation of local observations into high resolution ocean models.

Keywords: Coupled atmosphere-ocean models, Marine environment, Marine hazards and risk, Downscaling and data assimilation
Parallel Session

SCI-PS167.01 - Ensemble forecast sensitivity to observations: applications for proactive quality control

Eugenia Kalnay\textsuperscript{1}, Daisuke Hotta\textsuperscript{2,3}, Yoichiro Ota\textsuperscript{4,3}, Guo-Yuan Lien\textsuperscript{1}, Takemasa Miyoshi\textsuperscript{1,5}
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A new formulation of the Ensemble Forecast Sensitivity to Observations (EFSO, Kalnay et al., Tellus, 2012) is more accurate and efficient than the original ensemble sensitivity formulation of Liu and Kalnay, (QJRMS, 2008), and can be applied to the EnSRF used in the NCEP hybrid. Ota et al. (2013, Tellus) applied EFSO to the GFS coupled with the operational EnSRF used at NCEP, and assimilated all the observations used operationally during one month, after one week of spin-up. A new type of “Proactive QC” was introduced, using EFSO to identify observations that have a large negative impact in the 24 hr regional forecast. An example of large negative impact of MODIS high latitude winds detected with EFSO showed that running the system again without these MODI winds improved the forecast as predicted by EFSO. More recently we have shown that the Proactive QC works as well detecting these bad observations in the 6 hr forecast as in the 24 hr, and the results are not sensitive to the analysis used for verification, making Proactive QC feasible for operational use. EFSO has also been used to evaluate the impact of the 6hr averaged precipitation in the GFS. EFSO provides guidance on which type of precipitation observation should be assimilated. This application indicates that EFSO can also be used for more efficient developing and testing algorithms and the impacts on the forecasts for new types of observing systems.

\textbf{Keywords:} Ensemble Forecast, Quality Control
Parallel Session

SCI-PS167.02 - Estimating observation impact in a convective-scale localized ensemble transform Kalman filter

Matthias Sommer\textsuperscript{1}, Martin Weissmann\textsuperscript{1}

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In operational weather forecasting, knowledge about observation impact, i.e. the contribution of specific observations to forecast error reduction, is crucial to refine the observing and data assimilation system. However, assessing this quantity by direct computation (data denial experiments) is usually not feasible because of the high computational cost. This has motivated the derivation of approximated forms of observation impact. If an adjoint model is available, established methods exist that give a reliable estimate. On the other hand, in an ensemble-based environment, a recently developed algorithm \cite{Kalnay2012} uses the analysis and forecast deviations to approximate observation impact. This has now for the first time been implemented in the convective-scale limited-area model COSMO and has been thoroughly verified with data-denial experiments \cite{Sommer2014}. It has been found that the difference to data denial is not significant (less than 10\%) and accuracy can be expected to improve further when considering longer test periods. The peculiarities for an application on this scale include a strongly non-linear behavior and a typically small localization length. While the former can be expected to be reasonably addressed by the ensemble algorithm, the latter imposes constraints for a reasonable choice of lead time. It could also be shown that valuable information, such as the detection of disadvantageous observations can be gained. This presentation shows the feasibility and distinctive features of the method for a convective-scale setup, gives examples from a pre-operational application at Deutscher Wetterdienst, and discusses the sensitivity to lead time, localization and verification norm.


Keywords: Observation impact, Ensemble transform Kalman filter
Parallel Session

SCI-PS167.03 - Evaluation of observation impact and observation error covariance retuning

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In numerical weather prediction the value of a particular observing system can be assessed in terms of its impact upon both atmospheric analyses and forecasts. Understanding this impact allows the data assimilation and forecasting system to be optimised to make the best use of the available observations. Observation impacts have often been evaluated through observing system experiments (OSEs), in which a control analysis using all observations is compared to an analysis where the observations of interest are excluded from the assimilation. While running OSEs in a systematic way for all observations is computationally very expensive, it provides a useful measure of the relative contribution of various observing systems. In addition to OSEs, the adjoint-based forecast sensitivity to observations approach is an effective tool for assessing the value of observations in reducing the forecast error. At ECMWF, a global dry energy norm is used as the measure of forecast error. The adjoint approach has been also used to diagnose the forecast sensitivity with respect to the specification of the observation and background error covariances. An observation error variance tuning exercise and subsequent forecast observation impact is here presented for conventional and satellite data assimilated at ECMWF.

Keywords: observation impact, forecast impact, covariance tuning
Parallel Session

SCI-PS167.04 - Estimation of forecast sensitivity to observations within KIAPS-LETKF data assimilation system

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We have attempted to estimate forecast sensitivity to observations (FSO) within KIAPS-LETKF system using the method introduced by Kalnay et al. (2012) which has been applied to NCEP GFS-EnSRF data assimilation system by Ota et al. (2013). Ota et al. (2013) has shown promising results of 24-hour Ensemble Forecast Sensitivity to Observation (EFSO) with real conventional data. Within KIAPS-LETKF data assimilation system that has been successfully implemented to NCAR CAM-SE model, we have examined a performance of estimating EFSO for several forecast times. In addition, we have investigated a new method to define the localization for estimating observation impact in the case of forecast time from 24 hours up, using OSSEs with Lorenz 40-variable model and NCAR CAM-SE model. New localization method can change the localization scale depending on a moving distance of the center of localization function. Impact of different localization strategies on the results of EFSO will be presented at the workshop.


Keywords: Ensemble Forecast Sensitivity to Observations, Local Ensemble Transform Kalman Filter, localization function, various forecast lead time
Parallel Session

SCI-PS168.01 - The GOES-R Geostationary Lightning Mapper (GLM) and the Global Observing System for total lightning

Steven Goodman1, Richard Blakeslee2, William Koshak2, Dennis Buechler3, Lawrence Carey3,
Douglas Mach4, Monte Bateman4, Harold Peterson4, Eugene McCaul4, Scott Rudlosky5
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The Geostationary Operational Environmental Satellite (GOES-R) series provides the continuity for the existing GOES system currently operating over the Western Hemisphere. New and improved instrument technology will support expanded detection of environmental phenomena, resulting in more timely and accurate forecasts and warnings. Advancements over current GOES include a new capability for total lightning detection (cloud and cloud-to-ground flashes) from the Geostationary Lightning Mapper (GLM), and improved temporal, spatial, and spectral resolution for the next generation Advanced Baseline Imager (ABI). The GLM will map total lightning continuously day and night with near-uniform spatial resolution of 8 km with a product latency of less than 20 sec over the Americas and adjacent oceanic regions. This will aid in forecasting severe storms and tornado activity, and convective weather impacts on aviation safety and efficiency among a number of potential applications. The GLM will help address the National Weather Service requirement for total lightning observations globally to support warning decision-making and forecast services. Science and application development along with pre-operational product demonstrations and evaluations at NWS national centers, forecast offices, and NOAA testbeds will prepare the forecasters to use GLM as soon as possible after the planned launch and check-out of GOES-R in 2016. New applications will use GLM alone, in combination with the ABI, or integrated (fused) with other available tools (weather radar and ground strike networks, nowcasting systems, mesoscale analysis, and numerical weather prediction models) in the hands of the forecaster responsible for issuing more timely and accurate forecasts and warnings.


Keywords: lightning, satellites, nowcasting
Parallel Session

SCI-PS168.02 - The front range observational network testbed

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The Front Range Observational Network Testbed (FRONT) is an observational infrastructure for the collection of comprehensive mesoscale and climate process study data sets and for the testing of new observational technologies and retrieval methods. The foundation of the network is composed of the dual-polarization, multi-wavelength and Doppler remote sensing capabilities of the Colorado State University (CSU) CHILL National Radar Facility near Greeley, CO and the National Center for Atmospheric Research (NCAR) S-Pol Radar Facility near Firestone, CO. In addition, data from the CSU Pawnee (located near Nunn, CO) and the KFTG (Denver Airport) and KCYS (Cheyenne, WY) WSR-88D radars will be integrated into FRONT. This expansive radar coverage will provide dual-Doppler wind retrievals extending from Cheyenne to south of Denver. Other existing and available data sets will be integrated into the FRONT data set. FRONT is augmented by a VHF 3-D lightning network, which is operated and supported by CSU and by real time satellite data feeds. Additionally, there are several networks of surface stations are fielded within Colorado and the Colorado Front Range, such as RAWS (Remote Automatic Weather Stations) and AWOS (Automated Weather Observing System). Thus FRONT will provide a readily accessible integrated data set for the study of hydrometeorology; for climate process studies; for developing and testing new algorithms and instruments; for applied data assimilation activities and for validating numerical models. This paper describes FRONT and shows example data sets and applications.

Keywords: Radar, dual-polarization, Network, Testbed
A new multistation technique for lightning location was proposed. The principle of angle intersection was applied in this technique, which includes a computing center and at least three substations. Each substation has a vertical double antenna array and data acquisition (DAQ) equipment. Vertical antenna array is set to get the phase-difference or time-difference of the arriving lightning radiation signal, and then the elevation of the arrival signal can be estimated. According to the elevations supplied by at least three substations, non-linear equations will be constructed. With the help of the time arrival relationship, the only three-dimension position of the lightning radiation source can be calculated. Finally, the lightning channel, including the CG (cloud-ground lightning) and CC (Cloud-Cloud lightning), could be mapped. The further of the lightning, the more accurate of the elevation can be measured by the vertical antenna array, which had been proved in relevant essays. The new technique could enlarge the observation area significantly and have a much better performance on the long-distance lightning detection. Furthermore, compare to the congenic products, such as SAFFIR, the new technique will simplify the hardware dramatically. In addition, the construction of the substation would be much easier. Single station observation has been done. The results show that the vertical antenna could be competent for the estimation of radiation source elevations in the range of 120km without any help of signal-amplifiers. The continuous radiations sources of CG channels were also observed successfully.

**Keywords:** lightning location, angle intersection, phase-difference, Vertical antenna array
The July 2013 Toronto flooding event: What can we learn from crowdsourced smartphone data?

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On July 8 2013, a month’s worth of precipitation fell in the Greater Toronto Area in just over 2 hours. The event caused widespread flooding and disruptions to both surface and air traffic as well resulting in the loss of power to over 300,000 residents of the region. Estimates by the Insurance Bureau of Canada suggest that this storm was the most expensive natural disaster in Ontario history with damage to insured properties exceeding $850 million. In this presentation, the synoptic-scale environment in which the storm developed will be documented using both traditional data sources such as satellite imagery, surface data and reanalyses as well as a new crowdsourced archive of surface pressure data collected by individuals using the barometer installed on all Android smartphones and the PressureNet App. During this event, over 6,000 individual surface pressure measurements were archived by PressureNet in southern Ontario and adjacent regions of New York State, Pennsylvania and Michigan. Details of how this new dataset was integrated with the more traditional sources of data will be discussed. Both the traditional and the PressureNet data indicate that the heavy precipitation was associated with a mesoscale low-pressure system that developed over the region on July 8th. The high density of surface pressure data provided by PressureNet along with its high frequency of reporting suggests that this new source of data may lead to improved predictions of both day-to-day and extreme weather events.

Keywords: High Impact Weather, Crowdsourced Weather Data
Parallel Session

SCI-PS169.01 - The Forecast Skill Horizon

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In the past decade, ECMWF has further improved the models and the algorithms used to estimate the initial and forecast states, expressed in terms of a probability distribution function. Atmospheric processes have been made more realistic, and ocean processes, aerosols and chemical species have been included in the model. Algorithms have been upgraded to provide more accurate and reliable estimates of initial and forecast states, taking into account relevant sources of uncertainties. These advances have led to the extension of ensemble predictions to the sub-seasonal and seasonal range, with forecasts expressed in terms of average values over a space-time volume. Unpredictable “noise” can be removed by averaging to isolate the predictable signal. Operational practice indeed indicates that large-scale, low-frequency phenomena are more predictable than local, grid-point ones. Notwithstanding this, there is as yet insufficient insight of what determines the skilful forecast limits for predictable signals as the forecast range moves into the extended range and beyond, and how the signal propagate. Is there an objective, consistent and coherent way to estimate the skill of forecasts at different spatial and temporal scales? The “Forecast Skill Horizon” (FiSH) proposed here can be used to address this question. FiSH involves systematic averaging of numerical weather predictions over space-time volumes to determine the skill horizons of these predictable signals, and the use of consistent metrics. FiSH will be described using output from the ECMWF coupled ensemble and it will be applied to phenomena characterized by increasingly large spatial and long temporal scales.

Keywords: Predictability, Seamless, Monthly, Seasonal
SCI-PS169.02 - Seamless precipitation prediction skill in a global model: Actual versus potential predictability

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Motivation for this work is to explore the relative prediction skill and predictability in different parts of the globe and how it varies across a range of time scales (days to months). We do this with the aid of ensemble hindcasts from a couple ocean-atmosphere model focussing on precipitation. For a fair comparison across the seamless range of scales, we compute skill using data averaged over time windows equal in length to the lead time. At a lead time of one day, actual skill is greatest in the extratropics around 40-60º latitude, lowest around 20º, and has a secondary local maximum close to the equator. The extratropical skill at this short range is highest in the winter hemisphere due to the higher predictability of winter baroclinic systems. The local equatorial maximum comes mostly from the Pacific, and thus appears to be mostly from the El Niño-Southern Oscillation. As both lead time and averaging window are simultaneously increased, the extratropical skill drops rapidly with lead time, while the equatorial maximum remains approximately constant causing the equatorial skill to exceed the extratropical at leads of greater than 4 days in austral summer and 1 week in boreal summer. At leads longer than 2 weeks, the extratropical skill flattens out or increases, but remains below the equatorial values. Comparisons with potential predictability, computed assuming one ensemble member is truth, suggest that it is the short time scales in the tropics that have the greatest room for improvement.


Keywords: seamless, prediction, skill, verification
Parallel Session

SCI-PS169.03 - Subseasonal variability of North American wintertime surface air temperature

Hai Lin¹

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Using observational pentad data of the most recent 34 Northern Hemisphere extended winters, subseasonal variability of surface air temperature (SAT) over North America is analyzed. The four leading modes of subseasonal SAT variability, that are identified with an empirical orthogonal function (EOF) analysis, account for about 60% of the total variance. Lagged regression analysis is conducted to identify the precursors of large-scale atmospheric circulation for each mode a few pentads in advance, and to understand the processes that influence the subseasonal SAT variability and the predictability signal sources. EOF1 is found to be closely related to the Pacific-North American (PNA) circulation pattern and is preceded by the East Asian cold surge. The cold surge leads to low-level convergence and enhanced convection in the tropical central Pacific which in turn induces the PNA. EOF2 tends to oscillate at a period of about 70 days, and is influenced by the low-frequency component of the Madden-Julian Oscillation (MJO). On the other hand, EOF3 and EOF4 are connected to the high-frequency part of the MJO which has a period range of 30-50 days. These findings would help understanding the mechanisms of subseasonal variability in North America and improving subseasonal weather predictions.

Keywords: Subseasonal variability, Temperature, Teleconnection, Madden-Julian Oscillation
Parallel Session

SCI-PS169.04 - Improving understanding and predictions of extreme events: The Climate-Weather Connection

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We identify how phenomena and processes across the temporal spectrum from climate to weather contribute to extreme events, illustrating the contributions through a case study of record warm US temperatures in March 2012. Factors from a long-term climate trend to synoptic scale processes ultimately linked together to produce this extreme event, with particularly important contributions from phenomena evolving on subseasonal-to-seasonal time scales. The probability for exceptional warmth evolved dynamically as different phenomena became predictable. Increased understanding of the connections between climate and weather will be vital for better anticipating the possibility for extreme events, with more general implications for what information can be provided and when it might be provided. The WWRP Subseasonal to Seasonal Prediction Project can provide important contributions toward achieving this goal.


Keywords: Extreme events, Predictability, Attribution, Climate-weather connection
Parallel Session

SCI-PS170.01 - Interactions between continental convection and mesoscale circulations across model resolutions

Cathy Hohenegger\textsuperscript{1}, Linda Schlemmer\textsuperscript{1}, Levi Silvers\textsuperscript{1}, Bjorn Stevens\textsuperscript{1}

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Looking from space down to Earth often reveals that convective clouds are not randomly distributed over continental areas but follow an underlying pattern. One well-known example is the alignment of clouds along the coastline, a visible signature of the interactions between convection and the sea breeze circulation driven by the thermal contrast between land and ocean. This talk focuses on such interactions and on their representation in NWP models of various resolutions. An idealized case of a land sea breeze interacting with convection is simulated. The simulations are conducted with a large-eddy simulation (LES) model with fully explicit convection, a convection-permitting model (CPM) where only the deeper convective motions are explicitly resolved, and a coarse resolution model with parameterized convection. Investigation of the LES results allows a better understanding of some of the aspects controlling the interactions between convection and the mesoscale circulation. Comparison of the three simulations allows an assessment of the effect of the representation of convection on the results. It is for instance found that none of the model reproduces the same sensitivity: the LES is more sensitive to the vertical motion of the mesoscale circulation than the other two model configurations, the CPM appears overly sensitive to the sensible heat flux, whereas the coarse resolution simulation strongly responds to the latent heat flux. Reasons for this behavior and implications for NWP are discussed.

**Keywords:** Convection, Land-atmosphere interactions, Parameterization development
Parallel Session

SCI-PS170.02 - Predictability of convective precipitation: Convection-permitting ensemble simulations for West Africa

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Convection-permitting ensemble simulations were conducted for West Africa. At the peak of the monsoon season, mesoscale convective systems (MCSs) produce almost all of the annual precipitation in the Sahel - a region that is generally threatened by severe drought. The predictability of MCSs is examined by ensemble simulations considering two main components of perturbations. Different techniques were tested to construct the ensembles using the Consortium for Small-scale modeling (COSMO) model: 1) A multi-analysis approach was chosen; 2) members out of the ECMWF ensemble prediction system (EPS) were used as initial and boundary conditions (EC version). Additional perturbations were applied that are effective at the land surface. These land-surface perturbations were developed to account for uncertainties of the initialization of the soil properties as well as to investigate systematically the influence of the land surface on MCSs. Verification indicates a similar performance of the multi-model and the EC version. Skill scores for ECMWF forecasts itself only differ slightly, but precipitation sums are too low in the global forecasts, especially in the Sahel. The applied land-surface perturbations influence the prediction of MCSs by modifying boundary-layer temperature and moisture budgets as well as by horizontal heterogeneities conditioning secondary circulations that determine the location of convection initiation. Atmospheric perturbations rather influence the occurrence or suppression of MCSs on a particular day by dynamical forcing. The overall influence of different analyses and ECMWF-EPS members, respectively, on predictability of MCSs in West Africa is considered to be equal to the influence of the developed land-surface perturbations.

Keywords: numerical modelling, MCS, soil moisture, Sahel
Parallel Session

SCI-PS170.03 - A study on the heavy-rain-producing Mesoscale Convective System associated with diurnal variation and topography

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On 24-25 July 2010, a 500-hPa low vortex system forming north of Tibetan Plateau surprisingly moved westward after its several days eastward movement. Observational analysis showed that, during its westward movement, the large-scale forcing became favorable for the convection development, with the low-level southeasterly or easterly wind developing in the east slope of the western Sichuan plateau (WSP). The low-level warm advection was more favorable for convection development than the differential vorticity advection. The daytime scattered convections were organized into a mesoscale convective system (MCS) after sunset, which produced extremely heavy rainfall in the east slope of the WSP. The observational evidence and numerical simulation indicated that the topographical dynamical lifting over lower topography and the convergence owing to topographical blocking provided the dynamics for the convection initiation. The cold outflows due to surface rainfall evaporation drove the MCS to shift away from its original place slowly, with the convergence between the cold outflows and the environmental southeasterly flow supporting the maintenance of the MCS. The strengthening of the low-level flow, which was associated with the diurnal variation of solar-radiation forcing, leaded to the organization and intensification of the MCS. The results of sensitivity experiments further confirmed the role of topography in the convection initiation, the influencing of cold outflows owing to surface rainfall evaporation on the movement and maintenance of the MCS and the effects of the diurnal variation of solar-radiation forcing on the organization of the MCS.

Keywords: heavy rain, mesoscale convective system, diurnal variation, topography
Parallel Session

SCI-PS170.04 - Northern Rocky Mountains as the origin for Northwest Flow severe weather outbreaks

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In the U.S. central plains, summer progressive convective storms occurring under weakly forced environments are often coupled with short-wave perturbations embedded in the northwesterly flow. These are midtropospheric perturbations (MPs) and they contribute to the majority of the rainfall over the northern plains. MPs are initiated over the Rocky Mountains and occur most commonly at 12 UTC (early morning) and 00 UTC (late afternoon). The diurnal evolutions between the midtropospheric flows over the Rockies and over the Great Plains are nearly out-of-phase due to inertial oscillation. During the nighttime, the westerly flows over the Rockies intensify while flows at the same level over the Great Plains turn easterly. These two flows converge over the eastern Rockies and induce cyclonic vorticity through vortex stretching. After sunrise, the convergence dissipates and the cyclonic vorticity is redistributed by horizontal vorticity advection, moving it downstream. This process creates a climatological zonally propagating vorticity signal which, in turn, facilitates the early-morning MP genesis at 12 UTC. In terms of forecasting, the difficulties of the NAM model in predicting convective rainfall over the northern plains are partly attributed to its deficiency in forecasting MPs. This is because forecasted MPs exhibit slower propagation speeds and weaker vorticity than the observations, leading to biases in the propagation speed. Skill scores of precipitation forecasts associated with MPs are low, but can be improved after removing the MP position error that displaces the rainfall pattern.


Keywords: NWF outbreaks, instability, convection, derecho
Complementary to Zhang (2004 JAS) on the generation of mesoscale gravity waves in dry baroclinic waves, a series of cloud-permitting simulations with the Weather Research and Forecast (WRF) model are performed to study gravity waves in the moist baroclinic jet-front systems with varying degree of convective instability (Wei and Zhang 2014 JAS). Experiment with small amount of moisture and weak convective instability produces similar baroclinic life cycles to the dry experiment. However, the addition of weak convection generates a new wave mode of shorter-scale gravity wave packets that are found to interact with, strengthen, and modify the dry gravity wave modes. Further increase of the moisture content (up to 5 times in mixing ratio) leads to more vigorous moist convection. Besides a faster growing moist baroclinic wave, the convectively generated gravity waves are more prevalent and larger in amplitude, and are fully coupled with and hardly separable from the dry gravity wave modes under the complex background moist baroclinic waves. Ray-tracing analysis based on the Gravity-wave Regional Or Global Ray Tracer (GROGRAT) model is given to further examine the effect of moisture on the gravity waves in terms of initiation, amplification, propagation and dissipation, as well as possibility of wave capture under complex sheared environment. The comparison between wavelet-based filtered WRF-simulated data and wave amplitude calculations in GROGRAT also reveals the uncertainties in the estimations of wave characteristics, amplitudes, and momentum fluxes for waves within potential source regions (e.g., unbalanced jet, frontogenesis, moist convection), as well as non-monochromatic waves.


Keywords: Gravity Waves, Flow Imbalance, Baroclinic Jet-Front Systems, Moist Convection
Parallel Session

SCI-PS171.02 - Does mesoscale instability control sting jet variability?

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Recent studies have shown a link between mesoscale instability in the cloud head and slantwise descent from the tip of the cloud head of rapidly-developing, Shapiro-Keyser type extratropical cyclones. These studies have demonstrated how the descents contribute to damaging near-surface winds in the frontal fracture region of such cyclones. This wind maxima often occurs in addition to and ahead of the strong cold conveyor belt circulation typical of these cyclones. Known as sting jets, these descents represent a mesoscale circulation with unknown predictability and limited knowledge of its variability. This study addresses these unknowns by simulating three sting jet producing cyclones using the Met Office ensemble prediction system. A control simulation and 23 initial condition perturbation members have been run for each case. The spread of the synoptic-scale development is small but mesoscale variability is substantial. Trajectories that passed through the region of strongest winds were computed and then classified using a hierarchical clustering algorithm. This approach enables automated identification of coherent airstreams that contribute to the strongest winds in the cyclone. In this way, sting jets are objectively characterised to explore their variability within the ensemble. This provides an objective approach to testing whether the link between mesoscale instability and sting jets is causal.

Keywords: sting jet, mesoscale instability, extratropical cyclones, windstorms
Parallel Session

SCI-PS171.03 - Multi-scale Met Office unified model simulations of a mesoscale convective system in north-western Europe

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Mesoscale convective systems (MCSs) are large storm systems with cloud shields covering an area of at least 100000km². They occur frequently in places such as the central United States but are less common in north-west Europe. Their relative rarity means that they have been poorly studied here despite being associated with extreme weather. Although MCSs grow to cover a large area, the initial convection is small-scale and difficult for weather prediction models to represent correctly and position accurately. This, combined with a lack of understanding of north-western European MCSs can lead to unreliable forecasts. Here, we show that discrepancies between forecasts in finer and coarser resolution models can lead to differing forecasts of the downstream flow, impacting forecast skill. The interactions between scales at the development and evolution stages of MCSs can be diagnosed using potential vorticity (PV) analysis. Unlike in the USA, few previous studies of north-western European MCSs have considered PV development. A case study of an MCS that occurred on 5 July 2012 will be presented. This MCS formed over France before tracking northwards to affect the UK. The case was examined using the Met Office weather forecast model (the MetUM) at convection-permitting and convection-parameterizing resolutions. We found that PV anomalies are stronger in the higher-resolution models even after coarse graining to 25-150km scales. This is particularly noticeable at the jet stream level indicating implications for the downstream flow. The ultimate goal of this work is to improve short and medium-range forecast skill associated with MCS events.

Keywords: Mesoscale, convective, model
Parallel Session

SCI-PS171.04 - Analyses and thinking on the extremes of torrential rain on July 21, 2012 in Beijing

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Precipitation characteristics, environment conditions, development and progressions of MCS that brought about the torrential rain in Beijing on July 21th were analyzed using various conventional and unconventional data. Results showed that this process was long duration, great rainfall and wide coverage area was consisted of warm area and frontal precipitation. The warm area rainfall started earlier and was of long duration while the frontal rainfall consisted of several heavy rainfall center with the high precipitation efficient was stronger and of shorter duration. Interactions of high-level wind divergence, the wind shear and convergence with the vortex in low-level troposphere and the surface wind convergence line provided favorable environment. Extremely sufficient water vapor which was from tropic and sub-tropic manifested as high atmosphere column PW and strong water vapor convergence. In addition, the intense precipitation was intrigued and maintained by the vortex wind shear, wind disturbance on LLJ, surface wind convergence line and the effect of terrain. Heavy frontal rainfall was brought by the development and evolution of convective system made by the cold air and the suitable vertical wind shear while the cold front moved eastward. Stratiform cloud precipitation occurred firstly and the warm and steady stratiform cloud precipitation changed to be convectional precipitation as the cold dry air invaded. Some mesoscale convective clusters developed and formed MCC which led to extreme precipitation. Train effects were obvious in this process and the radar echo had the characteristics of backward propagation and low centroid which was similar to the tropical heavy rainfall.

Keywords: Extreme torrential rain, Warm area torrential rain, Systematization of convective cloud cluster, Mesoscale convective complex
Parallel Session

SCI-PS172.01 - Strategic goals for NWP Centres: minimising RMS error or maximising forecast reliability?

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Ensemble weather prediction has become a commonplace tool for weather services around the world - in recognition that forecasting uncertainty in the weather can be as important for users (and for the credibility of our profession) as forecasting the most likely weather. However, these ensemble prediction systems sit uncomfortably with their more traditional deterministic cousins. In discussing the path forward, the following question is pertinent. What should be the single most important strategic priority for a 21st Century numerical weather prediction centre - to produce a deterministic forecast with as low an RMS error (or as high an anomaly correlation coefficient) as possible, or to produce a probabilistic forecast where probabilities are as sharp as possible, but always reliable. This dichotomy is brought into sharp focus when considering the development of stochastic parametrisation schemes, as discussed in this talk.

Keywords: reliability, stochastic, parametrisation, probability
Parallel Session

SCI-PS172.02 - Addressing model error through atmospheric stochastic physical parametrisations: Impact on the ECMWF seasonal forecasting system

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ECMWF has been at the forefront of developing approaches to account for uncertainties due to the finite model resolution and related effects of sub-grid scale variability. In particular, the stochastically perturbed physical tendency scheme (SPPT) and the stochastically perturbed backscatter algorithm (SPBS) for the atmosphere are now used routinely for global numerical weather prediction. ECMWF also performs long-range predictions of the coupled atmosphere-ocean climate system in operational forecast mode and the latest seasonal forecast System 4 has the SPPT and SPBS schemes implemented in a similar way as for the medium range ensemble forecasts. Here we present results of the impact of these schemes in System 4 by contrasting the operational performance on seasonal time scales with comparable simulations that do not account for the representation of model uncertainty. We find that the stochastic tendency perturbation schemes help to reduce excessively strong convective activity especially over the maritime continent and the tropical Western Pacific leading to reduced biases of OLR, cloud cover, precipitation (more dry days, less drizzle?) and wind. Positive impact was also found for the statistics of the Madden-Julian Oscillation showing an increase in the frequencies and amplitudes of Madden-Julian Oscillation events. Further, the errors of ENSO forecasts become smaller while increases in ensemble spread lead to a better calibrated system if SPPT is activated. The backscatter scheme has overall neutral impact. Finally, evidence for noise-activated regime transitions has been found in a cluster analysis of mid-latitude circulation regimes over the Pacific-North America region.


Keywords: stochastic physical parametrisations, seasonal forecasts, convection model bias, MJO
The Madden-Julian oscillation (MJO) is the dominant mode of variability of the tropical troposphere at the intra-seasonal scale, and has a tremendous influence on the global weather patterns and climate variability. However, its representation is still a challenge for numerical weather prediction and general circulation models (GCMs) due to the inadequate treatment of convection by the underlying cumulus parameterizations. One new promising direction is the use of stochastic multicloud models (SMCM) that have been designed specifically to capture the missing variability due to unresolved processes of convection and their impact on the large scale flow. The SMCM specifically models the area fractions of the three cloud types (congestus, deep and stratiform) that characterize organized convective systems of all scales. The SMCM captures the stochastic behavior of these three cloud types via a judiciously constructed Markov birth-death process using a particle interacting lattice model. The SMCM has been successfully applied for convectively coupled waves in a simplified primitive equation model and validated against radar data of tropical precipitation. In this work we use for the first time the SMCM in a GCM. We build on previous work of Khouider et al. (JAS, 2011) where they coupled the HOMME NCAR-GCM to a simple deterministic multicloud model. We tested the new SMCM-HOMME model in the parameter regime considered in Khouider et al. (JAS 2011) and found that the stochastic model improves drastically the results. Clear MJO-like structures are reproduced by SMCM-HOMME in the physically relevant parameter regime.

**Keywords:** Stochastic, Multicloud, MJO, GCM
Parallel Session

SCI-PS172.04 - Stochastic Physics Developments for the Met Office ensemble prediction system

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The Met Office Global and Regional Ensemble Prediction System (MOGREPS) includes both a regional ensemble (MOGREPS-UK) for detailed predictions for the UK for a day ahead and a global ensemble (MOGREPS-G) covering the short to medium range. Uncertainties in the forecasts are represented both by using an Ensemble Transform Kalman Filter to represent initial condition uncertainties and also by using stochastic parameterizations to represent the effect of model errors. Currently the global ensemble uses two stochastic parameterizations: Stochastic Kinetic Energy Backscatter (SKEB), which counteracts diffusive energy dissipation by adding in stochastic wind increments, and Random Parameters (RP), which represents knowledge uncertainty by varying some of the physics parameters within a range of plausible values. This presentation will describe some proposed changes to the stochastic physics, including revisions to SKEB and possible inclusion of a Stochastic Perturbed Tendency (SPT) scheme. The initial implementation of the UK ensemble does not include any stochastic physics. A version of the RP scheme has been developed to improve representation of uncertainties in forecasts of fog and low cloud. Some early evaluations of this scheme will be presented.

Keywords: Stochastic, Ensembles, Parameterization
In ordinary least-squares methods the observations leverage is computed and used to monitor statistical multiple-regression analysis. In the generalized least square problem, of which 4D-Var is a special case, the observation leverage is used to provide protection against distortion by anomalous data, to compute the change in the estimate that occurs when one or a group of observations are deleted and to supply the degree of freedom for signal. The observation forecast impact clearly depends on the observation leverage, e.g. small data leverage will generate small forecast error decrease. The observation influence together with the estimation of the forecast error decrease due to the assimilation of that observation allow to monitor and evaluate the performance of the assimilation system and to diagnose system weaknesses. Poor observation leverage may indicate suboptimal observation and/or background weights whilst poor forecast impact associated with large observation leverage can illustrate model deficiencies. Examples of different observation types assimilated in the ECMWF system are shown. The examples provide the 'state of art' of the system and what can be done to improve it.

**Keywords:** Observation leverage, Assimilation performance, Assimilation system improvement
Parallel Session

SCI-PS173.02 - Impact of geostationary satellite data on Superstorm Sandy Forecast

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The geostationary satellite sensors can provide high spatial and temporal resolution observations, which are great benefit in monitoring and forecasting severe weather events. To optimize the usage of geostationary satellite data in numerical weather prediction, a series of sensitivity forecast experiments are designed for the simulation of Superstorm Sandy (2012) by using the Hurricane Weather Research and Forecasting model (HWRF) and Gridpoint Statistical Interpolation (GSI) system. Firstly, the impact of lateral boundary condition (LBC) of HWRF on the Superstorm Sandy forecast skill is evaluated. Ten groups of sensitivity experiments are performed with five different HWRF domain-1 sizes, and with and without the assimilation of all GSI currently used satellite data. It is found that the LBC impact on storm track forecast is decreased with the increase of HWRF domain size. The LBC impact is also reduced after assimilating satellite data. The maximum wind and minimum sea-level pressure forecast errors are not affected with the change of domain-1 size. Secondly, the GSI assimilation scheme is modified to increase the assimilation number of geostationary satellite data, including GOES Sounder and MSG SEVIRI, and to add the assimilation of GOES Imager data. Preliminary result indicates that the storm track forecast error can be reduced by increasing the use of geostationary satellite data in GSI assimilation. Finally, the mitigation of the Joint Polar Satellite System (JPSS) data potential coverage gap will be studied with sensitivity experiments by turning on and off the assimilation of JPSS satellite data and geostationary satellite data, respectively.

Keywords: Geostationary satellite data, Superstorm Sandy, HWRF, GSI
SCI-PS173.03 - Assimilation of dropsondes observations to improve forecasts of convection with WRF/DART

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Forecasts of deep convection remain a considerable challenge, but recent progress in convection-permitting ensemble forecast methods provide an opportunity to improve guidance. This progresses hinges on defining an appropriate ensemble initial state that represents initial condition (IC) uncertainty, and evolving this uncertainty in the ensemble forecast to map how forecast outcomes are sensitive to this IC uncertainty. From this, locations for targeted observations can be identified that have the potential to improve the reliability of convective forecasts. During Spring 2013, the Mesoscale Predictability Experiment (MPEX) sought to improve short-term (here 6-15 h) forecasts of convective weather episodes over the Great Plains. MPEX approached this challenge by increasing observation density with mesoscale spaced (~150 km) dropsonde observations in the vicinity of disturbances upstream of uncertain convective weather events. Potentially uncertain ICs were identified in part by formal ensemble sensitivity analysis (ESA) from longer-range forecasts. Fifteen dropsonde missions were conducted, which included events with a wide range of convective organization. In retrospective case studies, the impact of the additional dropsonde observations is determined through a set of data denial experiments with the WRF/DART ensemble data assimilation system and subsequent ensemble forecasts. Verification of ensemble forecasts is made against conventional and research observations. Further, we assess the relative utility of ESA to identify a priori targeted observation locations for convection forecasts. At the conference, we will provide a brief overview of MPEX and then will discuss results from retrospective case studies.

Keywords: EnKF, data assimilation, severe storms, ensemble forecasts
Satellite cloud observations contain a wealth of information about convective activity and are therefore seen as important input parameters for convective scale data assimilation. However, current operational data assimilation systems in general utilize only clear sky thermal infrared and microwave radiance observations, which mainly provide temperature and humidity information. Due to the lack of suitable forward operators, visible and near-infrared radiances, which contain information about cloud properties, are not considered. To address this shortcoming, a fast forward operator for visible and near-infrared reflectance observations has been implemented in the experimental km-scale Ensemble Data Assimilation (KENDA) system of DWD. The operator computes synthetic MSG-SEVIRI satellite images from COSMO-DE model output and relies on the discrete ordinate method to solve the radiative transfer equation. The accuracy of the operator is typically better than 6%, compared to 3D Monte Carlo results. A new version using a lookup-table based method allows for a reduction of the computational costs to a level that meets requirements for operational use and leads to only slightly increased errors. First results from the assimilation of visible satellite observations are presented. The cloud water content in the analysis is successfully modified by the assimilation of SEVIRI images. Besides the direct assimilation, such an operator is potentially also valuable to identify model deficiencies that lead to systematic errors in the model representation of clouds.

Keywords: data assimilation, satellite observations, forward operator, radiative transfer
Parallel Session

SCI-PS174.01 - The future of forecaster decision making: Is it automation or human-computer interdependence?

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The field of Cognitive Systems Engineering has revealed recurring patterns of the consequences of technological interventions for human performance. Cautionary tales include the Substitution Myth that human reasoning can be swapped out for algorithms, the myth that requirements analysis is sufficient to capture the decision maker's "desirements," the myth that performance can be enhanced and resilient decision making can be insured simply by the introduction of new technology. A theme to this presentation is the concept of human expertise, and the notion of studying the reasoning and knowledge of expert forecasters in depth and detail. Cognitive Work Analysis should be the horse pulling the cart in the development of new technologies. Human-Centered Design regards the human-machine relation as one of necessary interdependence. Calls for more automation may result in a work system in which the human is relegated to the role of a supervisor, which will inevitably make the work system brittle when confronted by off-nominal situations. This and other pitfalls can be predicted, with great confidence, as a result of the current drive to automate. The question addressed in this presentation is, "What is our vision of the way forward?"


Keywords: Forecaster reasoning, automation, human-system integration
Severe thunderstorm prediction in Canada is challenging for a number of reasons. At each of Environment Canada’s five Storm Prediction Centres, staffing is modest and the area of responsibility is immense - more than 1,000,000 square km. Forecasters must monitor data from a large number of sources, including multiple Doppler radars, to maintain situational awareness. In addition, storm activity in many regions is significantly influenced by mesoscale features such as drylines and sea/lake-breeze fronts. Thus, severe thunderstorm nowcasting and forecasting in Canada requires extensive use of high-resolution data, both from observations and NWP. A system integrating observations, NWP and automated algorithms with an intuitive forecaster interface for analysis/diagnosis/prognosis is needed. It is recognized, however, that such a system has to be carefully designed so that it does not erode but in fact enhances forecaster expertise. Thus, the human-machine mix must be optimized to make the best use of both human and machine strengths. To this end, a thunderstorm forecasting, nowcasting and alerting prototype named iCAST (interactive Convective Analysis and Storm Tracking) is being developed. It uses an area-based, object-oriented approach that allows forecaster interaction with graphical ‘MetObjects’ representing important features such as fronts, jets, storm tracks and probability areas. iCAST has been evaluated in a real-time, operational setting during the past several summers via a Research Support Desk at the Ontario Storm Prediction Centre in Toronto, and will serve as the basis for a ‘next generation’ forecasting, nowcasting and alerting demonstration during the 2015 Pan Am Games in Toronto.


Keywords: Severe Thunderstorm, Prediction, Alerting, Interactive
The Meteorological Service of Canada (MSC) is providing nowcasting weather elements for more than 500 locations over the Canadian territories. The Integrated Nowcasting System (INCS) generates weather elements mainly to support the MSC public weather forecast program and the Canadian Meteorological Center (CMC) weather data sets available on the Datamart web site. The INCS was built to allow forecasters to consult and integrate, interactively, real-time weather observations and nowcasting data directly in “Scribe” the operational forecasting production tool. Recent development has addressed some issues by optimising the interface and improving the reliability of the forecasted weather elements. Among these changes, the system is now able to ingest and extrapolates Radar observations. The 4 km PRECIPT-ET radar product from the Canadian Unified Radar Processor (URP) is used. An additional cleaning is added to remove remaining unreal echoes. The extrapolation of the radar and lightning data is accomplished with the MAPLE (McGill Algorithm for Precipitation Lagrangian Extrapolation) algorithm. The rule based system which integrates and processes all the input data (surface observations, radar, lightning, NWP) can now benefit of a probability of precipitations (POP) based on a sampling method approach applied to the RDPS (Regional Deterministic Prediction System) precipitation amount forecast field. The use of a spatial sampling technique showed a greater reliability to predict the occurrence of precipitation than the current technique only based on the predicted value at the forecast point. Real cases and objective verification results will demonstrate that these changes have improved the performances of the forecast system.

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Keywords: Nowcasting, Forcast System, Decision support, Extrapolation
We demonstrate the feasibility of interactive 3D visualisation of ensemble weather predictions in a way suited for weather forecasting during aircraft-based atmospheric field campaigns. Research flights with high-flying aircraft require the flight route to be planned several days in advance, hence, being able to assess the uncertainty of the forecast on which a flight is based is very valuable. Since the targeted upper-level features are of an inherently three-dimensional nature, it seems natural to aid their identification with three-dimensional visualization methods. We present “Met.3D”, a novel forecasting tool that makes recent advances in 3D and uncertainty visualization available to the forecaster. Interactive 2D and 3D visualization elements, displaying forecast meteorological fields and uncertainty measures derived from the ECMWF ensemble prediction system, enable the meteorologist to quickly identify atmospheric features relevant to a flight and to assess their uncertainty. Application of Met.3D is demonstrated with a case study from the 2012 T-NAWDEX-Falcon field campaign, a project that aimed at taking in-situ measurements in warm conveyor belts (WCBs). To predict a 3D “probability of WCB occurrence”, \( p(\text{WCB}) \), a method based on Lagrangian particle trajectories computed on the ensemble wind field is proposed. We discuss major challenges of our work: efficiently computing uncertainty measures from the terrain-following ECMWF model grids varying with each ensemble member, finding the best compromise between \( p(\text{WCB}) \) accuracy and computational demand, exploiting available graphics hardware to compute visualizations from the prediction data at interactive frame rates, and building a “bridge” from 2D views familiar to meteorologists to 3D views.

**References:** Rautenhaus, M., C. M. Grams, A. Schäfler, and R. Westermann, 2014. GPU based interactive 3D visualization of ECMWF ensemble forecasts. ECMWF Newsletter, 138 (Winter 2014), pp. 30-34.

**Keywords:** 3D visualization, uncertainty visualization, ensemble weather prediction, warm conveyor belts
Parallel Session

UAS-PS320.01 - The marginal value of weather warning systems

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To date, most research regarding the effectiveness of weather warning systems has been limited to case studies. While such studies are particularly informative regarding how warning systems are applied in practice, it remains difficult to estimate the value of warning systems because there is no clear counterfactual of how individuals would have fared without it. Quantitative estimates of this marginal benefit are important for determining the optimal levels of investment in various warning systems. To accomplish this task, this paper examines outcomes from all recorded U.S. tornadoes between 1950 and 2012 to estimate the marginal benefit of National Weather Service (NWS) transmitters. After controlling for differences in tornado and location characteristics, variation in the installation dates of NWS transmitters is used to estimate the marginal benefit of installed transmitters in terms of injuries prevented and lives saved. Initial results suggest that an additional installed transmitter per county in the path of a tornado prevented an average of 1 injury for every 5 tornadoes, and 1 death for every 200 tornadoes. These are economically significant impacts, given that (i) most tornadoes are small and naturally result in few injuries or deaths, and (ii) a large number of tornadoes occur across the U.S. each year. The marginal benefits of additional weather warning infrastructure appear to quite quickly outpace associated marginal costs.

Keywords: NWS transmitters, valuation, warning systems
Located on the south-east coast of Africa, Mozambique can experience extremely variable hydrometeorological conditions including river and flash flooding, cyclones, drought, heat, and severe thunderstorms and lightning. Facing these challenges The World Bank is working with the Mozambican national weather service and hydrological services to strengthen and optimize the physical meteorological monitoring networks, improve data management and quality control, and enhance modeling and early warning systems. In this talk, we discuss a contingent valuation method (CVM) survey eliciting preferences and values to households for improved hydro-meteorological information under the World Bank program. In mid-2013, 576 members of the general public were interviewed in 11 locations across Mozambique. A payment-card CVM question was implemented to elicit benefits to households for potentially improved forecasts and warnings. A multivariate analysis examines WTP as a function of income and other socio-demographic measures. Given that a significant portion of Mozambicans are subsistence farmers with no monetary income, we focus closely on the relation between income and WTP to test for internal validity and to consider potential distributional issues in societal benefits of improved warnings. We further examine WTP as a function of individuals’ experience with weather impacts; perceptions of their weather vulnerability; perceptions of forecast quality; concern and awareness of weather impacts; sources, uses, and importance of weather information. Integrating advanced approaches to non-market values, the analysis includes individuals’ responses to follow-up questions designed to identify scenario rejection and altruistic motivations for WTP.

Keywords: Contingent Valuation, Mozambique, Weather Information, The World Bank
Parallel Session

UAS-PS320.03 - The role of weather and climate service innovation in adaptation to climate change

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In the EU project Tool Supported Policy Development for Regional Adaptation (ToPDAd) it was identified that in many economic sectors so-called automatic or endogenous adaptation to climate change could be equally important to planned adaptation, if they can be enhanced by innovation. An important subset of adaptation-relevant innovations concerns those applied to weather and climate services, which in turn are closely linked to advances in information and communication technologies (ICT). The main drivers of the innovations are (1) the steady reduction in unit-cost of measurement, observation and data-exchange, (2) the integration of networks and data types, and (3) third party access to public weather and climate observation and basic model data. In ToPDAd the contribution of weather and climate service innovation to adaptation is explored in three phases. Firstly, the most relevant (upcoming) innovations are identified by means of surveys. Secondly, some innovations are integrated into economic sector model simulations of effects of adaptation measures. Thirdly, using results of the sector models, a broader macro-economic assessment is made. Stage 1 is based on 23 semi-structured interviews of end-users and experts regarding information and observation technologies and meteorological services. The partitioning in seven supply phases as applied in Weather Service Chain Analysis proved very helpful in the interview structuring. Furthermore, a statistical analysis of online and mobile weather service user data was carried out. This presentation focuses mainly on the results from this stage, including illustrative calculations on what adaptation benefits selected weather service innovations could bring.

Keywords: Weather services, Climate change, Adaptation, Innovation
Parallel Session

UAS-PS320.04 - Searching for the ideal wind power forecast

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Energy trading for wind energy needs day-ahead forecasts. Deriving a statistical model between historical pairs of numerical weather prediction (NWP) forecasts and measured energy production and applying it to current forecasts maximizes the amount of information used for a forecast. Which type of NWP model (global vs. regional, deterministic vs. ensemble, evolving vs. reforecast) fed into the statistical model of Messner et al. (2013) yields the largest revenue for the producer on the Austrian market, and the best traditional verification measures, will be revealed in this presentation.


Keywords: wind energy, wind, MOS, statistical postprocessing
Parallel Session

UAS-PS321.01 - The evolving role of the forecaster at the NOAA Weather Prediction Center

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The term “forecaster over-the-loop” (FOTL) is often used to reference the evolving role of the human weather forecaster. Historically, the human forecaster has been very much “in-the-loop”, using numerical weather prediction (NWP) guidance, available observations, and experience to manually construct a forecast. Traditional forecast preparation is often a time-consuming process, involving many subjective decisions based on various guidance tools. However, the proliferation of skillful NWP data is driving an evolution toward FOTL, because even the most highly trained and experienced meteorologist simply cannot digest all available data. For example, NOAA Weather Prediction Center (WPC) forecasters receive over 200 unique four-dimensional NWP datasets every day. In this presentation, the ongoing transition of WPC forecasters from “in-the-loop” to “over-the-loop” will be described. To facilitate the transition to FOTL, sophisticated post-processing techniques are increasingly used to combine and bias-correct raw NWP data. Deterministic ‘most likely’ values can be derived from the blended guidance. These values serve as the default forecast, and a forecaster who is knowledgeable about the constituent datasets and who oversees the process, may make modifications. Visualization tools are being developed that allow a forecaster to quickly interrogate the NWP data and decide when and how to intervene in an otherwise highly automated process. Additionally, the distribution of statistically corrected NWP data provides the foundation for probabilistic forecasts that convey the range of forecast solutions. Examples of how WPC uses these approaches will be shown, and some of the challenges and opportunities of a transition to FOTL will be discussed.

Keywords: Forecasting, Hydrometeorology
Parallel Session

UAS-PS321.02 - Implementing the global framework for climate services in Canada: A national effort to assess capacity

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The Global Framework for Climate Services (GFCS) is a global partnership of governments and organizations that produce and use climate information and services, in the context of a changing climate. It seeks to enable researchers and the producers and users of information to join forces to improve the quality and quantity of climate services worldwide; however, understanding the climate service capacity at the national level is the first step to implementing the GFCS. In Canada, we tested the application of the GFCS framework as a basis of a climate services assessment "tool". Through a consultative process with stakeholders and service providers across the country, our results suggest the "tool" is helpful for identifying gaps in service and areas where services can be optimized by reducing duplication, can help create a common understanding of water and climate services that will form the basis of improved coordination (governance). We have found that opportunities for improved sharing of climate information and products have been identified, such as sharing of data from observation networks currently not commonly shared with all providers. We are optimistic that the results form the basis for developing actions to address weaknesses in the current service model but there remain many challenges because of the lack of existing coordination and governance structures as a result of the diversity of jurisdictions involved.

\textbf{Keywords:} climate, services, GFCS, Canada
Parallel Session

UAS-PS321.03 - The UCAR Community Advisory Committee for NCEP

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The UCACN – University Corporation for Atmospheric Research (UCAR) Community Advisory Committee for NCEP (U.S. National Centers for Environmental Prediction) was established by UCAR to conduct a comprehensive review of NCEP every five years, starting in the year 2015. The review will assess the individual nine Centers, as well as their interactions with each other and with other NOAA, Federal, academic and non-governmental entities to determine how effectively NCEP is accomplishing its mission and realizing its vision. In particular, for each center and NCEP as a whole, the review will assess the productivity, quality, relevance, impact, effectiveness, and balance of the Centers' scientific activities and operational products and services. Between the reviews, UCACN will monitor progress of the Centers in the context of the NCEP strategic plan and the previous review recommendations, and provide informal updates and advice to its UCAR sponsor. The UCACN also provides input to the strategic planning and long-range goals of the Centers and NCEP as a whole. This paper will describe the recent activities, findings and recommendations made by UCACN, including a summary of recommended strategic directions for the U.S. National Weather Service model development and support for stakeholders. In particular, the paper will discuss recent findings that NCEP has improved greatly over the past 5 years and recommendations from the recent UCACN meeting regarding strategic planning for science-based decision making, a unified modeling framework for days to months forecast guidance, and strengthened partnerships with the research community.

**Keywords:** NCEP, NMHS
Parallel Session

UAS-PS321.04 - Be a part of building a weather-ready nation

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NOAA is committed to the mission of reducing loss of life, property, and the disruption from high impact weather and water-related events. To this end, NOAA envisions a Weather-Ready Nation where society is prepared for and responds to these events. The Weather-Ready Nation (WRN) strategic priority is about building community resilience in the face of increasing vulnerability to extreme weather. To achieve this vision, NOAA recognizes it is essential to work collaboratively with external stakeholders within all levels of government, industry, nonprofits, and academia. NOAA’s contribution to building a Weather-Ready Nation focuses on improvements in the following areas: • Communicating preparedness messages to user groups and the general public in a consistent, unified manner; • Providing impact-based decision support services to NOAA core partners during high impact events; • Performing both physical science and social science research and transitioning innovative technologies into operations; • Delivering lifesaving forecast and warning information to the public via multiple pathways (e.g., Wireless Emergency Alerts, use of social media); • Enhancing pre-existing NOAA partnerships and establishing new partnerships across all sectors of society. Partnerships are essential. Government cannot do it alone. To formally recognize the value our partners add to this initiative, NOAA launched the Weather-Ready Nation Ambassador initiative in early 2014 as a way to engage external organizations on how they can take part and contribute to promote preparedness and strengthen community and business resilience. Together we can build a Weather-Ready Nation.

Keywords: Weather-Ready, Nation, resilience, Ambassador
An air quality forecasting system for Europe has been set in the frame of a series of European funded projects over the past ten years. The latest of these projects is MACC-II (Monitoring Atmospheric Composition and Climate- Interim Implementation) in which the forecasting system has been further improved and consolidated towards an operational status to be reached in 2014. This unique system is based on an ensemble of 7 state-of-the-art chemistry transport (off-line) models developed by recognised European research groups. The seven models use the same framework: dynamical forcing and meteorological conditions from the ECMWF operational weather forecasting system, boundary conditions for the main chemical compounds from the pre-operational MOZART/IFS system and emission products (including fire emissions) developed within the project. The quality of the 4-day forecasts of ozone, NO2, SO2, CO, PM10 and PM2.5 is evaluated daily using statistical indicators based on measurements from the European air quality monitoring network. Additionally, birch pollen forecasts are provided since 2013 during the pollen season (March to June). The use of seven different models opens the possibility to apply ensemble methods in order to provide better scores on average than any individual model. The ensemble method currently applied consists of computing the median of the forecasts at each gridpoint. Other methods have also been tested. The MACC-II ensemble forecasting system will be presented on behalf of the MACC-II regional consortium together with the latest work on ensemble methods.

Keywords: air quality, ensemble methods
Parallel Session

SCI-PS175.02 - Air quality forecasting in Canada: current status, performance and future developments

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The Canadian Regional Air Quality Deterministic Prediction System (RAQDPS) is a set of models, tools, data and software that produces Environment Canada’s current operational numerical air quality forecasts. At the heart of the RAQDPS is Environment Canada’s GEM-MACH model, an on-line coupled meteorology and chemistry model that simulates gas-phase, aqueous-phase, and heterogeneous chemistry and a number of size-resolved aerosol (PM) processes, including wet and dry deposition. GEM-MACH computes weather-dependent biogenic emissions, and is fed with hourly gridded anthropogenic emissions that are prepared by the Sparse Matrix Operator Kernel Emissions (SMOKE) processing package. The current version of the RAQDPS generates 48-hour forecasts twice daily on a North-American domain with 10-km horizontal grid spacing and 80 vertical levels. In locations where real-time monitoring data are available, a statistical model (UMOS-AQ) is applied to enhance the forecast reliability. UMOS-AQ output is used as the primary guidance, from which operational meteorologists generate public Air Quality Health Index (AQHI) forecasts. The RAQDPS also benefits from several support systems, such as the VAQUM (Verification for Air QUality Models) system, which allows for continuous monitoring of the model’s performance. Hourly objective analyses are also produced for surface ozone and PM2.5, which provide the best approximation of current air quality conditions. Finally, an experimental version of the RAQDPS that includes near-real-time forest fire emissions (FireWork-GEM-MACH) is under formal evaluation. This presentation will give an overview of the various components of the RAQDPS and describe system performance and current system improvements. Short-term and long-term development plans will be discussed.

Keywords: Air Quality, Forecast, Operations, Modelling
NOAA provides operational predictions of ozone and wildfire smoke for the United States and predictions of airborne dust over the contiguous 48 states. Predictions are produced beyond midnight of the following day at 12 km spatial and hourly temporal resolution and are available at http://airquality.weather.gov. Ozone predictions combine the NOAA National Centers for Environmental Prediction (NCEP) operational North American Mesoscale (NAM) weather predictions with inventory based emissions estimates from the U.S. Environmental Protection Agency (EPA) and chemical processes within the Community Multiscale Air Quality (CMAQ) model. Predictions of wildfire smoke and dust storms use the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model. Smoke emissions combine NOAA analyses of satellite imagery with the U.S. Forest Service's BlueSky framework. Dust emissions use potential source locations from a satellite climatology of dust emissions modulated by predicted winds and soil moisture. Routine verification of ozone predictions relies on surface AIRNow observations, whereas smoke and dust verification uses satellite retrievals. Evaluation of ozone predictions shows that prediction accuracy is maintained while pollution sources are changing through updates in emission source estimates, refinements in process representation and updates in model configuration. Recent efforts include testing of predictions at higher 4 km resolution and validation against a suite of atmospheric composition observations from intensive field experiments. Development of fine particulate matter (PM2.5) predictions is exploring bias correction and data assimilation using real-time observations. Longer-term plans include development of PM2.5 predictions and comprehensive linkages between national air quality predictions and global atmospheric composition predictions, as resources allow.


Keywords: ozone, wildfire smoke, dust, fine particulate matter (PM2.5)
Parallel Session

SCI-PS175.04 - The regional chemical transport model over northeast Asia area operated by Japan Meteorological Agency

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Japan Meteorological Agency (JMA) issues bulletins about photochemical oxidant when the high oxidant concentration is expected. Recently, Meteorological Research Institute (MRI) of JMA has developed a regional-scale chemical transport model offline-coupled with the JMA non-hydrostatic model (NHM-Chem) over Northeast Asia. The model has a horizontal resolution of 20x20 km and a vertical resolution of 18 layers from the surface to 50 hPa in terrain-following coordinates. The lateral and upper boundaries of meteorological fields and ozone concentrations are given by a JMA operational global forecast model and a global chemical transport model. In the NHM-Chem model, we use the regional emission inventory in Asia (REAS Ver. 1.11) and the SAPRC99 gas-phase atmospheric chemical module which includes 72 species and 214 reactions. We validate the simulated surface ozone concentration by comparing domestic surface observations provided by the Ministry of the Environment of Japan. Although the variation of diurnal change of simulated surface ozone concentration coincides well with observations, the model overestimates by up to 50\%, especially at local grids. The overestimation in ozone concentration may be caused by the chemical process in the model. During the period from April 2010 to September 2013, the model bias from the observation, the root mean square error, and the coefficient of correlation averaged over all calculated grid points are +10.3, 17.1, and 0.44, respectively. In this study, we show that the model can accurately simulate surface ozone concentration, and JMA has a plan to start operation to provide more detailed bulletin in 2015.

Keywords: Oxidant, Chemical transport model, Northeast Asia
Parallel Session

SCI-PS176.01 - Replacing localization with explicit correction of regression sampling errors in ensemble filters

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Localization of the impact of observations has been a key part of applications of ensemble filters to numerical weather prediction models. Localization is designed, at least in part, to reduce errors due to spuriously large correlations between observations and state variables that can occur with small ensembles. An alternative to localization is to estimate sampling errors in correlations and explicitly correct for them as part of the assimilation process. The method described in this talk generates a prior probability distribution function for the correlation between a given observation and a state variable as part of the ensemble algorithm. An application of Bayes rule combining this prior and the ensemble sample correlation is used to find a maximum likelihood estimate of the proper correlation and this is used to compute the posterior for the state variable. The sample correlation is also used to update the probability distribution function for the correlation. This method can eliminate the need for tuned localization in low-order model examples. Challenges for implementation in NWP models are outlined.

Keywords: Data Assimilation, Ensemble Filters
Parallel Session

SCI-PS176.02 - New analytical methods for adaptive localization for Ensemble Methods in data assimilation.

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Ensemble data assimilation systems are very popular for many applications. They provide a flexible alternative to large-scale variational systems. Many different versions of ensemble filters have been suggested and tested over the last years. However, although Ensemble-DA has high potential, its theoretical justification is still under development, both on the application side testing the development and operational setup of EnKF systems for different data types as well as the mathematical analysis looking into approximation properties of ensembles with ensemble-size small compared to the total number of degrees of freedom in the model. It is very common to use space localization in order to reduce the effect of spurious long range correlations and increase the effective size of the ensemble space. It is the goal of our analysis to understand the basic properties of localization. We derive deterministic error estimates for the EnKF and study its dependence on localization. In particular, we investigate the convergence of the localized EnKF when the localization radius tends to zero. Then, we demonstrate the practical meaning of the analysis by derivation of a formula for an optimal localization radius depending on the observation density and the observation error. The validity of the formula is also demonstrated by numerical experiments for some simple assimilation systems.

Keywords: Ensemble Kalman Filter, Localization, Analytical Methods, Data Assimilation
SCI-PS176.03 - Linear filtering of sample covariances for ensemble data assimilation: theory and applications of optimality criteria

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The estimation of forecast error covariances estimation is a key-point to get flow-dependence in the data assimilation (DA) scheme of a numerical weather prediction (NWP) system. For several years, it has been shown that ensemble methods are the most accurate for this task. However, their huge computational cost raises a strong limitation to the ensemble size. Consequently, covariances estimated with small ensemble are spoiled with random sampling error, especially at convective scales. A theory of covariances filtering has been developed in order to remove most of the sampling noise while keeping the signal of interest. This theory arises from the merging of theory of linear filtering and theory of sample centered moments estimation. Its strength comes from the definition of a criterion for optimal filtering that relies on known quantities, that are the raw and the filtered sample covariances. This criterion paves the way for new algorithms and interesting applications for NWP. Two of them are detailed: spatial filtering of variances and covariances localization. The theory is tested with real background error covariances computed using a large Ensemble Data Assimilation (EDA) at convective scale coupled with a large EDA at global scale, based respectively on the AROME and ARPEGE operational NWP systems. Variances filtering algorithms, both homogeneous and heterogeneous, show very good and consistent results. Localization functions are successfully diagnosed from the ensemble, providing relevant localization length-scales that strongly depend on the number of members, on the meteorological variables and on the vertical levels.

Keywords: Ensemble data assimilation, Sample covariances, Variances filtering, Covariances localization
Parallel Session

SCI-PS176.04 - Convergence of the Desroziers' scheme and its relation to the lagged-innovation diagnostics

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The convergence properties of the Desroziers scheme is first reviewed using simple models. We show that the scheme always converge but may not converge to the true estimate. Additional information about the innovation covariance is always needed for the scheme to converge to the truth. For example, if the background error is estimated then the knowledge of the observation error variance is required for the estimate to converge to the truth. If both background and observation error variances are estimated then accurate knowledge of the error correlations are required for the scheme to converge to the truth. If the background and observation error variances and correlation length-scales are estimated, that is a total of four parameters are estimated, then accurate knowledge of the correlation model type is needed for the scheme to converge to the truth. We show that the Desroziers diagnostic is in fact related to the lagged-innovation covariance introduced by Daley (1992). When the Desroziers scheme converges to the truth then the lagged-innovation covariance converges to zero. In real application where the additional innovation covariance information required for the Desroziers scheme to converge to the truth maybe missing or difficult to estimate, is it suggested that the monitoring of the lagged-innovation covariance is indicative of the convergence to the truth.

Keywords: Desroziers' scheme, Lagged-innovation, data assimilation, diagnostics
Forecasting and monitoring of high impact weather has made significant progress over the past decades due to advances in technology and science. These developments are associated with an ever increasing amount of information. High density in particular remote sensing observations allow further progress in numerical weather prediction and enable the forecaster to monitor the weather in high detail. Nowcasting applications and numerical weather predictions provide a plethora of forecasts on many scales. Forecasters can rely on a technical infrastructure that provides them with all necessary data in real time. In order to be able to issue timely and high quality warnings, the forecaster has to be supported by applications extracting the essential information and eventually providing a semi-automated first guess. Using this information the final forecast or warning needs to be monitored, validated or modified by the forecaster. This talk will focus on the design of these applications considering different scenarios ranging from winter or summer nowcasting to the forecasting of wind storms or heavy precipitation. The main components of the warning system like lagrangian nowcasting methods, convection permitting ensembles or applications to produce or edit automated warnings will be discussed. Finally the role and the necessary expertise of the forecaster will be looked at.

Keywords: high impact weather, semi-automated forecasts, warning operations
Parallel Session

SCI-PS177.02 - Forecasting a Continuum of Environmental Threats (FACETs): A proposed next-generation warning concept for the U.S.

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The National Severe Storms Laboratory (NSSL) and the National Weather Service (NWS) of the United States’ National Oceanic and Atmospheric Administration (NOAA) are jointly exploring a next-generation concept for forecasting and communicating hazardous weather impacts. For over 40 years, U.S. watches and warnings have changed little from their deterministic roots. A new concept, called Forecasting a Continuum of Environmental Threats (FACETs), takes a holistic, modernized approach to the watch/warning practices of the U.S. by exploring probabilistic hazard information (PHI) communicated across a temporal continuum from days to seconds while applying social and behavioral science to the entire watch/warning process. Designed to capitalize on Warn on Forecast and other storm-scale modeling output, FACETs is simultaneously a new watch/warning paradigm and a comprehensive framework to focus and direct efforts to improve the science, technology and tools for forecasting environmental hazards of all types. This presentation will introduce the FACETs concept and describe the progress being made in its development and testing.

Keywords: Warnings, Future, NOAA, FACETs
Parallel Session

SCI-PS177.03 - Australian NexGen Forecast and Warning System

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A gridded weather forecast and warning value-chain in the Bureau of Meteorology is based on the Graphical Forecast Editor (GFE) for forecast production and Visual Weather for data visualisation and situational awareness. After outlining the value-chain, this paper focusses on the development and use of high-resolution (1.5km) rapid-update-cycle (RUC) and calibrated probabilistic ensemble guidance. It will also outline the use of such guidance by forecasters in GFE forecast processes, and communication of resulting gridded digital GFE outputs, on seamless timescales from nowcasting to medium-range predictions. Ensemble guidance generated for GFE input includes precipitation and tropical cyclone probability forecasts, and ensemble mean forecasts with the lowest RMSE for other fields. This guidance reduces the need to edit direct model output for routine forecasts, allowing greater forecaster focus on high-impact weather. A trial project incorporates bias-corrected high-resolution RUC guidance into the forecast process, with automatic production of first-guess hazard forecasts and alerts. Forecast production efficiency is being improved through routine forecast automation, improved guidance and verification. The forecast and warning process is framed by a well-managed set of semi-automated GFE “smart tools”, which facilitate service quality management. Forecasts and warnings are derived from the same gridded data and so remain consistent. The system is suited to blending digital weather forecasts with exposure and vulnerability layers to deliver hazard impact-based services. The resulting Digital Forecast Database provides national text, graphical and gridded digital coverage at 6km resolution, and supports quantitative downstream systems, including fire spread models, as well as products through third-party providers.

Keywords: forecast, warning, system, value-chain
Parallel Session

SCI-PS177.04 - Automated weather warning proposals based on post-processed numerical weather forecasts

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Within project AutoWARN the German Weather Service (DWD) has been developing and introducing automated components to its weather warning process. While the forecasters still have the final responsibility for issuing warnings, they are guided by automated warning proposals derived from nowcasting data (NowCastMIX) as well as from several numerical (ensemble) weather forecasts post-processed and combined with Model Output Statistics (MOS; ModelMIX). In this work the AutoWARN project is introduced in general. It is described how to derive automated warning proposals from ModelMIX forecasts. The main challenge is to extract the significant information from several numerical (ensemble) forecasts and then generate a meteorologically consistent set of warning proposals close to the expected impact of the predicted weather related hazards. A compromise needs to be found between accuracy and complexity to make sure the forecasters can handle the automated warning proposals properly within the weather warning process. In a first step a spatial and temporal filter algorithm was developed so that only the significant information in the ModelMIX forecasts is kept. Noise that cannot be explained with any forecast skill is removed. Thresholds are used to identify the strength and the spatial and temporal development of the high impact weather events. Then spatially coherent warning regions – i.e. where warnings are proposed to be issued - are determined from the filtered ModelMIX data. Finally, the warning regions are temporally structured with a clustering algorithm. The algorithm is designed in a way to ensure a meteorologically meaningful temporal development of the warnings.

Keywords: weather warnings, forecast guidance, model post-processing
Parallel Session

SCI-PS178.01 - Chinese contributions to the space-based GOS: Fengyun meteorological satellites and their application to NWP

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The history, current status and future program of the Chinese Meteorological Satellite, i.e. Fengyun satellite (FY) is introduced in this presentation. Currently, there are 2 FY polar satellites and 3 FY geostationary satellites are in operational. The type of the instruments amounted on FY satellites includes the optical imager, the atmospheric sounder, the microwave imager, the atmospheric composition detector, and the radiation budget mapper. The variety of measurements from FY satellites provides the NWP communities an independent data source. The data quality of FY satellites is illustrated through global space-based inter-calibration system (GSICS) in this presentation. The works of FY satellite data assimilation is reviewed. The applications of the FY-3 sounding data and the FY-2 cloud derived wind product are emphasized especially. The program of the FY-3 early morning orbit satellite is presented at last. The initial utilization has built the confidence that FY satellite data can contribute positively to NWP model forecasting. It is believed that the FY series not only benefit the nation of China, but they are also a valuable contribution to the international meteorological, hydrological, and environmental community.


Keywords: Fengyun Meteorological Satellite, data quality, satellite data assimilation
Parallel Session

SCI-PS178.02 - Continuity and Innovation provided by EUMETSAT’s New Satellite Programmes

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EUMETSAT satellites are cornerstones in the operational space-based observing system of weather and climate. They provide atmospheric, land and ocean observations for use in Numerical Weather Prediction, Nowcasting and for Climate Monitoring. The current contributions from EUMETSAT include geostationary Meteosat and the polar orbiting Metop satellites. Currently Metop-A and Metop-B, are operated simultaneously, with Metop-B being the prime satellite. Metop, with its various instruments, provides a large contribution to today’s quality of global NWP. We show specific examples of new products such as Atmospheric Motion Vectors (AVMs) derived from both Metop satellites, and the GOME-2 (Global Ozone Monitoring Experiment) tandem operations. The presentation also informs about EUMETSAT’s next generation of geostationary (Meteosat Third Generation - MTG) and polar orbiting Metop Second Generation satellites (named EPS SG = EUMETSAT Polar System Second-Generation). The approved MTG programme includes a total of six satellites four of which carry i) an advanced Flexible Combined Imager (FCI) with 16 channels, and ii) a lightning imager (LI). The two MTG sounding satellites carry iii) an infrared hyperspectral sounder (IRS) and iv) a spectrometer measuring trace gases and aerosol in the UV, visible and near-infrared (UVN). While the imager provides continuity and improvements over and above MSG, the other three instruments on MTG, though they have heritage from polar satellites, can be seen as a step enabling innovation and better operational services. Finally the future Metop Second Generation is presented.

Keywords: Satellite Observations, New Instruments, Applications, Impact on NWP
The US, Japanese, Korean, and European meteorological agencies are all upgrading their geostationary weather imagers to provide much more frequent Full Disk Earth images (every 5 to 10 minutes). Exelis' Advanced Baseline Imager (ABI) will fly on GOES-R East, GOES-R West, Himawari (Japan), and GEO-KOMPSAT-2A (Korea), providing these missions the additional capability for interleaved mesoscales delivering storm observations every 30 to 60 seconds. Arctic weather observation, however, is still limited to a few passes a day from low Earth orbit (LEO) satellites, many of which are well beyond their intended operational life. Arctic weather could obtain the same temporal fidelity as equatorial and mid-latitude weather if Canada's Polar Communication and Weather (PCW) mission flies with ABI imagers. This would provide full images of the Arctic every 10 minutes plus interleaved storm watches every minute, rather than just a swath every 100 minutes. Such coverage would dramatically improve the quality of Arctic weather observation and prediction. This poster will explain the capabilities of ABI on PCW and discuss how these capabilities would significantly improve Arctic weather models and forecasting.

**Keywords:** Arctic, Weather, ABI, PCW
Parallel Session

SCI-PS178.04 - Research and development on satellite radiance assimilation at the Canadian Meteorological Center

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Optimizing the impact of observations on forecasts is the key objective of data assimilation (DA). Here, we focus on recent developments linked to satellite radiance assimilation at the Canadian Meteorological Center (CMC). These data account for nearly 90% of all assimilated data. The sensitivity to various parameters defining radiance quality control was reviewed: bias correction, observation error, channel selection, and data density. With the upcoming ensemble-variational (En-Var) DA system, the number of assimilated hyperspectral infrared channels will double to reach about 140 for each sensor (AIRS, IASI, Cris). The impact of significantly reducing the thinning (currently 150 km) is under evaluation. At the same time, the DA system was upgraded to consider inter-channel error correlations for all radiances. Results will be available at the time of the conference. Research is also progressing on the assimilation of infrared radiances which are sensitive to the surface over land. En-Var creates a new DA environment in many ways, in particular by providing flow-dependent background errors, error correlation between surface skin temperature and atmospheric variables, and error correlations between temperature and humidity.

Keyword: radiance data assimilation,
SCI-PS179.01 - Towards the assimilation of near-surface winds: Development of a geo-statistical observation operator

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Although increasing NWP model resolution helps improve forecast skills in the lower troposphere, the main sources of near-surface wind forecast errors are still the analysis inaccuracy due to the limited number of assimilated near-surface wind observations, the atmospheric boundary layer modeling, and the growth of large-scale errors in the analyses. The main objective of this project is to improve lower tropospheric analyses by assimilating near-surface wind observations (over land) in the ensemble variational data assimilation system (EnVar) developed at Environment Canada. To achieve this, it is necessary to complete: 1) an evaluation of near-surface background error correlation with the upper air atmosphere; 2) the development of a geo-statistical observation operator including systematic and representativeness error corrections; 3) the estimation of the observation error covariances; and 4) a validation of the method where observation system experiments are performed, assimilating only near-surface wind observations. The resulting analyses are verified against non-assimilated collocated radiosondes to assess the vertical corrections. This approach allows an estimation of the observation error statistics based on independent observations. Propagation of the information in the vertical has been evaluated when using both static and flow dependent background error covariances. Results from one month of assimilation experiments show that the geo-statistical operator eliminates observation biases and reduces representativeness errors standard deviation by $\sim0.3$m/s. When compared to a bilinear interpolation, the geo-statistical operator improves the near-surface wind analysis by 5%-10%, mainly over complex sites. While the bias correction is a key component, representativeness error is also significantly contributing to the improvement.

Keywords: Observation operator, Near-surface wind, Representativeness error, Bias correction
At DWD, the Ensemble Kalman Filter has been implemented to be used for the numerical weather prediction model COSMO at the convective scale (2.8km horizontal resolution). A recently developed approach to assimilate cloud information from Meteosat-SEVIRI satellite cloud products in the LETKF will be introduced. Depending on whether an observed pixel is cloudy or cloud-free, different pseudo-observations are derived from the satellite cloud-top height product, and the corresponding model equivalents are computed. These are cloud-top height and relative humidity at cloud-top height for observed cloudy scenes, and cloud cover in several layers for observed cloud-free scenes. Single observation experiments, data-dense hourly cycling experiments, and forecasts initialized based on these analyses have been carried out. Especially for low-stratus clouds typical for stable winter-time high-pressure systems improvements in cloud-cover are obtained. Clouds which are not properly represented in the first guess are enhanced in the analysis, and spurious cloud cover in the first guess which has not been observed, can be reduced. Compared to experiments with assimilation of only conventional data, the experiments with additional assimilation of cloud information show more realistic cloud fields, even after several hours forecast time. The method itself and results from experiments will be presented. Other ongoing research and developments at DWD towards incorporating high-resolution data at the convective scale will be highlighted briefly. The overall aim of these developments is not only to improve the short-range numerical weather forecasts per se, but a special focus is to improve the strongly weather dependent renewable energy power predictions.

**Keywords:** satellite cloud product, data assimilation, convective scale, ensemble Kalman filter
Parallel Session

SCI-PS179.03 - Applying GSI 3DVAR-Ensemble Hybrid Data Assimilation System for rapid refresh with regional ensembles

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NOAA’s Rapid Refresh forecast system (RAP) is an hourly-updated regional data-assimilation and forecasting system that uses the Weather Research and Forecasting (WRF-ARW) model with 13-km horizontal grid spacing and the Gridpoint Statistical Interpolation (GSI) analysis package. The RAP version 2 has been running operationally at NCEP since February 2013 including a GSI 3DVAR-Ensemble hybrid assimilation with the GFS EnKF global ensembles. In 2013, we focused on testing and tuning a number of GSI hybrid configurations based on the needs of RAP, including using EnKF ensemble forecasts at one hour intervals, tuning the ratio of static and ensemble background error (BE), and finding better vertical and horizontal localizations for this mesoscale application. Radar reflectivity assimilation is a key component of the RAP assimilation using specification of latent-heating within a forward-backward digital filter initialization at 13km and in forward mode only at 3km. The current application of GSI hybrid data assimilation within the RAPv2 has significantly improved mid- and upper-level wind and moisture forecasts, but we anticipate further improvement replacing GFS-ensemble forecasts with regional RAP ensemble forecasts within the GSI hybrid. In 2014, we plan to build RAP ensembles, which would be initialized from GFS EnKF ensemble members, to feed into RAP GSI hybrid system with a goal of improving RAP forecasts of near-surface fields and localized weather phenomena including cloud/hydrometeor fields. This talk will introduce the RAP data assimilation system and then focus on the progress of applying the RAP GSI hybrid assimilation with regional RAP ensembles.

Keywords: GSI, Hybrid, RAP, radar data assimilation
Parallel Session

SCI-PS179.04 - Using data assimilation to explore precipitation - cloud system - environment interactions

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While data assimilation (DA) has many applications, its fundamental purpose is the combination of information from disparate sources. In most modern DA algorithms, each piece of information is associated with a probability distribution. These are then related through a model that maps from one probability space into another. The outcome is an estimate of the probability structure of one or more variables of interest conditioned on each piece of information; typically prior knowledge, a set of observations, and the formulation of the model itself. Information derived from this probability distribution may include an optimal estimate and/or measures of variability and relationship between variables (e.g., (co)variance). This presentation demonstrates how this very general perspective on data assimilation can be used to explore fundamental relationships in the hydrologic cycle. Specifically, a Bayesian Markov chain Monte Carlo algorithm is used to compute the probability distribution of cloud systems joint with their environment. Two different physical systems are considered. The first example explores the multivariate functional relationships between precipitation, cloud microphysics, and the environment in a deep convective cloud system. The second examines the relationship between orographic precipitation and the upwind sounding and mountain geometry. In each case, the Bayesian framework can be shown to provide unique information on the inter-dependencies present in the physical system.


Keywords: Hydrologic cycle, Markov chain Monte Carlo, Convection, Orographic precipitation
Severe fire weather in southern Australia is invariably associated with strong anticyclones, which direct very dry northerlies or northwesterlies on their western flanks from the interior of the continent across southern Australia. Such dry airstreams precede the passage of very strong cold fronts, which are themselves followed by strong southerlies or southwesterlies. This pattern is the signature of all days producing catastrophic wildfires and is associated with propagating Rossby waves, which grow to large amplitude and eventually irreversibly overturn. Rossby wave breaking in the region produces an upper-level cyclonic potential vorticity anomaly to the north (towards the equator) with an upper-level anticyclonic potential vorticity anomaly to the south (towards the pole). The process of overturning produces the low level anticyclone and dry conditions over southern Australia, while simultaneously producing an upper-level trough and often precipitation in northeastern Australia. From this perspective, catastrophic wildfires in the southeastern part of the continent and heavy rain in the Australian tropics can be two sides of the same coin. Moreover, heavy rain in the Australian tropics and the associated production of anticyclonic potential vorticity in the upper troposphere amplifies the breaking process, which in turn results in more severe fire weather. The south Atlantic or South America appears to be the origin of these Rossby waves, which propagate along the large potential vorticity gradients co-located with the jet. During summer, the principal jet stream in the Southern Hemisphere is directed from the Atlantic to south of Australia.

**Keywords:** Rossby Wave, Wildfire, Front, Tropical Convection
Parallel Session

SCI-PS180.02 - Experiments with the FIM global model for blocking at seasonal to medium-range

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Frequency and longevity of stationary wave events (a superset of Tibaldi-Molteni blocking events) is a critical driver for extreme temperature and precipitation anomalies. NOAA/ESRL continues numerical, physics, and coupled ocean refinements to the FIM global model (Flow-following finite-volume Icosahedral Model) with a unique combination of an adaptive largely isentropic vertical grid and an icosahedral horizontal grid. The FIM model is being applied to both medium-range and seasonal prediction with success and is a candidate for NOAA global prediction including within a multi-model ensemble and as a research earth system simulator with ocean and inline chemistry components already in use. FIM is currently run at down to 10-km resolution in real-time. Recent 12-month AMIP experiments with the FIM model showed 2 key results: 1) excessive stationary wave frequency with 120km and 240km resolution vs. 30km and 60km, and 2) a cold bias using a conventional sigma-pressure vertical coordinate vs. the adaptive isentropic-hybrid coordinate normally used in FIM. An extension to these initial experiments will be reported at WWOSC including addition of 15km experiments and MJO behavior through the DYNAMO 2011 period. Evaluation of stratospheric sudden warming events will be added in these experiments comparing the effect of FIM’s isentropic vertical coordinate vs. a sigma-pressure option for stratospheric dynamics and stratospheric-tropospheric exchange. Performance of the FIM global model vs. GFS and other models for medium-range prediction will be summarized in a poster, including detail on its full earth-system capability with inline chemistry and a matching icosahedral version of the HYCOM ocean model.

Keywords: blocking, potential vorticity, isentropic
Parallel Session

SCI-PS180.03 - Mediterranean moisture supply during an extreme precipitation event in the northwestern Mediterranean

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In autumn, the Mediterranean region is very often affected by heavy precipitation and following flash floods. Precipitation amounts of more than 200 mm/24h are not rare. Several such events occurred between September and November 2012, during the HyMeX (Hydrological cycle in Mediterranean Experiment). The collected dataset allows detailed studies of these extreme weather events. Between 11th and 13th October 2012 a Mediterranean cyclone developed east of Spain and moved towards Italy. Embedded convection developed in its warm sector and lead to strong precipitation all over the northwestern Mediterranean. Convection permitting simulations with the COSMO model give us insight into processes leading to this strong precipitation. Our focus here is on the role of local evaporation from the Mediterranean sea in feeding this system as opposed to advection of moisture into the region. The diagnosed processes are validated with measurements of atmospheric moisture and surface fluxes by aircrafts, ships and buoys.

Keywords: high precipitation, surface fluxes, convection, Mediterranean
High impact weather events in the western Mediterranean basin can provoke locally high precipitation rates which cause floods and landslips. These events mostly occur from September to November. In autumn 2012 the international field campaign HyMeX (Hydrological cycle in Mediterranean Experiment) took place in the western Mediterranean. It provides a wide dataset to study heavy precipitation events. At the end of September 2012, a very prominent mesoscale convective system - causing huge damage and several casualties - affected the Spanish, French and Italian Mediterranean coasts. Our goal is to distinguish between different processes which led to uncertainties in forecast for this HyMeX case, especially on the grid cell scale (e.g. mesoscale flow and diabatic processes). To study the case, several different simulations were carried out. In order to study involved physical processes, we performed a high resolution run of the German COSMO (Consortium of small scale modeling) model (horizontal resolution of 2.8km), which was validated with different kinds of HyMeX measurement data. To investigate the impact of a stochastic convection scheme, the recently developed Plant-Craig scheme was implemented in a coarser COSMO simulation (horizontal resolution of 7km). In this way, we performed an ensemble analysis of the heavy precipitation event. An emphasis of this study lays on different settings of the stochastic convection scheme and its results in precipitation intensity, timing and distribution.

**Keywords:** Heavy precipitation events, Stochastic convection parameterization, HyMeX campaign
Parallel Session

SCI-PS181.01 - Physically-based stochastic parameterisation

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Stochastic parameterisation is widely recognised as an important source of variability in ensemble weather prediction. While the introduction of randomness in an atmospheric model is often motivated as representing the effects of unresolved small-scale processes, most implementations currently in operational use are pragmatic in that they are configured to produce the desired effect on the ensemble output rather than being based explicitly on a representation of the small-scale processes. Ideally a parameterisation scheme should be designed from the start to represent variability at length and time scales corresponding to the model resolution. This talk will review the key issues that arise when attempting to formulate a physically-based stochastic parameterisation, including - relationship of stochastic variability to closure assumptions - incomplete representation of uncertainty by a scheme that only represents a single process - verification of stochastic parameterisation - interaction with resolved variability and resolution dependence. The general concepts will be illustrated with examples using the Plant-Craig stochastic parameterisation of deep cumulus convection.

**Keywords:** stochastic parameterisation, parameterisation
Parallel Session

SCI-PS181.02 – WITHDRAWN - Impact on convective initiation of a stochastic boundary layer parameterisation

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The predictability of high impact weather and the related uncertainty originates in instabilities and hence variability on both small and large scales. The relative importance of different mechanisms seems to depend on the controlling weather regime. In this study, we focus on the representation of the initiation of convection in numerical weather prediction models. Here, small-scale variability seems to be important. In weakly forced convective regimes, a common error is that numerical models often trigger convection too late. We hypothesise that this is due to missing variability in the atmospheric boundary layer. Therefore, we develop a stochastic parameterisation to introduce variability representing the physical processes in the boundary layer which affect the initiation of convection: surface heating, subgrid scale orography and cold pools. The terms representing these processes are identified in the model's boundary layer parameterisation and their product with Gaussian random perturbations is added to the tendencies. This approach is tested in the COSMO model in experiments with 2.8 km horizontal resolution for case studies representing different weather regimes. Sensitivity tests are conducted to quantify the relevance of free parameters in the approach.

**Keywords:** convection, stochastic parameterisation
SCI-POT1131 - A Hybrid, NWP-Analog Ensemble

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An analog ensemble is constructed by first matching up the current forecast from an NWP model with similar past forecasts from the same model. Then the past verifying observation from each match is used as an ensemble member. The advantages include application to a higher resolution real-time forecast model, avoidance of model perturbation challenges, and production of calibrated forecasts. However, the analog ensemble may have a limited ability to capture flow-dependent error growth due to reliance on a single model solution, whereas a traditional NWP ensemble may do better. A hybrid ensemble may be an optimal approach, combining strengths of an NWP and analog ensemble. The hybrid ensemble is constructed by finding m analogs for each member of a small n-member NWP ensemble, to produce a total of m*n members. Real-time compute cost is kept low with only a few model runs, but those runs reveal the major aspects of flow-dependent error growth. The analogs then increase the sampling and map from model space to reality to produce a calibrated forecast PDF. Comparing performance of the analog ensemble and hybrid ensemble shows mixed results. The hybrid ensemble performs worse for probabilistic 10-m wind speed forecasts and somewhat superior for 2-m temperature forecasts. A possible explanation is the hybrid ensemble’s use of the Environment Canada’s Regional Ensemble Prediction System (REPS) in which all members share the same model configuration. The hybrid ensemble approach may work best when applied to a multi-model NWP ensemble where the members’ diversity can be considerably greater.


Keywords: ensemble, analog, probabilistic, multi-model
Parallel Session

SCI-PS181.03 - An investigation of the evolution of forecast uncertainty in Global Model Forecasts

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We investigate the evolution of forecast uncertainty in global model forecasts with the help of the TIGGE data set and numerical experiments by CAM. We argue that beyond forecast times day 3-5, synoptic scale patterns dominate the forecast uncertainty. We investigate the process by which uncertainties, due to initial condition and model errors, propagate toward the synoptic scales. We demonstrate that there are important differences between the efficiency of the different ensemble forecast systems included in TIGGE in representing the forecast uncertainty during the initial transient phase. While the differences between the performance of the different systems are smaller at the later forecast times, the different ensemble systems are clearly tuned to satisfy different optimality conditions. The systems that employ stochastic schemes for the representation of the effect of model uncertainty perform well in predicting the first and second statistical moments of the forecast errors, even though the justification for the formulation of the particular schemes may not be well-founded. CAM experiments are used to explain the behavior of the existing schemes and to design new ones.

Keywords: forecast uncertainty, TIGGE, stochastic schemes
Parallel Session

SCI-PS181.04 - Initial ensemble perturbations provided by convective-scale ensemble data assimilation

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How to derive proper initial conditions for convective-scale ensemble prediction systems (EPS) is still an open question. Initial condition perturbations are frequently generated through dynamical downscaling of information from lower resolution models. This approach has been showing overall good results and also is used currently in the operational Consortium for Small-scale Modeling (COSMO) EPS for the German domain (COSMO-DE-EPS) at Deutscher Wetterdienst (DWD). An alternative approach to derive proper high-resolution initial ensemble perturbations, is to apply an convective-scale ensemble data assimilation system which provides a full analysis ensemble in addition to a deterministic analysis. The derived analysis ensemble, which gives an estimate of the current theoretical analysis uncertainty, can be used as initial conditions for subsequent ensemble forecasts. A kilometer-scale ensemble data assimilation (KENDA) system for the COSMO model, which applies a local ensemble transform Kalman Filter (LETKF), is currently under development at DWD. In this study, we investigate the potential benefits of LETKF generated initial conditions for ensemble forecasting. We compare COSMO ensemble forecasts using ensemble perturbations provided by the KENDA-LETKF against the operational issued COSMO-DE-EPS. The results show that using LETKF ensemble perturbations lead to an improved representation of uncertainty in ensemble forecasts. The LETKF ensemble perturbations are able to represent uncertainty in the initial state also at the convective-scales. Further, different inflation methods in KENDA are compared which are crucial to account for unrepresented model and sampling errors in the LETKF.

Keywords: Initial ensemble conditions, high-resolution forecasts, LETKF, COSMO-DE-EPS
One of the most well-known climate modes is El Niño/Southern Oscillation (ENSO) in the tropical Pacific. In 1999, another but similar climate mode associated with a dipole sea surface temperature (SST) pattern was catalogued in the tropical Indian Ocean. The phenomenon is now called Indian Ocean Dipole (IOD) based on Saji et al. (1999). The discovery was rooted in recognition of absence of the fall Yoshida-Wyrtki jet related to intraseasonal disturbances in 1994 (Vinayachandran et al. 1999; Behera et al. 1999). Interestingly, we also noticed another unusual condition in the tropical Pacific in 1994; it led us to introduction of another climate mode called ENSO Modoki showing a tripole SST pattern in longitudes in the tropical Pacific (Ashok et al. 2007; Weng et al. 2007, 2009). Those climate modes in the tropics have some influences on subtropical climate modes such as the Subtropical Indian Ocean Dipole catalogued in 2001 (Behera and Yamagata, 2001). More recently, the discovery of coastal ocean-atmosphere coupled modes as typified by the phenomenon named Ningaloo Niño off the western coast of Australia (Feng et al. 2013; Kataoka et al. 2013; Doi et al. 2013) has opened a new dimension in regional climate research. The predictability of new climate modes may depend on the degree to which those are linked with ENSO, but capturing their unique independent nature is also important. In the present talk, the predictability of newly catalogued climate modes is discussed with the rich future scope for societal applications.

**Keywords:** Climate mode, Predictability, ENSO, IOD
Parallel Session

SCI-PS182.02 - Understanding the role of the Maritime Continent in the global weather-climate continuum: YMC

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The Maritime Continent (MC) is known to play a key role in the global climate by hosting the ascending branch of the Walker circulation, whose migration is tightly related to various phenomena such as the El Nino Southern Oscillation, Indian Ocean dipole, monsoon, and Madden-Julian Oscillation. It is, however, unclear how the local circulation and convection over the MC interact with these phenomena. Their complicated topography with steep mountains and surrounding warm waters in the MC region produce frequent convection with strong diurnal cycle. Current global climate models as well as numerical weather prediction models fail to reproduce the observed precipitation diurnal cycle and suffer from mean dry/wet biases over the ocean/land in the region. Coordinated field campaigns are strongly desired to advance the study on the MC. Since various temporal (several hours to inter-annual) and spatial (several kilometers to basin)-scale phenomena interact with each other, coordinated interdisciplinary campaigns over a longer period are required. To achieve this, a unique approach of field campaign called the Year of the Maritime Continent (YMC) is proposed to take place in 2017 - 2018, which will cover two monsoon seasons. With its philosophy of providing a framework for international collaboration under this umbrella, the ultimate goal of YMC is to understand the role of the MC in the global weather-climate continuum. In this presentation, several coordinated intensive observations under planning are introduced.

Keywords: Maritime Continent, field campaign, YMC, MJO
Parallel Session

SCI-PS182.03 - Intraseasonal variations in west Africa and east Pacific easterly wave energy budgets

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Previous studies have documented significant intraseasonal variability (ISV) in easterly wave activity in west Africa and the east Pacific warm pool that may contribute to ISV in tropical cyclone activity. The Madden-Julian oscillation is responsible for some of this ISV in easterly wave activity. We use reanalysis fields and a regional model to examine the perturbation kinetic energy (PKE) and perturbation available potential energy (PAPE) budgets of east Pacific and west African disturbances, including an examination of variability in these budgets on intraseasonal timescales. In west Africa, variability in baroclinic and barotropic energy conversions dominate variability in the energy budgets, including a significant enhancement in baroclinic energy conversions near the entrance to the African easterly jet (AEJ) before west African PKE maximizes. This signal is associated with an eastward extension of the AEJ into this region. Diabatic heating anomalies appear to weaken easterly waves downstream in west Africa during periods of enhanced easterly wave activity. In the east Pacific, barotopic energy conversions and diabatic heating serve as the major contributors to ISV in easterly wave activity. Whether convective disturbances in the Bight of Panama serve as precursor disturbances for east Pacific easterly waves is examined, in isolation of the need for African easterly waves to seed wave formation in this region. Medium range tropical cyclogenesis predictions may be aided by understanding the processes that control intraseasonal variability of easterly waves.

Keywords: Easterly waves, Intraseasonal energy budgets, West Africa, East Pacific
Parallel Session

SCI-PS182.04 - Numerical examination of tropical disturbances using the high-resolution global nonhydrostatic model NICAM

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The advantage of the high-resolution global nonhydrostatic model is that it can calculate more explicitly tropical convective systems including their meso-scale characteristics by use of a cloud microphysics scheme without deep convective parameterization. It naturally reproduce multi-scale structure of tropical disturbances covering meso-scale convection, cloud clusters, synoptic scale disturbances such as tropical cyclones (TCs), and more larger scale cloud systems associated with intraseasonal variabilities (ISV). Thanks to the recent progress of computer power like the K-computer in Kobe, Japan, the researches of the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) have extended to the following directions. First, a global experiment with much higher resolution at the horizontal mesh size 870 m is achieved and showed that convective cores become resolvable near this resolution (Miyamoto et al. 2013, Geophys. Res. Lett.). Second, longer time simulations with modest resolution are conducted: one year experiments with 3.5 km and 7 km meshes, and more than twenty years experiments with 14 km mesh. Dataset of these experiments enables us to discuss more statistical characteristics and predictability of tropical disturbances, especially ISV and TCs. In addition, since the simulated clouds of NICAM are produced at the resolution comparable to satellite observations, cloud characteristics are more directly evaluated with satellite data, and the cloud microphysics scheme can be improved from such comparisons. Future changes of clouds and cloud forcing are also discussed using the results with NICAM. Our experiences suggest that the global nonhydrostatic modeling is a prospective candidate of environmental prediction studies especially for the tropical regions.


Keywords: intraseasonal variabilities, tropical cyclones, global nonhydrostatic model, cloud microphysics scheme
Parallel Session

SCI-PS183.01 - Seasonal climate prediction in a climate services context

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The current status of climate forecasting at monthly and seasonal time scales will be described. The presentation will include illustrations from dynamical ensemble forecast systems and statistical models. The relevance of the forecast quality assessment, the physical mechanisms responsible for skill, reliability and predictability, the benefits of downscaling and calibration, the role of anthropogenic climate change, the relative merits of different methods for ensemble forecast generation and initialisation, a description of approaches to address model uncertainty and the implementation of seamless forecasting systems will also be discussed. A special focus will be put on the discussion of operational forecast systems and how they are expected to deal with the emerging climate services, using examples of their application for the renewable-energy sector.

**Keywords**: seasonal prediction, climate variability, global model
SCI-PS183.02 - Soil moisture forecasts potential to predict rain anomalies over land-atmosphere “hot spots” in South America

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Land surface variables (e.g. soil moisture) play an important role in the energy balance between the land surface and the atmosphere as well as in the evolution of the hydrological cycle. A better representation of the “slowly” varying variables (e.g. SST, soil moisture) in numerical models is essential to improve monthly and seasonal forecasts. The goal of this work is to evaluate monthly and seasonal soil moisture and rainfall retrospective forecasts (up to 4 months) in the Climate Forecast System (CFS, v2) over South America compared against the GLDAS (Global Land Data Assimilation System) for 1982-2010 summer periods. Previous work showed that GLDAS Version 2 provides good estimates of soil moisture variability over southern South America and is suitable to disclose areas with strong land-atmosphere coupling – identified following Notaro (2008) methodology-. Our analysis focuses over two sub-regions of interest: Southeastern South America and the South Atlantic Convergence Zone. Monthly forecasts show similar soil moisture variability patterns to those obtained with the GLDAS, with error increase (both systematic and non-systematic) with forecast length. These errors are related with the uncertainty in the initial condition and also with errors in the representation of soil moisture model driver, mainly rainfall. The comparison of forecasted and GLDAS coupling strength further contributes to understand the impact of soil moisture errors on rainfall forecast skill, and shows that soil moisture anomalies may be an adequate tool to anticipate rainfall anomalies one month in advance.


Keywords: Soil moisture, Prediction, Precipitation anomalies, Coupling strength
SCI-PS183.03 - Improvement of climate simulations: an ENSO example

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A new methodology is suggested here to improve climate simulation of the state-of-the-art coupled GCMs by a post-processing. It is well known that interannual variability in climate system is closely related to the climate mean state. Firstly, based on the multi-model ensemble and its diversity, the distinctive relation between interannual variability and basic state is found. For example, the pattern of ENSO-related precipitation anomalies is highly correlated to the pattern of climatological precipitation over the tropical Pacific. This indicates that the mean precipitation bias in climate models lead to systematic biases in simulating ENSO-related pattern. Since the mean biases of individual climate models are known, the model simulation can be calibrated based on a covariance matrix between the mean state and interannual variability. When this method is applied to ENSO-related precipitation, the simulated patterns of individual models as well as multi-model ensemble mean are considerably improved. In particular, the westward shifted bias of the equatorial precipitation anomalies, one of common problems in climate model simulation, is much improved after the correction.

Keywords: Climate simulation, ENSO
Parallel Session

SCI-PS183.04 - Toward probabilistic seasonal prediction

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Moving from the multimodel ensembles that are available from national and international weather prediction centers to calibrated probability distributions of climate variables of interest to users at subseasonal to interannual lead times remains a challenge. Here, we will report on work done toward improving climatology probability distributions to account for observed climate trends, providing a solid baseline for quantifying the gain from incorporating dynamical model simulations using information gain (IG) as the metric. We will also show preliminary results for model bias correction and accounting for error correlations between ensemble members and models, using hindcasts/forecasts from the North American Multimodel Ensemble (NMME) as case studies.

Keywords: Seasonal forecasting, NMME, Information gain, Bayesian inference
Managing heat health hazards in a climate of change: Mitigating risks for extreme weather in preparation for the Pan Am Games

Weather, climate variability, and other environmental factors are important determinants of health. Across Ontario extreme weather events are becoming more frequent and more intense. Extreme temperatures and high humidity poses a significant health risk to Canadians. There is a demonstrated link between heat and excess mortality. Mortality is largely preventable, given appropriate notification and interventions. There is no consistent national approach for issuing heat advisories and/or the responses required to reduce heat related mortality and morbidity. In Ontario, a decentralized system exists where public health authorities have chosen different approaches to triggering their heat alerts and response plans. Greater coordination is required amongst federal, provincial and municipal decision-makers in the identification of risks and vulnerabilities and the innovative responses to those challenges. The Meteorological Service of Canada, Health Canada, Ministry of Health Long-Term Care and Toronto Public Health have been working closely to continuously improve evidence-based capacity building and decision-making at the provincial and local levels in order to reduce morbidity and mortality related to heat in Ontario. This initiative is focused on developing an efficient, coordinated, evidence-based system comprised of robust, standardized criteria for calling heat alerts, and language easily understood by the public as well as the flexibility to address local vulnerabilities and needs. This innovative system will be piloted at the Pan Am Games in 2015 and it will provide a suite of inter-jurisdictional heat health management tools to anticipate and adapt to the ongoing challenges of climate change and extreme weather events.

UAS-PA405.01 - Panel Participant

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UAS-PA406 - Panel Discussion

Special Joint Panel on the Future of the Weather Enterprise

Public Sector Information at work: Make open, make available

This special joint panel on Weather Services Infrastructure is the first in a series of three designed to advance dialogue on the collaboration of private, public and academic elements of the weather enterprise—the first two explore important issues and problems while the final panel is oriented towards finding solutions. Infrastructure can be defined as everything necessary to design, develop and deliver products and services. It includes weather and climate observations, models and numerical weather prediction, and applications to specific customer decision making needs. It also includes the underlying information technologies (data processing, visualization, communications) as well as the education, training, and management of people—weather service providers, R&D scientists, and especially clients and users. Panel discussion will consider the gaps and weaknesses in present infrastructure that limit achieving the full potential of weather services? What infrastructure improvements are needed to increase the value of weather services to society?

Chair: David Parsons

UAS-PA406.01 –Panel Participant

Kristin Lyng

1 Norwegian Meteorological Institute, Oslo, Norway

In the context of empowering enterprises which are oriented towards new and innovative technologies and markets, MET Norway believes that free access to weather data and products has a huge potential to foster innovation and value creation for the society at large. There is a need of a change in attitude in public agencies towards openness, beyond the legal duty of transparency. Our work should be accessible and available for re-use with no restrictions, using standardised licenses.

UAS-PA406.02 - Panel Participant

Bob Marshall

1 Earth Networks, Germantown, USA

Severe weather impacts lives and livelihoods worldwide. Fortunately, communities can leverage advanced storm detection and alerting technology to build resilience and protect lives and livelihoods. Public-private partnerships play a central role by providing technology that can deliver the earliest possible warnings to literally billions of people. Private-sector innovations -- including real-time lightning detection – are helping countries adapt to climate change by making it possible to inform and alert to severe weather via apps and data so that national meteorological agencies and officials -- from the USA to Brazil to West Africa to Australia -- can know before severe weather strikes.
UAS-PA406 - Panel Discussion / Cont

UAS-PA406.03 - Panel Participant

Anne Hale Miglarese¹
¹PlanetIQ USA, Bethesda, USA

Severe weather impacts lives and livelihoods worldwide. Fortunately, communities can leverage advanced storm detection and alerting technology to build resilience and protect lives and livelihoods. Public-private partnerships play a central role by providing technology that can deliver the earliest possible warnings to literally billions of people. Private-sector innovations -- including real-time lightning detection -- are helping countries adapt to climate change by making it possible to inform and alert to severe weather via apps and data so that national meteorological agencies and officials -- from the USA to Brazil to West Africa to Australia -- can know before severe weather strikes.

UAS-PA406.04 - Panel Participant

Julia Slingo¹
¹Met Office, Exeter, UK

Putting it all together: An integrated Science programme, high performance computing infrastructure and team

Numerical weather and climate prediction are considered to be among the leading science and technological challenges of our time. Over the past six decades the weather and climate science communities have made significant progress on this challenge, both nationally and internationally, but somewhat independently. Now the scale of the challenge means that weather and climate science programmes of multidisciplinary research and development (meteorologists, oceanographers, physicists, mathematicians, chemists, computer experts and more) worldwide are needed to make cutting-edge contributions to the weather, climate and environmental prediction problem. Clearly more efficiency and progress will be achieved in the future with increasing integrated science programmes.

Central to all of these is high performance computing. Numerical weather prediction was one of the most important motivations behind the first computer applications fifty years ago and is still a major user of HPC. Computational power is needed to improve the accuracy of weather and climate models by: improving space-time resolution, increasing complexity of the processes we need to represent, and better quantifying forecasting uncertainties. Our five-day forecast today is as accurate as a one day forecast from 40 years ago. Each order of magnitude increase in computing power pushes this accuracy, with huge economic impact for cities clearing snow, emergency response to high impact weather events, or supporting insurance and financial markets. Hence we need to accelerate our investment in HPC infrastructure.
UAS-PA406 - Panel Discussion / Cont

UAS-PA406.05 - Panel Participant

Ajit Tyagi

\(^1\) Indian Meteorological Service, New Delhi, India

Last two decades have witnessed significant growth of Weather Enterprise in the most of developed and in some of the developing countries. While Academia and Public Sector, notwithstanding budgetary constraints, continued to play key role in generation of new knowledge and improving skill of weather forecasts, private sector has also contributed significantly to the growth of Weather Enterprise. The growth of private sector in developed countries is being driven by demand of value added services from weather/climate sensitive economic activities/sectors. The story is not the same with Least Developed Countries (LDCs) and most of the developing countries. Many of the National Meteorological Services in these countries are finding it difficult to maintain observational network and provide basic weather forecast and services. Private sector does not find much of opportunities in such countries and at the best carries out some projects funded by international agencies. On the other hand In many advance developing economies private sector is sensing opportunities to carry out business and contribute to Weather Enterprise. However the growth of private sectors in developing countries is not going to be smooth in the absence of the clarity about the role of private sector in the National Weather Enterprise. There is need to develop professional guidelines about the role and responsibilities of private sector in Weather Enterprise It needs to be appreciated while countries can learn from the experiences of other countries, each country will have its own model of Weather Enterprise driven by political, economic, and academic factors.

UAS-PA406.06 - Panel Participant

Eric Webster

\(^1\) Exelis Geospatial Systems USA, McLean, USA

Weather satellites continue to be the backbone and foundation for the global weather enterprise; they provide the vast majority of data used in numerical weather prediction models and enable us to observe the great expansiveness of the oceans, the atmosphere and the land areas not equipped with regional or local sensors. The world has become even more dependent on this crucial data and its impacts on business and life and property. Yet there are only a few countries possessing the means and ability to develop, launch and operate weather satellites – with the U.S. being one of the leaders. In the U.S. there is considerable confusion about the near and long-term state of weather satellites: the development of next generation programs has encountered significant schedule, budget and technological challenges; many satellites in orbit are beyond their design life; start-up companies are claiming they can provide data and information for less cost than legacy systems; and the overall worries of gaps and their impacts is causing heated debates in the Administration, in Congress, and in the private sector about what to about it.

Here in Canada, the government has been studying development of its own Polar Communications and Weather Mission (PCW), examining different business models, public/private partnerships, and international contributions, including participation by the U.S.

How do we balance the role of governments in providing critical weather satellite data, the increasing desire of the commercial sector to be involved, the demand by many in the enterprise for more open and standardized data, and the fundamental need of the public for improved weather forecasts and information?
Parallel Session

UAS-PS323.01 - How does introducing nowcasting tools in weather warnings help civil protection agents?

Thorsten Ulbrich¹, Martin Goeber²

¹Freie Universität Berlin, Hans Ertel Centre for Weather Research (HErZ), Berlin, Germany, ²Deutscher Wetterdienst (DWD)

WEXICOM (improving the process of Weather warnings and EXtreme weather Information in the chain from the meteorological forecasts to their COMMunication for the Berlin conurbation) is a project within DWD's Hans Ertel Centre for Weather Research (HErZ). WEXICOM investigates how weather warnings are being communicated and applied. Cooperating with DWD we conducted two online surveys with German civil protection agents before and after a nowcasting application was introduced into FeWIS (Fire Brigade Weather Information System), i.e., a weather warning platform offered by DWD to provide information on weather hazards to registered German civil protection agents. In June 2013 DWD added a nowcasting tool based on NowcastMIX named "GewitterMonitor". This tool uses short-term weather models and observations in order to estimate storm attributes including warning cones based on a 1x1 km grid. Both surveys aim at assessing how the nowcasting product meets the needs of civil protection and how agents make use of nowcast information. One survey provided prior to including nowcast information investigated users' trust and how they benefit from FeWIS. After the introduction, users gained experience in applying nowcasting. In December 2013 we launched a post-survey which analyzed the use of the GewitterMonitor and inquired how nowcasting supports civil protection to respond to weather extremes. The post survey repeats questions on FeWIS and poses questions derived from the preceding survey. This second survey collects practitioners' feedback on GewitterMonitor and relates responses to the prior survey to detect how users' perception of the performance of FeWIS has changed.

Keywords: Risk Communication, Online Information Tools, Civil Protection, Weather Warning
Parallel Session

UAS-PS323.02 - Improving Canadian climate and water data dissemination

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The Open Government and Open Data movements have led governments, especially in Canada, to improve access to an increasing amount of climate and water data through the Internet. Many initiatives (WMO, Government of Canada and Environment Canada) foster the publication of the metadata of these datasets on public portals, and also make them accessible through different technologies (WMS, HTTP, mobile applications, etc.). However, due to the lack of uniformity between the diverse sources of data, formats, and accessibility, it is still too often challenging for the user to find the relevant information. In order to overcome this problem, Environment Canada has initiated a project aiming at providing relevant and timely climate and water information to Canadian decision-makers. In this presentation, we will describe the criteria that must be taken into account in the context of the Government of Canada alignment with Open Data activities, to provide a better access to climate and water data. We will list the available options and how we can take advantage of other initiatives. Finally, we describe the strategy that we intend to deploy in order to make the data available, as well as the benefits of the technology we believe should be used to reach that goal.

Keywords: Open Government, Climate data, Water data
Parallel Session

UAS-PS323.03 – WITHDRAWN - Vanishing Points(TM) in South Louisiana: future implications of a community-based mobile application on climate adaptation

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Currently, southern Louisiana is undergoing extreme land loss at an alarming rate of about one football-sized swath of land every hour. The combined deleterious effect of land subsidence, sea level rise, salt water intrusion, and various other processes threaten the culture and livelihood of the residents living in this region. This study uses participatory techniques to highlight the need for collaborating with community members for future climate change adaptation decision-making and planning. Traditionally, research into environmental disasters, such as land loss, has been attributed to physical sciences. This approach, however, does not address the human elements such as risk perception and attachment to place. To address this limitation, this study investigates the use of an interdisciplinary approach by collaborating with the residents of South Terrebonne Parish to develop the mobile application Vanishing Points(TM). The application serves as an educational tool that provides awareness of the culture being threatened by land loss in this region. Vanishing Points(TM) showcases locations and history of cultural significance attained through participatory action research (PAR) methodology. Additionally, surveys completed by 200 residents provide insights to their attachment to place as well as their understanding and/or concerns about coastal land loss, wetland restoration, and climate change. It is expected that these survey results will support PAR projects such as Vanishing Points(TM) for use in disaster and climate change adaptation, planning, and mitigation.

**Keywords:** Louisiana land loss, participatory action research, mobile application, adaption
Satellite derived ocean winds and waves have increasingly become key observations used by operational marine weather forecasters issuing warnings and forecasts at the NOAA Ocean Prediction Center. The oceans have long been data sparse for conventional surface observations. Wide swath scatterometer winds help fill the gaps in conventional ocean surface data by providing high resolution full vector wind fields at the scale of ocean cyclones. Altimeter wave heights also help fill the gaps for wave height observations. Forecasters use scatterometer winds and altimeter waves to enhance situational awareness, compare numerical model wind and wave fields with satellite inferred or measured fields, to update warnings, and verify forecasts and warnings. The NOAA Ocean Prediction Center uses integrated workstations called National Centers - Advanced Weather Information Processing System (N-AWIPS) to view weather information and for graphical product generation. N-AWIPS will be replaced by AWIPS II in late 2015. Ocean winds and waves from three scatterometers and three altimeters are available in N-AWIPS in near-real time with complimentary imagery, numerical model fields, and observations. This integrated display capability has greatly enhanced forecaster awareness and is reflected in the text and graphical products generated by the Ocean Prediction Center. This paper will discuss the operational application of satellite derived ocean winds and waves. Specific examples discussing the impact to forecaster based decisions, to warning and forecast products, and to marine weather services will be given.

**Keywords:** satellite, marine weather, ocean winds, ocean waves
Parallel Session

UAS-PS323.04 - How to communicate weather forecasts on web services: Yr, a Norwegian example

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1NRK, Oslo, Norway, 2The Norwegian Meteorological Institute, Oslo, Norway

Yr (www.yr.no) has advanced the communication of weather information to the Norwegian public. Its impact since the start in 2007 is measurable: Peek value of about 3.5 million unique users per week (more than double worldwide); On the order of 10 million downloads per day of weather data; Increased objective forecast skill; 43% regard Yr as having the most trustworthy weather forecast. In Norway, Yr is synonymous to weather. A novelty is the ~900.000 site specific forecasts (~9 million worldwide), creating a very strong user ownership. The user-interface and feedback have been essential in adding value to the forecast quality and products. The short-term forecasts are updated 4 times per day from the regional model AROME-MetCoOp. The data are post-processed both in terms of correcting for local sources of error and product generation. For instance, the medium-term graphical uncertainty products, based on the ECMWF forecast ensemble, provide an example of displaying uncertainty information. Outside Norway the forecasts are based on the high-resolution ECMWF. The open data policy of MET Norway paved the way for Yr and the collaboration with NRK (The Norwegian Broadcasting Company) on the complex process of designing an appealing and useful web page consisting of, in addition to weather forecasts, observations, verification and daily weather articles. Yr is organized in an operational part and a development part. Both operations and development are cross-cutting and follows a project/activity organization model. Yr has as such increased the effectiveness and automation of the weather service.

Keywords: Weather forecast, Communication, Web service, Open data policy
Over the last decade or so, predicting the weather and climate has emerged as one of the most important areas of scientific endeavour. This is partly because the remarkable increase in skill of current weather forecasts has made society more and more dependent on them, day to day, for a whole range of decision-making. And it is partly because climate change is now widely accepted and the realisation is growing rapidly that it will affect every person in the world profoundly, either directly or indirectly. In the past, the separation between weather forecasting and climate prediction has been essential and understandable, because numerical weather prediction was far more advanced and sophisticated and because the science of climate prediction was relatively immature. That is increasingly no longer the case. The importance of hazardous weather in driving some of the most profound impacts of climate variability and change, and with the developing interest in monthly to decadal forecasts from users, there is a clear need for a more seamless approach to modelling and prediction. At the same time observations of the Earth system, especially from space, are providing ever-increasing information about the full system. This talk will provide evidence that in achieving a more unified and seamless approach, building on the synergies between weather forecasting and climate prediction, and between fundamental and applied research, we will be in the best possible position to accelerate the advancement of weather, climate and environmental services to address society’s increasing needs.

**Keyword:** Prediction
Parallel Session

SCI-PS201.01 - Results from the Diurnal land/atmosphere Coupling Experiment (DICE)

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Many studies of boundary layer parametrizations treat the surface as a fixed lower boundary condition, either specifying the surface fluxes or near surface temperatures. In a similar way, land surface models are widely developed and tested in isolation, driven by observed near-surface atmospheric variables. Whilst simplifying the system in this way has undoubtedly delivered many improvements to models on both sides, the applicability of such studies to the real world is readily called into question because feedbacks between the atmosphere and land are being suppressed. As an example, analysis following the protocol of the GLACE experiment suggested that interactions between the atmospheric parametrisations were responsible for the land/atmosphere coupling strength in some models, but our understanding of these interactions within models is limited. DICE is an international experiment designed to identify and understand the interactions and feedbacks between the land and atmospheric boundary layer. The GABLS2 (CASES99) experiment has been re-visited, but with both boundary layer and land surface communities included within the project development and analysis. The result is a multi-stage project with ensembles of simulations that allows the sensitivity characteristics of each component (land and atmosphere) to be assessed and compared with the characteristics of the coupled versus uncoupled simulations. In this presentation we will give details of the experimental protocol, including the justification for each of the stages. Initial results from the experiment will be presented along with conclusions about characteristics of the integrated system responsible for the coupling strength in the models.

**Keywords:** coupling, land-atmosphere, diurnal cycle, DICE
Parallel Session

SCI-PS201.02 - Towards seamless mesoscale prediction of the land system for Europe

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An advanced mesoscale modeling system has been developed based on WRF-NOAH-MP. Earth system simulations can be performed from the nowcasting range to decadal regional climate simulations towards a seamless prediction over all these forecast ranges. Key science topics are the simulation of all components of the water cycle including soil and vegetation processes, land-surface-atmosphere feedback, and the predictability of precipitation. Through all compartments of the land system, model physics has been improved and tested including new dynamic parameterizations for crop roots and leaf areas as well as land surface exchange. Combinations of parameterizations were studied for advanced simulations of the European climate. For reanalyses, nowcasting, and short range forecasting, the model system is operated with a rapid update cycle using 3D variational data assimilation (3DVAR). A huge observational data set is assimilated such as surface observations, aircraft measurements, observations of the European GPS and radar networks as well as satellite winds and radiances. Model performance is presented for quantitative precipitation estimation, nowcasting, and short-range forecasting of extreme precipitation events. Future improvements include model forward operators for GPS slant total delays and polarization radar as well as the extension of the data assimilation system to En3DVAR. Reanalyses and regional dynamical downscaling results within CORDEX Europe are also presented. It is shown that the CORDEX 0.12° grid increments are leading to substantial errors in the simulation of the water cycle - particularly precipitation. It is demonstrated that the improvement of the resolution to the convection-permitting scale is essential for future dynamical downscaling efforts.

Keywords: Short-range forecasting, Climate projections, Land system, Land-surface-atmosphere feedback
SCI-PS201.03 - Impacts of soil moisture-climate feedbacks in the tropics in the GLACE-CMIP5 experiments

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The impact of projected changes in the soil moisture conditions in a CMIP5 climate scenario on climate in the tropics, with special focus on precipitation, is investigated on the basis of three simulations. These cover the period 1950-2100 and involve the atmospheric component of the EC-Earth global coupled climate model in accordance with the GLACE-CMIP5 experiment. In the reference experiment (ExpR) the conditions of both the sea surface and the land surface (soil moisture content) are prescribed on a daily basis as obtained from a CMIP5 simulation with the fully coupled version of EC-Earth under the RCP8.5 scenario. In one of the sensitivity experiments (ExpA), the mean seasonal cycle of soil moisture has been prescribed as the climatology over the period 1971-2000 obtained from ExpR. In the other sensitivity experiment (ExpB) the seasonal cycle of soil moisture is prescribed as a transient climatology from ExpR, i.e., with 30-year running mean values. The direct comparison between ExpB and ExpA for future climate conditions allows for assessing the contribution of the projected changes in soil moisture to the overall changes in climate simulated in ExpR. The projected changes in soil moisture contribute to the climate changes in the tropics through two kinds of coupling, the soil moisture-temperature coupling and the soil moisture-precipitation coupling. These couplings might further extend into two feedback loops, with induced changes in temperature and precipitation feeding back on soil moisture.


Keywords: Future climate projection, Soil moisture-climate feedback, Tropics, Precipitation
Parallel Session

SCI-PS201.04 - Terrestrial carbon fluxes and pools simulated with diurnal variability in both photosynthesis and respiration

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The Canadian Terrestrial Ecosystem model (CTEM), which was developed at the Canadian Centre for Climate Modeling and Analysis (CCCMa) is a dynamic vegetation model that incorporates photosynthesis and respiration sub-modules among many other physiological processes of the terrestrial biosphere. The photosynthesis sub-module in CTEM operates at a time step of 30 min while respiration is modeled at a daily time step. Combined autotrophic and heterotrophic respiration from terrestrial ecosystems (Re) is one of the major CO2 fluxes in the global carbon cycle, and its accurate estimation is important. This presentation will assess the effect of modeling respiration in CTEM at a 30-min time step, to capture its diurnal variation, including the importance of a primary driving variable like temperature which itself exhibits a strong diurnal cycle. Modelling respiratory fluxes at a sub-daily time step is expected to change net atmosphere-land CO2 flux, modelled equilibrium states of vegetation and soil carbon and the model response to climate variability and climate change. This presentation will assess these impacts and its spatial and temporal pattern.

Keywords: Terrestrial carbon fluxes, Terrestrial Ecosystem model, photosynthesis, respiration
Parallel Session

SCI-PS202.01 - The relative contribution of atmospheric and oceanic uncertainty in TC intensity forecasts

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Although tropical cyclone (TC) intensity change is fairly well understood under idealized scenarios, the predictability of TC intensity change under more realistic conditions is not as well known. In particular, it is unclear how the combination of errors associated with the vortex structure, near-storm environment and lower boundary condition (i.e., sea surface) limit intensity predictability. This study attempts to determine the relative importance of different error sources using multiple sets of Advanced Hurricane WRF (AHW) ensemble forecasts of 20 Atlantic TCs over 35 initialization times during 2008-2011. Each set of ensemble forecasts is characterized by a different source of uncertainty, which include the atmosphere, ocean, and physical processes (i.e., surface layer physics, microphysics). The results from these experiments suggest that the uncertainty from the atmosphere has the greatest impact on intensity, with small TCs showing greater probability of large error growth compared to large TCs. By contrast, errors from the ocean or physical processes have lower error growth and more consistent error growth from one case to another. The dynamical processes responsible for the growth of errors for select cases will be explored for select cases using the ensemble-based sensitivity technique.

Keywords: Tropical cyclone, Predictability
Parallel Session

SCI-PS202.02 - Adjoint sensitivity to control discretization errors: Goal-oriented adaptivity for idealized tropical cyclone scenarios

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The influence that perturbations of the atmospheric state have on user-defined meteorological structures can be quantified by means of adjoint sensitivity (AS). This information is used successfully by meteorologists e.g. to identify sensitive regions for targeted observations or to investigate perturbation growth mechanisms in tropical cyclones that limit the predictability. A newer and very promising application of AS is goal-oriented adaptivity where discretization errors are controlled to enhance the efficiency of numerical models e.g. by mesh adaptation. In that context, the discretization errors arising from the use of a discrete model are interpreted as perturbations of the model output. A mathematical error estimator is applied to quantify these errors and allows for characterizations even on a cell-wise level. Automatic mesh adaptation can then be accomplished by increasing the resolution locally at regions where the AS indicates high influence on the feature of interest.

We present a mathematical error estimator for the error in user-defined output functionals and explain the overall adaptive procedure for the situation of a space-time finite element discretization. Based on an idealized model, we consider a scenario of two tropical cyclones for which the forecast is delicate due to the storms' mutual interaction. We interpret the adjoint sensitivity information for different output functionals related with the storm positions, present error estimates and correspondingly adapted grids and time step distributions. On the basis of this scenario we demonstrate the efficiency improvement that can be achieved exploiting AS in the context of goal-oriented adaptivity.

Keywords: goal-oriented adaptivity, idealized tropical cyclone scenario, adaptive finite element discretization
Parallel Session

SCI-PS202.03 - Evaluating the predictability of tropical cyclogenesis via wave-relative analyses

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The predictability of tropical cyclogenesis is investigated via the evolution of ECMWF ensemble forecasts for 21 developing tropical waves during the 2010 Atlantic hurricane season. Examined variables include area-averaged relative vorticity, thickness anomaly, upper-level and low-level divergence, mid-level and deep-layer wind shear, and relative humidity (RH). Variables are examined within a 300 km radius “core”, as well as a 300-1000 km radius “environment” about the center of circulation. In the first part of this study, the degree to which the predicted strength of circulation at verifying times of genesis is related to the favorability of the predicted environment and/or the strength of the pre-genesis vortex is evaluated. The relationship between the variance of the predicted environment and the variance of the possible genesis outcomes is also explored. In the second part of this study, two-dimensional (and in a few cases, three-dimensional) joint distributions between the aforementioned variables are analyzed to explore relationships between these physically-related quantities. For example, the relationships between shear and strength of circulation, or core RH and environmental RH, are examined. Lagged-correlations are also examined in order to establish causality; e.g. does a dry core 48 h prior to genesis lead to weakened upper-level divergence at time of genesis, or does weak upper-level divergence prior to genesis lead to a dry core? Lastly, the wave-relative variance prediction is quantified in order to determine whether or not the ensemble is producing a reasonable amount of forecast variance given typical errors at a given lead time.

Keywords: tropical cyclones, tropical cyclogenesis, predictability, ensemble forecasts
SCI-PS202.04 - Multi-annual forecasts of Atlantic tropical cyclones in a climate service context

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Seasonal predictions of tropical cyclone activity are now routinely performed in all major ocean basins supporting cyclone formation. In the Atlantic, these forecasts are now emitted at the beginning of each hurricane season by a range of different groups, from Met-Services, to academic groups and catastrophe modeller. These forecasts are made possible because (some of) the factors controlling Atlantic hurricane activity variability have been identified and can be predicted with some accuracy for the upcoming hurricane season. Although interesting from an academic point of view, these forecasts are only of limited use, mostly because the time frame covered is too short for societal actors with assets in exposed area (e.g. insurance industry) to make use of them. For such stakeholders, multi-annual forecasts of hurricane activity would be of significantly greater interest. As such, we build on recent work suggesting predictability of Atlantic hurricanes beyond the seasonal level, to develop a multi-annual forecasts of Atlantic cyclone activity. Making use of the large array of data produced in the context of the CMIP5 project, we investigate, using a hybrid dynamical-statistical approach, the skill of multi-annual hurricane re-forecasts for the period starting in 1960. Similar to current seasonal forecasts, different metrics representing different aspect of basin-wide activity (number, intensity, duration) are predicted (e.g. hurricane count, accumulated cyclone energy, landfalling) and the skill of each of these predictions over a five year horizon is evaluated using standard statistical tests.

**Keywords:** decadal forecast, tropical cyclones, Atlantic variability
Parallel Session

SCI-PS203.01 - Integrated services addressing urban weather, climate and related environmental hazards

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The rapid urbanization that is currently taking place will require new types of services making best use of science and technology. Cities face unique sets of hazards and the services need to be tailored to these needs. This will require strong and wide-reaching institutional cooperation. Megacities and large urban complexes offer better job and education opportunities, and well-planned, densely populated areas can reduce land conversion and use energy more efficiently. However, these urban complexes present also numerous social and environmental challenges with many cities in developing countries expanding rapidly with poor planning. The new services will provide opportunities through weather, climate and environmental predictions for optimizing, e.g., the functioning of the urban environment in terms of energy and transport. City services will heavily rely on high resolution coupled environmental prediction models that will include realistic city specific processes, boundary conditions and fluxes of energy and physical properties. New observational systems focused on the urban environment will also be required, as will be data sharing between institutions, and skill and capacity to make best use of latest technologies, to produce services in the challenging and rapidly evolving city environment. These services will assist cities in facing hazards such as storm surge, flooding, heat waves, and air pollution episodes.

Keywords: Urban, Environmental Hazards
Parallel Session

SCI-PS203.02 - Megacities and large urban complexes: Next phase of the GURME project

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Global urbanization has become an irreversible trend with 23 megacities projected for 2015 worldwide, amongst which 18 are coastal cities and many in the emerging countries. Urbanization alters many surface parameters such as roughness, albedo or permeability, which propagate to the atmosphere in terms of changes to turbulence intensity, stability, mixing height, etc. This leads to phenomena specific to the urban environment such as heat islands, enhanced flooding risk, channeling of wind, etc. Combined with particulate and gaseous emissions it further alters the atmospheric state and composition, including through the formation of condensation nuclei, increase turbidity, decrease radiation and visibility, exacerbation of air pollution... The mountainous terrain/sea interface in most coastal cities adds to the complexity of understanding and predicting in urban environments which also evolve under, respond, and contribute to climate change. The significant technical, social and environmental stressors is driving the demand for more accurate environmental assessments and prediction services based on urban meteorology and addressing an expanding range of urban environmental concerns such as hydrological and water resources in addition to air quality and health related issues. The presentation will focus on recent accomplishments and future plans for GURME/megacities.

Keywords: Megacities, Urban environment, GURME
Parallel Session

SCI-PS203.03 - Dispersion modeling of particulate matter concentration reductions due to alternative aviation fuels

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Emissions due to the commercial aviation sector are quickly gaining prominence as a research topic due to the increasing demand for aviation services and the success of emissions reduction strategies in other transportation sectors. One proposed method to reduce aviation emissions is through the introduction of 'drop-in' alternative aviation fuels (alt-fuels) with superior emissions properties which would not require a change in fueling or airport infrastructures. Alt-fuels include biofuels and fuels produced from coal or natural gas feedstocks. Where these alt-fuels do not meet aviation fuel standards, blends of alt-fuels with standard jet fuel may still be used as drop-in fuels. Initial measurements at the engine exit plane show reductions in important pollutants when these fuels are used, including black carbon particulate matter (PM, see e.g. Lobo et al. 2011). The current research uses the American Meteorological Society / Environmental Protection Agency (AMS/EPA) Regulatory Model (AERMOD) to perform dispersion modeling of black carbon PM emissions near the Hartsfield-Jackson Atlanta International Airport. Comparison of PM concentration data from different fuel use scenarios allows for an evaluation of the air quality impacts of the use of drop-in alternative aviation fuels. The use of dispersion modeling provides the capability for simulating air quality at finer spatial scales when compared to chemistry-transport modeling. Future work will include chemistry-transport modeling for the same scenarios, allowing a direct comparison between the two approaches.


Keywords: Air Quality, Aviation, Dispersion Modeling, Alternative Fuels
Parallel Session

SCI-PS204.01 - A unifying framework for hybrid data-assimilation schemes

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Hybrid data-assimilation methods combine e.g. 4DVar and Ensemble Kalman filters to extract ‘the best of both’. While practical, it is unclear what is actually done. Variational methods solve for the mode of the posterior probability density function, while ensemble methods try to find the mean. Mode and mean are the same for linear Gaussian systems but not so for real world nonlinear systems. Some centres use an ensemble method to provide a flow-dependent background error covariance B for a 4DVar. However, the ensemble mean and the 4DVar forecast are not the same, so the ensemble perturbations are shifted to the 4DVar forecast. Furthermore, the 4DVar analysis is taken as the ensemble mean for ensemble forecasts. Hence ensemble perturbations are moved around in an ad hoc manner. Other centres run an ensemble of 4DVars similar to an ensemble Kalman smoother, with again the ensemble informing part of the B matrix. While this is correct for linear systems, it is ad hoc for nonlinear systems. Bayes Theorem provides a unifying framework. All hybrid schemes are approximations to the prior. Interestingly, any approximation can be incorporated in a proposal density and invokes an extra factor in Bayes theorem consisting of the ratio of the real prior to this proposed prior. The natural framework for these approximations is the particle filter/smoker, and we show that the particle filter reduces to the other methods in the linear limit and how the present schemes can be made consistent for nonlinear systems.

Keywords: data assimilation, hybrid data assimilation, nonlinear data assimilation
Parallel Session

SCI-PS204.02 - Estimating the full posterior probability density function with particle filters

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The majority of data assimilation schemes rely on linearity assumptions. However as the resolution and complexity of both the numerical models and observations increases, these linearity assumptions become less appropriate. A need is arising for fully non-linear data assimilation schemes, such as particle filters. Particle filters represent the full posterior probability density function (pdf) of the model state given the observations using individual particles or model runs, similar to the Ensemble Kalman Filter. Unfortunately standard particle filters fail to represent the full posterior pdf when the number of independent observations is high. Recently, new particle filter schemes have been generated, such as the equivalent-weights particle filter and the Implicit particle filter, that adapt the standard particle filter for high dimensional systems using the freedom inherent in proposal densities. In non-linear data assimilation, the solution to the data assimilation problem is a representation of the full posterior pdf using only a limited number of particles or model runs. Although the new particle filter schemes show promising results in reproducing the truth by the mean of the particles in twin experiments, less is understood about their ability to represent the full posterior pdf. Here, a posterior pdf produced through Markov-Chain Monte Carlo methods is used as a gold standard with which to compare the particle filter representations. We present various examples that look at how these representations are affected by both the scheme parameters and the setup of the models.

\textbf{Keyword:} Nonlinear data assimilation
Parallel Session

SCI-PS204.03 - Toward new applications of the adjoint sensitivity tools in variational data assimilation

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Adjoint-data assimilation system (DAS) observation sensitivity techniques have gained acceptance as a computationally feasible approach to monitor the observation impact on reducing short-range forecast errors. However, the observation impact estimates only provide an assessment of the observation performance in the status quo DAS; the observation value may be increased by improving the error covariance models that weight the information content of the model and measurements in the DAS. The extension of the adjoint-DAS approach to evaluate the forecast sensitivity to error covariance parameters allows the identification of high-impact covariance parameters and provides a priori guidance to the design of error covariance tuning procedures. Theoretical aspects and new applications of the adjoint-DAS error covariance sensitivity are considered to assess and improve the DAS performance. Results of forecast error sensitivity to observation error variance-weight and innovation-weight coefficients are presented with the adjoint versions of the Naval Research Laboratory Atmospheric Variational Data Assimilation System-Accelerated Representer (NAVDAS-AR) and the NASA Goddard Earth Observing System (GEOS) DAS developed at the NASA Global Modeling and Assimilation Office. It is also explained that the adjoint-DAS approach allows testing a generic observation error covariance model prior to its actual implementation in the DAS and that a first-order estimation of the forecast impact may be performed in a particularly efficient fashion when the specified error correlations are derived from an a posteriori covariance consistency diagnosis. Preliminary results are shown for radiances assimilated from the Atmospheric Infrared Sounder (AIRS) and the Infrared Atmospheric Sounding Interferometer (IASI).


Keywords: observation sensitivity, adjoint model, parameter tuning, error correlations
Parallel Session

SCI-PS204.04 - An unbiased estimation of analysis and short-range forecast error variances

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Accurate estimates of error variances in numerical analyses and forecasts (i.e., difference between analysis or forecast fields and nature on the resolved scales) are critical for the evaluation of forecasting systems, the tuning of data assimilation systems, and the proper initialization of ensemble forecasts. A number of issues, however, hinder related efforts, such as errors in observations and the difficulty in their estimation; the fact that estimates of analysis errors derived via data assimilation schemes are influenced by the same assumptions as those used to create the analysis fields, the quality of which we wish to evaluate; and the presumed but unknown correlation between analysis and forecast errors. This presentation will introduce a new technique for the unbiased estimation of error variances in the initial state (i.e., analysis field) and numerical forecasts of chaotic systems. The method is independent of any assumption or tuning parameter used in DA schemes. In a simulated forecast environment, the method is demonstrated to reproduce the true analysis and forecast error within the predicted error bounds. The method is then applied to forecasts from four leading Numerical Weather Prediction centers to assess the performance of their corresponding data assimilation and modeling systems. A general relationship between the quality of shadowing (i.e., error variances in the initial and forecast states), the strength of chaotic behavior, and the effectiveness of the observing and DA systems will also be introduced and used to interpret the experimental results.

Keywords: Analysis and forecast error variance, Error growth, Functional analysis
SCI-PS205.01 - Incorporating volcanic eruptions into near real-time aerosol forecasts

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The sporadic and complex nature of volcanic eruptions complicates the inclusion of volcanic aerosols, such as sulfates and ash, into aerosol forecasts. Observations routinely yield information about the location and mass loading of volcanic aerosols, but modeling a volcanic eruption and forecasting the resulting aerosol cloud requires information about the eruption parameters. Such eruption parameters, like the emission altitude, starting time, duration, and magnitude, provide a much needed “first guess” to allow the inclusion of a volcanic eruption into an aerosol forecasting system. In this presentation, we demonstrate a two-step process where (1) eruption parameters are estimated by using satellite observations to constrain dispersion model simulations. Then, (2) the eruption parameters are used to initialize conditions for a volcanic eruption in an aerosol forecasting system. Subsequent satellite observations are used refine the transport of the volcanic aerosol cloud within the aerosol model. Improvements to an aerosol forecast due to the inclusion of volcanic eruptions will be demonstrated using NASA’s Goddard Earth Observing System Model, Version 5 (GEOS-5) which includes the online Goddard Chemistry Aerosol Radiation and Transport (GOCART) module.

Keywords: Volcanic Eruptions, Aerosol Forecasts, Volcanic Ash
GEOS-5 is the latest version of the NASA Global Modeling and Assimilation Office (GMAO) earth system model. GEOS-5 contains components for atmospheric circulation and composition (including data assimilation), ocean circulation and biogeochemistry, and land surface processes. In addition to traditional meteorological parameters, GEOS-5 includes modules representing the atmospheric composition, most notably aerosols and tropospheric/stratospheric chemical constituents, taking explicit account of the impact of these constituents on the radiative processes of the atmosphere. The assimilation of Aerosol Optical Depth (AOD) in GEOS-5 involves very careful cloud screening and homogenization of the observing system by means of a Neural Net scheme that translates MODIS radiances into AERONET calibrated AOD. These measurements are further quality controlled using an adaptive buddy check scheme, and assimilated using the Local Displacement Ensemble (LDE) methodology. An Ensemble Kalman Filter (EnKF) is currently in development, including assimilation of radiances and LIDAR (attenuated) backscatter. GEOS-5 aerosols are driven by daily QFED biomass burning emissions derived from MODIS fire radiative power retrievals. In this talk we will highlight the main results from the MERRA Aerosol Reanalysis (MERRAero), discuss the application of GEOS-5 forecasts for several NASA field campaigns, and post-mission data analysis. In particular, we will discuss the impact of assimilated and interactive aerosols on Tropical Cyclogenesis during the NASA African Monsoon Multidisciplinary Analysis (NAMMA) campaign.

**Keywords:** aerosol, forecasting, data assimilation, tropical cyclogenesis
Parallel Session

SCI-PS205.03 - Aerosol optical properties assimilation from low-earth orbiting and geostationary satellites: Impacts on regional forecasts

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A three-dimensional variational data assimilation technique is developed for the Gridpoint Statistical Interpolation (GSI) system when WRF-Chem forecasts are performed with a detailed aerosol sectional model (MOSAIC). The system can simultaneously assimilate a variety of satellite-based aerosol optical properties (AOPs), such as single or multiple-wavelength aerosol optical depth (AOD), fine fraction AOD and absorbing AOD. The system is used to perform assimilation experiments over North America and East Asia. Over North America, we show the ability of the forecasting and assimilation system to provide guidance for flight planning during a NASA field experiment (SEAC4RS) and we use data collected during the campaign to validate the assimilation. For East Asia, we perform experiments to assess the impacts when assimilating different AOPs from both low-earth orbiting (LEO, MODIS-Terra/Aqua) and geostationary (GEO, GOCI-COMS) satellites. The experiments seek to explore the effects of assimilation during the deployment of the AERONET DRAGON-Asia 2012 network, where long-range transport of dust, biomass burning smoke and anthropogenic pollution over Korea and Japan was observed. As WRF-Chem is a coupled meteorological and air quality modeling system, the sensitivity of the meteorological predictions to aerosols modified by assimilation will also be discussed. One of the highlights of our work is to perform an observing system experiment, where real data will be used to assess the impacts on aerosol forecasts when including GEO data into a system that already assimilates LEO retrievals. Such studies are important for assessing the importance of future geostationary missions.


Keywords: assimilation, aerosol optical depth, WRF-Chem, GSI
Parallel Session

SCI-PS205.04 - Enhancing the Barcelona Supercomputing Center chemical transport model with aerosol data assimilation

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This study tested an enhancement of a multiscale chemical transport forecast system (known as the NMMB/BSC-CTM model) with the assimilation of satellite products of aerosol optical depth. The study has focused on mineral dust only, a prominent type of aerosol. The NMMB/BSC-CTM model is maintained and developed at the Barcelona Supercomputing Center (BSC) in collaboration with the US National Centers for Environmental Prediction and other research institutions. A highly valuable characteristic of the model is the ability to switch dynamically from the hydrostatic to the non-hydrostatic mode according to the horizontal grid resolution. An ensemble Kalman filter technique (namely Local Ensemble Transform Kalman Filter - LETKF) has been utilised to statistically combine model background and satellite retrievals. The LETKF is a development of an ensemble Kalman Filter particularly suited to high-performance computing applications. Data assimilation experiments have been executed on the BSC MareNostrum supercomputer, and evaluated against ground station aerosol optical depth observations. The experiments show how aerosol optical depth products retrieved from satellite measurements can help us to better forecast atmospheric dust, provided that an accurate selection is made of dust-only observations, and provided that bias corrected measurements are fed into the system. In the future, we plan to extend this work, initially performed on the forecast of mineral dust, to the other main aerosol species. This work aims to improve the forecast currently provided by the NMMB/BSC-CTM model to the regional centre of Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) of the World Meteorological Organization.

Keywords: aerosol, data assimilation, dust forecast
Parallel Session

SCI-PS206.01 - The Central European floods in June 2013: the role of “preconditioning” and warm conveyor belts

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In June 2013 Central Europe was hit by a century flood affecting the Danube and Elbe catchments after a 4-day period of heavy precipitation and causing severe human and economic loss. In this study model analysis and observational data are investigated to reveal the key atmospheric processes that caused the heavy precipitation event. The period preceding the flood was characterised by a weather regime associated with cool and unusual wet conditions resulting from repeated Rossby wave breaking (RWB) in Europe at the downstream side of an Atlantic blocking ridge and the upstream side of a Scandinavian blocking ridge. The RWB events lead to unusually high accumulated rainfall amounts in many parts of Europe in the two weeks prior to the event. During the event a single RWB established a reversed baroclinicity in the low to mid troposphere in Central Europe with cool air trapped over the Alps and warmer air to the North. The upper-level cut-off resulting from the RWB instigated three consecutive cyclones in eastern Europe that unusually tracked westward during the days of heavy precipitation. Continuous large-scale slantwise ascent in warm conveyor belts (WCBs) associated with these cyclones is found as the key process that caused the 4-day heavy precipitation period. Fed by moisture sources from continental evapotranspiration, these WCBs unusually ascended equatorward along the southward sloping moist isentropes. Although such equatorward ascending WCBs are climatologically rare events in Europe, they have great potential for causing high impact weather.


Keywords: weather regime, heavy precipitation, warm conveyor belt, flood
Sea ice in the Arctic is experiencing declines that are projected to result in a purely seasonal ice cover regime in the 22nd century. In regions of sea ice loss, this will lead to local changes in the sensible and latent heat flux from the ocean to the atmosphere. Subsequent impacts on mid-latitude weather and climate may occur, for example through changes in air mass generation and properties, mass fields, and jet stream dynamics. The goal of this research is to examine the remote influences of sea ice loss on the atmosphere, with particular focus on loss in the western Arctic. Many studies have been conducted using atmospheric component models forced with specified (reduced) sea ice concentration and sea surface temperatures. These studies have the advantage of clearly separating the signal of sea ice loss from other changes in the climate system, however the experimental configuration negates the inclusion of atmosphere-ocean feedbacks. The approach used in this study is to employ simulations of future climate using a fully coupled global climate model (GCM) from the Climate Model Intercomparison Project 5 (CMIP5) and apply a technique of self-organizing maps to identify patterns in air masses, mass fields, jet streams, and sea ice concentration. Relationships between the atmospheric self-organizing map patterns and sea ice concentrations in the model are used to investigate dynamical links between sea ice loss and atmospheric variability in the context of a fully coupled GCM.

**Keywords:** Sea ice, GCM, cryosphere-atmosphere interaction, self organizing maps
Using station precipitation and NCEP’s reanalysis data, large-scale circulations associated with the heavy rainfall event that occurred around 21 July 2012 (or the July 21 heavy rainfall) is examined. Our analysis focuses on the response of the large-scale circulations to the Okhotsk-Japan (OKJ) circulation pattern. Results show that (1) the July 21 heavy rainfall occurred within a 10-day period of the OKJ pattern; (2) this circulation pattern was dominated by a blocking high between the Ural Mountains and the Baikal Lake, which was different from the normal OKJ circulation. The eastward Rossby wave propagation was broken around the Baikal Lake and regenerated on 20 July, leading to the development of a low pressure system around the Baikal Lake and the weakening of a ridge around the Okhotsk Sea; and (3) the OKJ circulation slowly moved eastward and created a favorable environment for the moisture transport to northern China, assisting in the generation of the July 21 heavy rainfall.

**Keywords:** Rossby wave, OKJ circulation, Heavy rainfall, East Asian summer monsoon
SCI-PS206.04 – WITHDRAWN - A new method for Tropopause Folding Detection and its application in middle-latitude disastrous weather

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Tropopause folding is an important mid-latitude atmosphere phenomenon within the upper troposphere and lower stratosphere which is always found to be corresponded to the cyclogenesis, rainstorm and convection generation and precipitation enhancement. Since the atmosphere environment for any of these above-mentioned weathers is terribly complicated, those preexisting popular schemes taking no account for water vapor may not suitable for detecting tropopause folding that dealt with these weathers. With regard of the merits and demerits of the pattern recognition scheme on basis of satellite and numerical data, a dynamic new scheme based on FY2E geostationary weather satellite data is presented to detect tropopause folding related to rainstorm. The core idea of this scheme is based on the statistical relationship between tropopause folding and the water vapor at high level troposphere, the general moist potential vorticity, ozone and upper-level jet with considering the auxiliary effect of the height of dynamic tropopause simultaneously. After accuracy verification using the total amount of ozone and ozone profile operational products retrieved by FY3A and FY3B and the potential vorticity calculated by ECMWF Interim data, this scheme is applied to analyze two typical middle-latitude weather processes. One is the famous Beijing extreme rainfall of 21 July 2012 and the other is South China rainstorm during May 14-17, 2013. A good application effect of both cases suggests that our new method for tropopause folding detection is feasible and can be helpful in middle-latitude disastrous weather monitoring and forecasting.

Keywords: tropopause folding, upper troposphere and lower stratosphere, general moist potential vorticity, geostationary weather satellite
Parallel Session

SCI-PS207.01 - Defining the initial conditions for medium-range ensemble forecasts with an ensemble of data assimilations

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In the introduction, we give an overview of the current configuration of the medium-range ensemble prediction system at the European Centre for Medium-Range Weather Forecasts (ECMWF). This will include a summary of upgrades that took place in 2013 (increase of vertical resolution, perturbations to the surface initial conditions and the coupling to the ocean). Then we focus on how the skill of the ensemble depends on the way the initial conditions are constructed. The ECMWF ensemble uses a combination of perturbations based on singular vectors and perturbations based on the Ensemble of Data Assimilations (EDA). The EDA perturbations are defined as the difference between the perturbed EDA members and the EDA mean. In a re-centring step, the perturbations are added to the high resolution analysis to generate the perturbed initial conditions for the different ensemble members. Here, we investigate the sensitivity of the ensemble skill to the quality of the centre analysis and the impact of starting directly from the perturbed EDA members. The implications of the results for future improvements of the ECMWF ensemble forecasting system will be discussed.

Keywords: Ensemble Forecasting, Perturbation Methods, Ensemble Data Assimilation
Parallel Session

SCI-PS207.02 - Issues in the initial conditions error sampling within PEARP

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PEARP (Prévision d'Ensemble ARPège), Météo France global short-range ensemble prediction system, uses a 4D-Var ensemble to build its initial states in addition to singular vectors. Because of the numerical cost of 4D-Var, the ensemble data assimilation has less members than the forecast one. In the next generation system, operational at the beginning of 2015, about 25 perturbed analyses will be available to the 35 forecast members. How to assign one analysis to each prediction member in order to obtain the best system? In the future, a 4D-EnVar will replace the 4D-Var ensemble and increase drastically the size of the assimilation ensemble. Consequently, the ensemble prediction system will have to discriminate the perturbed analyses to keep only a few dozens solutions among hundred. So the problematic is reversed, but the issue is still the combination of two different-size sets: which analysis for each member of the ensemble prediction system? Different random combinations are tested, as well as the sensitivity to sampling effects. The interest of a positive-negative perturbation pairs strategy will be discussed too. Then a bayesian weighting is used to discriminate the assimilation members by updating the initial probability distribution in accordance to the freshest observations.


Keywords: short-range ensemble prediction system, initial perturbations, ensemble data assimilation
Parallel Session

SCI-PS207.03 - A climatology of ECMWF ensemble hurricane track forecast variability

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Ensemble forecasts of Tropical Storm Debby (2012) exhibited a wide range of possible storm tracks, which included a 180° difference in the direction of motion at 48 h lead time. This kind of variability in track guidance presents a significant challenge for forecasters; therefore, it is of interest to determine how often similar track forecasts occur, and how the leading direction of position variability corresponds to the along and across-track directions. This project derives a global climatology of tropical cyclone track variability within the 51 member European Center for Medium-Range Forecasting (ECMWF) ensemble from 2008-2012 contained in the THORPEX Interactive Grand Global Ensemble (TIGGE) dataset. For each 12 h lead time, eigenvectors of ensemble member position variability are computed to determine the direction of maximum track variability. The standard deviation of position uncertainty in the direction of maximum variability is compared with the standard deviation in the normal direction. Lead times where the position variability is larger in one direction relative to the other are characterized by elliptical position variability. The results are stratified by basin, motion, and intensity to ascertain under what conditions forecasts with elliptical position variability are most likely to occur. Preliminary results show that elliptical position variability is more likely to occur in the West Pacific, with the Atlantic basin the least frequent. The presentation will conclude by evaluating the source of large track differences associated with Tropical Storm Debby.

Keywords: ensemble, ECMWF, tropical cyclone track
Parallel Session

SCI-PS207.04 - ENSO prediction using Multi-ocean Analysis Ensembles (MAE) with NCEP CFSv2: Deterministic skill and reliability

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To better sample the structural uncertainty in the ocean initial conditions (OIC), a multi-ocean analysis ensemble (MAE) initialization strategy is developed for predicting ENSO, using NCEP CFSv2. For this purpose, four sets of OICs are used to initialize the 12-month hindcasts of the climate for 1979 to 2007 starting from boreal spring. These four sets of OICs are chosen from four state-of-the-art ocean analysis products, two each produced by NCEP and ECMWF. For each OIC, an ensemble of hindcasts is generated with four different atmosphere/land initial states. Thus, each MAE case includes 16 ensemble members in total. The predictive skill in the tropical Pacific Ocean is assessed based on hindcasts from each OIC as well as the MAE. The results indicate that there exists a substantial spread in the SST prediction skill with different ocean analyses. Specifically, the ENSO prediction skill in terms of the anomaly correlation of Niño-3.4 index can differ by as much as 0.1-0.2 at lead times longer than 2 months. On average, the MAE has prediction skill equivalent to the best hindcast derived from the individual ocean analysis. What’s more important, the merit of MAE initialization is demonstrated by the improved ENSO forecasting reliability. In particular, compared with the atmospheric perturbation or lagged ensemble approaches, the MAE initialization more effectively enhances ensemble dispersion in ENSO forecasting. A quantitative probabilistic measure of reliability also indicates that the MAE method performs better in forecasting all three equi-probable (warm, neutral and cold) categories of ENSO events.


Keywords: Ensemble prediction, ENSO, Multi-ocean Analysis Ensemble
Enormous progress has been made in the last decade in the area of parameterization of sub-grid processes in global Numerical Weather Prediction (NWP) and climate models. This has been achieved through observations focusing on processes, high resolution modelling with CRM and LES models to improve process understanding, inter-comparison projects and studies dedicated to particular phenomena like MJO, cloud feedback, arctic clouds, atmosphere / surface interaction etc. To illustrate, a few examples of model improvement in the ECMWF NWP system will be shown. One of them is the introduction of the proper sensitivity of deep convection to environment moisture. There are many remaining issues. Some of them are related to lack of resolution, others relate to lack of understanding of processes and the need to represent complex processes in a bulk fashion. Improving model resolution to a convection permitting level will solve some of the problems but shallow convection and boundary layer clouds will still require improved parameterization approaches. Higher resolution will reduce the need for sub-grid orography schemes, but the representation of turbulent surface drag over land will remain highly uncertain. The coming decade will see again major progress. For instance, a better use of advanced data assimilation techniques in the NWP environment will help to optimise land surface characteristics that control surface drag and thermodynamic coupling between atmosphere and surface. Progress on NWP and climate modelling will require close partnership between modelling centres and the research community at large.

**Keywords:** parameterization, global atmospheric models
Cold air outbreaks are a common winter time feature over Northern Europe where cold air breaks free from the polar cap and sweeps over open oceans. The convection typically begins as organized rolls and eventually changes into open cellular convection as the boundary layer evolves. Cold air outbreaks are challenging for numerical weather prediction models as the depth of the boundary layer and the scale of the convection approaches the model resolution. Cloud morphological evolution during such events can have important impacts on the transport of heat and moisture as well as radiative effects. In the present study, which is conducted as part of the WGNE Greyzone project, a large-eddy simulation model, the UCLA LES, is used to evaluate high-resolution global numerical weather prediction (NWP) model hindcasts of a cold air outbreak crossing from the Norwegian Sea into the Atlantic Ocean. The large-eddy simulation is based on observations taken during the UK Met Office CONSTRAIN campaign from January 31st 2010 and associated simulations with the UK Met Office Unified Model. The day was characterized by northerly flow and stratocumulus clouds in the early stage of the event. As air advects over warmer seas the stratocumulus transitions into mixed-phase cumulus clouds, prior to reaching land. We discuss microphysical sensitivities in the large-eddy simulations, and compare the results of the large-eddy simulations with global NWP model hindcasts at different resolutions. Implications for parameterizations of heat, moisture and momentum mixing within the convective boundary layer in NWP and climate models are reconsidered.

**Keywords:** cold air outbreak, sub-grid parameterizations, grey zone
A sub-grid parameterization: CLUBB (Cloud Layers Unified by Binormals) has been incorporated into the GFDL atmospheric general circulation model (AM3). Based on an assumed double-Gaussian multivariate probability density functions with dynamics, CLUBB explicitly predicts sub-grid variations in vertical velocity, temperature, and total water. The inclusion of vertical velocity not only offers sub-grid variations required by aerosol activation, but also combines dynamic and thermodynamic variabilities within a self-consistent framework. More than that, CLUBB is also a unified cloud and turbulence scheme which is able to uniformly represent planetary boundary layer, shallow convection, and cloud macrophysics. With the incorporation of CLUBB in AM3, coupled with a two-moment cloud microphysical scheme, AM3–CLUBB allows for a more physically based and self-consistent treatment of aerosol activation, cloud micro- and macrophysics, boundary layer, and shallow convection. The configuration and performance of AM3–CLUBB are documented. Cloud and radiation fields, as well as most basic climate features, are modeled realistically. Relative to AM3, AM3–CLUBB improves the simulation of coastal stratocumulus, a longstanding deficiency in GFDL models, and their seasonal cycle, especially at higher horizontal resolution (e.g., 1-degree resolution or higher), but global skill scores deteriorate slightly. Through sensitivity experiments, it is shown that 1) the two-moment cloud microphysics helps relieve the deficiency of coastal stratocumulus, 2) using the CLUBB sub-grid cloud water variability in the cloud microphysics has a considerable positive impact on global cloudiness, and 3) the impact of adjusting CLUBB parameters is to improve the overall agreement between model and observations.

**References:**

**Keywords:** sub-grid parameterization, double-Gaussian PDF, cloud and turbulence
Parallel Session

SCI-PS208.04 - Successes and challenges of a seamless development of physical parameterizations

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Until recently, three distinct physical packages have been used in the operational Arome (convective scale) and Arpege (global) NWP models and in the Arpege GCM. A convergence on physical parameterizations has been undertaken based on multi-scales validations ranging from short range forecast to coupled ocean-atmosphere climate simulations in order to benefit from complementary expertise and diagnostics in NWP and GCM communities. Some important successes have been obtained with the representation of surface, radiative and turbulent physical processes. The turbulence scheme (Cuxart et al., 2000) based on a prognostic equation for the turbulent kinetic energy improved significantly the representation of the PBL in Arpege compared with the previous schemes. The scheme representing PBL thermals in Arome (Pergaud et al., 2009) has been adapted for long time steps with an implicit solver for mass flux and diffusion terms and validated on the globe in Arpege highlighting some weaknesses in the entrainment formulation. Statistical cloud schemes and prognostic microphysics are used both in Arpege and Arome models, but with different degrees of sophistication. A new prognostic convection scheme has been developed for Arpege NWP and Climat models including a prognostic treatment for convective updraft fraction, vertical velocity and cloud condensates to address some systematic model biases, such as the tropical diurnal cycle of precipitation and the sensitivity of moist convection to environmental humidity. Diagnostics based on multi-scales validations will be presented to illustrate some improvements, but also some challenges, for instance the need of using distinct entrainment formulations in NWP and Climat simulations.


Keywords: seamless, physics, parameterization, model
Over the past two decades, upper ocean impacts on intensity has received considerable attention including the cold wake structure and the negative feedback over quiescent oceans. In the western parts of the oceanic basins where the ocean state is not at rest, currents (e.g., Kuroshio, Gulf Stream, Loop Current) transport warm water poleward as part of the gyre circulation. In these regimes, the upper ocean current shears do not necessarily develop as in regions with shallow ocean mixed layers where significant sea surface temperature cooling often occurs. Transports by these energetic western boundary currents tend to be resistive to mixing events since the layer is already deep and the thermal response tends to be minimized. The implication is since the oceanic mixed layers do not significantly cool and deepen during TC passage, there is a more sustained enthalpy flux to the atmospheric boundary layer, thus representing an important mechanism for observed deepening of observed severe TCs (Haiyan). Recent studies have shown the surface drag coefficient to level off between 28 to 33 m/s at values from 0.002 to 0.003. While it is clear that the surface drag cannot continue to increase with wind speeds, the ratio of the enthalpy and surface drag coefficients still remains quite uncertain as this ratio ranges between 0.5 to 1.5. Results from CBLAST revealed a ratio of 0.7 that is still large enough for sustained enthalpy fluxes over deep mixed layers.

**Keywords:** Ocean, Atmosphere, Ocean Mixed Layer, Enthalpy Fluxes
Parallel Session

SCI-PS209.02 - ‘Category-6’ Typhoon Haiyan (2013) and ongoing subsurface warming over the western-north pacific main development region

I-I Lin1, Iam-Fei Pun1
1Pacific Science Association

With intensity peaked at 170kts, i.e., 35 kts above the 135 kts threshold for category-5 intensity, supertyphoon Haiyan devastated the Philippines in November 2013. Using satellite altimetry, in situ upper ocean thermal structure observation from Argo floats and numerical modeling, the upper ocean thermal condition for Haiyan is diagnosed. It is found that Haiyan intensified over the southern part of the typhoon main development region (MDR) over the western North Pacific (WNP). More interestingly, recent study from Pun et al. (2013) discovered that this MDR region is currently undergoing strong subsurface warming. As compared to the early 1990s, upper ocean heat content has increased by 15%. In this study, we showed that due to this ocean subsurface warming, the additional enthalpy flux supply contributed to the observed extra-ordinary intensification for Haiyan. This work also uses the recently-proposed new ocean coupling potential intensity (OCPI) index (Lin et al. 2013) to explore the associate change in the intensity upper bound. The use of OCPI instead of the traditional PI (or SST_PI, i.e. Emanuel 1988) is because the traditional PI does not consider the subsurface ocean condition but OCPI include ocean subsurface condition in the intensity upper bound estimation.


Keywords: Supertyphoon Haiyan, ‘Category 6’ intensity, Significant subsurface warming, Ocean coupling potential intensity
Parallel Session

SCI-PS209.03 - The effect of land-sea contrast on tropical cyclone track and structure

Johnny Chan¹
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As a tropical cyclone moves close to a landmass, the part of its circulation over the landmass, especially in the presence of topography, will experience very different conditions such as increase in frictional drag, reduction in latent heat flux and possibly increase in sensible heat flux, all of which will lead to changes in the dynamic and thermodynamic processes associated with the tropical cyclone. For track changes, it is found that differential friction results in a tropical cyclone drifting towards the rougher surface through the development of (a) a pair of counter-rotating gyres generated by changes in the relative vorticity budget and (b) asymmetric diabatic heating. In the presence of topography, the induced upslope and downslope flows also lead to the development of a set of counter-rotating gyres that tend to cause the tropical cyclone to move towards the onshore side. Topography at a large distance away from the tropical cyclone could also have an effect of its track as well through a similar mechanism. While it is intuitive that more precipitation will occur on the upslope side in the presence of topography, whether stronger convection occurs on the onshore or offshore side depends on moisture availability as well as the vertical wind shear. Examples from both observational analyses and numerical modeling results will be presented to illustrate the validity of these statements.

Keyword: tropical cyclone landfall
Parallel Session

SCI-PS209.04 - Mixture-based partitioning of operational ensemble forecasts for hurricane Sandy (2012)

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Forecasts of Hurricane Sandy (2012) from operational global model ensembles (GEFS, ECMWF, CENS and UKMET) are partitioned into clusters in physical space and cyclone Phase Space (CPS) using the curve clustering methodology of Gaffney et al. (2007) A novel approach is used to develop a mixture model (Kuruppumullage Don 2011) that provides a robust partition of the 113 multi-model ensemble members into distinct paths in physical space and CPS. Based on this analysis, a mixture model with five clusters and a third-order polynomial curve is used. The cluster evolution between October 23 and October 27 is examined, including the relationship between physical space clusters and CPS clusters, as well as the distribution of the ensemble members of each individual global model among the five clusters. In the October 23 and October 24 forecasts, there is substantial divergence among the track clusters, including multiple clusters in which Sandy does not make landfall in the United States. By October 25, the mean track of all clusters make landfall in the United States; however, great differences remain as to where the landfall occurs. On October 26 and 27, the differences among clusters decreases, showing that a landfall on the Mid-Atlantic coast is increasingly probable CPS clusters show a substantial variation throughout the forecast period, though the variation decreases as the clusters converge on Sandy transitioning into an extratropical cyclone as it approaches the Mid-Atlantic coast.

Keywords: Ensemble Forecasts, Hurricane Sandy, Mixed base partitioning
Parallel Session

SCI-PS210.01 - The Impact of the MJO on global ocean surface wave heights

Duane Waliser\textsuperscript{1}, Benjamin Wu\textsuperscript{2}, Bin Guan\textsuperscript{3}, Yuk Yung\textsuperscript{2}, Jose-Henrique Alves\textsuperscript{4}, Hendrik Tolman\textsuperscript{4}, Arun Chawla\textsuperscript{4}

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The Madden-Julian Oscillation (MJO) is an organized, low frequency (~50 days), planetary-scale, storm system that propagates eastward across the tropics, most notably from the Indian to the Pacific Ocean. It is associated with systematic variations in precipitation, clouds, winds, and ocean surface temperature. In recent years, operational global forecast models have demonstrated useful MJO prediction skill with lead times exceeding 2-4 weeks depending on the model and conditions. In this study, we document the link between the MJO and ocean wave heights, due to latter's importance on maritime operations (e.g. shipping, naval activities, tourism, rescue, coastal hazards). We use daily MJO indices, which contain the date, phase, and amplitude of MJO events, and NOAA Wavewatch III ocean wave data from 2005 to the present, which contains daily estimates of significant wave height at all global ocean points. We composite the daily ocean wave maps according to the (Wheeler & Hendon) phase of the MJO, and do this compositing separately for both boreal winter and summer. The findings illustrate a definite link between MJO events and global wave heights. Significant impacts (+/- 20-50% of seasonal mean values) are evident in the composites in the tropical regions, particularly near the Maritime continent, eastern Pacific, southeast Asia and in a number of high latitude areas (e.g. N. Pacific). Examination of the corresponding near-surface wind illustrates the local, and in some cases remote, mechanistic links between the MJO, the anomalous wind forcing and the anomalous ocean wave heights.

Keywords: MJO, ocean waves, teleconnections, subseasonal prediction
The role of air-sea interaction in the simulation of the MJO has been the focus of many modeling studies. The problem is vexing because the atmosphere does not respond directly to sea surface temperature (SST), but to its effects on surface latent and sensible heat fluxes. The fact that MJO convection leads maximum surface fluxes challenges our understanding of how the latter can impact the former. However, most studies demonstrate improved MJO simulation when an atmosphere-only GCM (AGCM) is coupled to an ocean model (CGCM). We examine the role of coupling in three GCMs: CAM3, CAM4, and the "super-parameterized" SPCAM3/SPCCSM3. Each is run as a CGCM, and as an AGCM using SSTs derived from SPCCSM3, which simulates a realistic MJO. The sensitivity of latent and sensible heat fluxes to SST anomalies is largest in the coupled models, and smallest in AGCMs. Local SST variance explains only ~10% (25%) of latent (sensible) heat flux variance in coupled simulations; wind speed variance explains the rest. We turn to the moisture budget for insight into how coupling increases the wind speed variability associated with improved MJO simulation. When MJO convection is located in the eastern Indian Ocean, coupling enhances Maritime Continent midlevel moistening by horizontal advection. The Q2 profile reveals that the elevated moisture advection is supplied by shallow convective moistening in the eastern Pacific, that gradually deepens toward the west. Our analysis suggests that Indian Ocean air-sea interactions increase convective vigor and its convectively-driven circulations, which ultimately drive moistening to the east.

**Keywords:** Madden-Julian Oscillation, Air-sea interaction
Parallel Session

SCI-PS210.03 - Vertical structure and diabatic processes of the Madden-Julian oscillation in climate models

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The Madden-Julian Oscillation (MJO) exerts pronounced influences on global climate and weather systems. The quasi-periodic occurrence of the MJO provides one of the primary sources for the predictability on subseasonal time scales, which may bridge the forecasting gap between weather forecast and short-term climate prediction. Our current general circulation models (GCMs), however, exhibit rather limited capability in representing this prominent tropical variability mode. Meanwhile, the fundamental physics of the MJO are still elusive. Given the central role of the diabatic heating for prevailing MJO theories and demands for reducing the model deficiencies in simulating the MJO, a global model inter-comparison project on diabatic processes and vertical heating structure associated with the MJO has been organized through a joint effort by the WCRP-WWRP/THORPEX YOTC MJO Task Force and GEWEX GASS Program. Three experimental components were designed for this project, including i) a twenty-year climate simulation, ii) a 2-day hindcast, and iii) a 20-day hindcast component. In this presentation, progresses of this model inter-comparison project will be reported, with main focus on climate simulations from about 27 atmosphere-only and coupled GCMs. Vertical structures of heating and diabatic processes associated with the MJO based on multi-model simulations will be presented along with their reanalysis and satellite estimate counterparts. Key processes possibly responsible for a realistic simulation of the MJO, including mean state, moisture-convection interaction, surface fluxes, and ocean coupling, will be discussed.

Keywords: Madden-Julian Oscillation, Climate models, Vertical heating structure
Parallel Session

SCI-PS210.04 - Multiscale interactions and their resolution dependencies within Madden-Julian Oscillations produced by NICAM.

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The increase of computational power now allows global cloud resolving Madden-Julian Oscillation (MJO) simulations for multiple cases. In this study, we explore the multi-scale interactions in the MJOs simulated with three different horizontal resolutions (3.5 km, 7 km, and 14 km) in a global cloud/cloud-system resolving model NICAM. We seek to generalize our results by evaluating the resolution dependencies of multi-scale interactions and also analyzing large number of cases at the low resolution (14 km) simulations. Acknowledgements: This study is funded by SPIRE (Strategic Programs for Innovative Research) and JAMSTEC. Simulations were done on the K computer (RIKEN AICS) and the Earth Simulator (JAMSTEC). Simulations were aided by the NICAM team.

Keywords: Madden-Julian Oscillation, Convective momentum transport, Global cloud resolving model
Parallel Session

SCI-PS211.01 - Mesoscale modeling at high (but not turbulence-resolving) resolution

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Meteorological modeling with fine [O(1km)] grid meshes is now common. The scales resolved by these meshes are small enough to capture features of the larger turbulent eddies that may exist in the planetary boundary layer (PBL), but too large for the simulation of the turbulent cascade that regulates their amplitude and structure, as would occur in a Large-Eddy Simulation where grid meshes are O(10m). The issue addressed in this talk is that PBL parameterizations developed for the larger-grid-mesh simulations of the past may in fact set up situations in which the mesoscale model produces convectively unstable motions, the reason being that in an attempt to represent observed heated-PBL profiles, most parameterizations produce potential-temperature profiles that are superadiabatic over much of their depth. From the point of view of a mesoscale model, however, these profiles are absolutely unstable and are prone to producing circulations at the minimum resolved scale at short lead times since the growth rate is inversely proportional to the resolved scale. Although the production of these circulations corresponds to a real physical process, the smaller-scale turbulence that determines their ultimate form depends on scales not resolved by the mesoscale model. For mesoscale models with grid meshes O(1km), the motions immediately downscale of the minimum resolved scale are too large to fall within the inertial subrange of turbulence and no theory based on first principles exists for the parameterization of their effects. Several consequences of mesoscale modeling in this regime are discussed.


Keywords: Mesoscale, Numerical Models, Convective Instability, PBL
Parallel Session

SCI-PS211.02 - The effect of the physical parameterizations and the land surface on rainfall events in Poland

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In this study, we evaluate a number of different microphysical, boundary layer, and land surface parameterizations applied to the forecast of significant rainfall events over Poland. This study is performed using the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) and a number of observational- and satellite-based verification techniques. Several significant precipitation events occurred over Poland during the spring and summer months of 2010, and these events are used for sensitivity tests for various parameterizations. These cases are dominated by late spring/summer frontal/convection conditions. The results indicate that while some precipitation events are simulated quite well, others pose problems for all parameterizations. Also, within any one case, a large spread in the forecasts can exist when using different parameterizations. This talk will include brief descriptions of the baseline version of COAMPS and the precipitation events that make up this study, and the results and validation of the tests that have been performed; along with suggestions for further work that is required in this area.

Keywords: Precipitation, Physical Parameterizations
Parallel Session

SCI-PS211.03 - Assessment of hailstorms in WRF weather simulations over Switzerland in summer 2012.

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The presented study aims at estimating the capacity of the WRF regional model to reproduce the convective activity over Switzerland, in particular the hailstorms, in different weather types. A series of simulations with the WRF 3.4 model were driven by the 6-hourly ECMWF analysis data on a 415x376, 2-km latlon domain for the summer (JJA) season of 2012. Four microphysics schemes have been tested; the role of the domain size, vertical resolution and the Alpine orography was also studied. Life cycle, trajectories, diurnal variations and amplitude of simulated convective cells were analysed and compared with the weather radar data, MeteoSwiss weather type classification and COSMO-2 analysis. An optimal domain configuration for studying the hailstorm activity over Switzerland in changing climate conditions has been elaborated.

Keywords: Hailstorm, WRF, Switzerland, Convection
Parallel Session

SCI-PS211.04 - The role of moist convection in the West African Monsoon

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Predicting the West African Monsoon (WAM) remains a major challenge for weather and climate models. Moist convection not only generates rainfall, but forms an integral part of the monsoon system. We compare multi-day continental-scale simulations of the WAM that explicitly resolve moist convection, with simulations which parameterize convection. The more realistic explicit convection gives greater latent and radiative heating further north, with latent heating later in the day. This changes the timing of heating and the resultant low-level pressure gradients, relative to the diurnal cycle of weak-daytime and strong-nighttime flow. This substantially alters the entire monsoon and its water cycle. Cold-pool outflows from storms provide a significant component of the monsoon flux, which is missing in parameterized runs. In an operational global model, biases resemble those in our parameterized case, with most forecast model bias in the summertime central Sahara observed to be due to missing cold pools. We show that the initiation of storms in explicit runs depends on local convergence, but not always convergence at 100-km scales. Parameterized simulations struggle to capture this, which is consistent with the recent studies showing that parameterized models fail to capture the role of soil-moisture gradients in initiating convection. Improved parameterizations of convection that better capture: initiation, storm structures, their diurnal cycle and rainfall intensities will therefore substantially improve predictions of the WAM and coupled aspects of the Earth system.

Keywords: Convection, West African Monsoon, cold pool, diurnal cycle
Parallel Session

SCI-PS212.01 - Building a weather-ready nation: linking services to observations, forecasts, and dissemination

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An increase in extreme weather, water, and climate events around the world is being recognized for the major impacts these events are having on population centers and related infrastructure. Numerous floods, droughts, heat waves, wildfire, hail, tornadoes, tropical and winter storms continue to make headlines and inflict major societal and economic. At the same time, accurate forecasts of extreme events now extend 4 to 8 days in advance. The emergency management community in the United States view these forecasts as a fundamental part of their decision process in preparing for extreme weather events. This new development to link the forecasts to decision support services is the basis for the National Weather Service’s (NWS) Weather-Ready Nation. Becoming a Weather-Ready Nation is about establishing community preparedness and resiliency in the face of increasing vulnerabilities to extreme weather. This strategic outcome revolves around delivering “Impact Based Decision Support Services” that consistently link forecasts to decision makers to ensure the message provided and the message received results in the actions needed to save lives. The presentation will consider the basis for improved understanding of and techniques for decision-making, the characterization and range of decision-making from an "organized" response to a "loosely-coupled" collaborative response to local/organic-personal responses; and how these different response mechanisms drive communication strategies from forecaster to the user/partners. The presentation will conclude with a discussion of ongoing efforts to improve forecast skill, reduce forecast uncertainty, improve the dissemination of forecasts and warnings, feed into the decision-making process and improve the societal response.

Keyword: Weather-Ready Nation,
Parallel Session

SCI-PS212.02 - Coastal storm surge flooding impact under different climate scenarios in Pearl River Delta

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The Pearl River Delta, located in south-eastern China, is one of the most economic regions in China. After 20 years development, the region created 10% of Chinese gross domestic products and gathered 3% of the national population on the territory just accounting for 0.4% of the total territory. Due to the low lying topography of the Pearl River Delta, flooding risk caused by storm surge becomes the major risk along the coastal area in Pearl River Delta. This research aims are to analyze and assess inundation risks by storm surges, using hydraulic modeling approaches Anuga Model (developed by Australia National University and Geoscience Australia) and SAGA GIS (developed by Dept. for Physical Geography, Göttingen and University of Hamburg) based topological analyses to identify areas, which face highest risks under present and future climate conditions. Comparing the Delft 3D model to analysis the uncertainty. Given that Typhoons and storm surges impact almost every year the Pearl River Delta Area, research focuses on the uncertainty analysis and modeling of flooding inundation caused by storm surges under consideration of economic losses. The simulated case is closed to the observed data. The simulated water height and water depth is accorded well with measured data in Pearl River Delta area.

Keywords: storm surge, flooding, Coastal Area, climate
Parallel Session

SCI-PS212.03 - Assessing risks to infrastructure projects in the middle east from drifting/blowing sand using WRF

J. Wayne Boulton¹, Stuart Carmichael¹, Jeff Lundgren¹, Duncan Phillips¹, Ewan Crosbie², Giles Wiggs³, Cheryl Mckenna Neuman⁴

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Significant planning and engineering efforts are underway to develop an integrated, multi-national rail network across the Arabian Peninsula. Passenger lines, some designed to support speeds in excess of 200 kilometres per hour, and mineral / bulk material lines are under development. Many of the planned routes cross long stretches of open desert, including sections of the Rub' al Khali or 'Empty Quarter' where sand dunes reach heights in excess of 200 metres. Wind-blown and drifting sand poses a significant threat to the integrity of a number of aspects of rail systems. However, meteorological stations in these remote desert areas are essentially non-existent, representing a significant challenge to railway engineers. To fill this gap, the authors leveraged the Weather Research and Forecast (WRF) model to simulate the meteorology over nested model domains down to four kilometre resolution over the Arabian Peninsula for a contiguous ten-year period from 2001 through 2010. WRF model outputs were post-processed using Weibull fitting techniques to develop site-specific climate models for numerous locations along proposed sections of track in Saudi Arabia and the United Arab Emirates. These climate models were then integrated with results from wind tunnel studies of sand transport mechanics to develop frequency and magnitude statistics concerning sand transport, which in turn were used to develop climate sensitive mitigation strategies. In addition to the development of representative sand transport statistics, one-of-a-kind maps depicting near-surface wind fields, annual sand transport rates, and vector plots of sand transport pathways were also developed.

Keywords: WRF, Sand, Infrastructure, Middle East
Parallel Session

SCI-PS212.04 - Downscaling meteorological quantities for waves and storm-surges hind-casts in IncREO project

Emilie Bresson\textsuperscript{1}, Philippe Arbogast\textsuperscript{1}, Anna Kortcheva\textsuperscript{2}, Denis Paradis\textsuperscript{3}, Florence Rabier\textsuperscript{4}, Lotfi Aouf\textsuperscript{3}, Patrick Ohl\textsuperscript{3}, Andrey Bogatechev\textsuperscript{2}, Vasko Galabov\textsuperscript{2}

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The European project IncREO, Increasing Resilience through Earth Observation, aims at providing Earth Observation-based solutions to Civil Protection and disaster management to improve preparedness and mitigation planning for areas highly vulnerable to natural disasters and already noticeable climate change trends. The goal of our Work-Package (WP202) is to generate high resolution atmospheric data (10-m wind and mean sea level pressure) that occurred in the past to be able to simulate the high waves and storm-surges over coastal areas in France and Bulgaria. First of all, we define 30 historical situations from a more or less recent past (from 1924 to 2012) with storm conditions associated with high waves and/or high storm surges over French coasts (20 cases) and Bulgarian coast (10 cases). Then we directly use re-analyses performed at ECMWF (ERA-Interim, ERA-40 and ERA-Clim) and downscale these analyses with a higher resolution NWP models (ARPEGE and ALADIN) to the horizontal and time scales relevant to storm surges and waves simulations. We make another set of experiments based on a more promising albeit more challenging option: assimilating more observations in the analyses for the simulation of ten French events. For all these storms, hind-casts of ocean waves and storm surges have been performed by using wave model (MFWAM) and ocean models (HYCOM ans SWAN respectively for French and Bulgarian cases). Comparisons between experiments with and without downscaling show encouraging results and valid the downscaling procedure.

\textbf{Keywords:} Downscaling, Re-analyses, High wave, Storm-surge
UAS-PA407 Panel Discussion

Special Joint Panel on the Future of the Weather Enterprise

Weather Services – Present Status, Trends, and Innovations

This special joint panel on Weather Services is the second in a series of three designed to advance dialogue on the collaboration of private, public and academic elements of the weather enterprise—the first two explore important issues and problems while the final panel is oriented towards finding solutions. Weather Services can be defined as the research and development, production, delivery, and evaluation of weather, water and climate knowledge to support customer decision making. Customers are broadly defined to include agencies, organizations and enterprises from government, non-government, public, industry, and academia. Panel discussion will focus on today’s weather

Chair: Neil Gordon

UAS-PA407.01 - Panel Participant

Michael Elits

Weathers Decision Technologies, Norman, USA

Standardized and Open Access to Observations and Government Forecasts and Warnings

One of the key roles of the private sector in the Weather Enterprise is to communicate weather information to enterprises and the public in forms that both inform and provide actionable information to the end user. The private sector makes significant investments in developing capabilities to access data, manipulate those data, and provide forecasts, advisories and warnings to their customers via web pages, apps, alerts, emails, direct communication, etc. Government national meteorological services organizations manage sensors, run models and produce forecasts and warnings. My presentation will discuss the synergistic partnership between the private sector and the public sector in the weather enterprise and how the greatest value to society could be created if government national meteorological services would work with the private sector on a global basis to standardize and make available watches, advisories and warnings so that the private sector can communicate these high priority messages to Enterprises and the public in a seamless manner across the globe.
In his capacities as Assistant Deputy-Minister of the Meteorological Service of Canada (MSC) and as President of the World Meteorological Organization (WMO) David Grimes has emphasized that collaboration amongst all sectors of society is essential to advancing the weather enterprise. Weather events are becoming more complex, vulnerability and exposure are increasing and citizens’ expectations for tailored information and just-in-time delivery are growing. While economic sectors as well as governments need to closely manage their resources, more focus is placed on enabling weather and climate smart decision-making by enhancing services and engaging end-users through a variety of mechanisms. Innovation is required to develop impact-based forecasting and risk-based warnings as well as new ways of sharing them. From a global perspective, the WMO is ideally placed to bring together experts and work towards enabling development of such services in less developed countries. Care will be required to ensure governments remain the authoritative source of critical health and safety information while developing innovative public-private partnerships to increase our reach and relevance.

Big Data And Big Decisions

The future of the Weather Enterprise will be affected by three fundamental trends – stepwise improvements in global models as the foundation of numerical weather prediction, advances in cloud computing that allow more operational and real-time decision tools, and advances in connected cars, homes, planes, and people which allow better, faster, and more precise decisions and actions. The weather enterprise will become more globally connected, and migrate from data services to decision services as a result.

Reliable meteorological services are becoming increasingly important for businesses and the general public. The continuous improvements in numerical modeling and application development allow providing the bulk of the meteorological data fully automatically. But critical warning operations will remain semi-automated with forecasters interacting with the data or the warnings. Meteorological information will be integrated in user’s decision support system. Forecasters will become advisers rather than sole interpreters of data. Communicating forecast uncertainty and adverse weather impacts will remain a big challenge. The increased vulnerability of critical infrastructure requires tackling special forecasting challenges, like forecasts for renewable energy. Providing the final forecast to the customer needs a close cooperation between NWSs and the private sector.
UAS-PA407 Panel Discussion
Special Joint Panel on the Future of the Weather Enterprise / cont
Weather Services – Present Status, Trends, and Innovations

UAS-PA407.05 - Panel Participant

Barry Myers
1
1 Accuweather, State College, PA, USA

Weather may never be conquered, but meteorology and technology enable us to “tame” the weather though more accurate forecasts and rapid distribution of them using the latest communication tools. A paradigm used by the American Weather Industry, supported by the U.S. government, is to ensure a constantly growing enhancement of weather action and mitigation efforts – better forecasts, rapid communication, and actionable messages. This joint action saves lives and property. It is an approach that is applicable in many countries. Barry Myers, leads a company, whose weather information is available on 1.3 billion devices globally, cooperatively works to develop national solutions.

UAS-PA407.06 - Panel Participant

Roland Stull
1
1 University of British Columbia, Vancouver, Canada

Operational NWP by a Canadian University

Issues include:
1) Increasing availability of community models (from government/academic partnerships), initial-condition data (from government), and inexpensive computers.
2) Forecast production and sales by academia brings revenues that enhance pure research productivity.
3) Recent relaxation of Canadian government disincentives leaves a hole for entry by academia/private sectors.
4) Fast response of private and academic operations to tailor regional forecasts to client needs.
5) East to west decrease in forecast skill, causing mismatch between government goals and actual needs, and affecting client perception of forecast value
Regional climate change can strongly impact on local surface vegetation characteristics, which can in turn modulate the regional climate by modifying key surface characteristics. To capture these feedbacks a dynamic vegetation model, the Canadian Terrestrial Ecosystem Model (CTEM), has been implemented in the 5th generation of the Canadian Regional Climate Model (CRCM5). Two recent-past experiments (1971–2010) of CRCM5 are compared – one with dynamic vegetation and the other with static vegetation – in order to assess the impact of dynamic vegetation on the regional climate over North America. Simulated vegetation attributes, temperature and precipitation are compared to those observed. CTEM improves the model (CRCM5) in some regions, although it introduces new biases in other regions such as western USA, due to large differences in the leaf area index (LAI), greatly affecting biosphere-atmosphere interactions with respect to energy and water fluxes. Although implementation of dynamic vegetation in CRCM5 does not improve the model in a clear manner with respect to the mean climate, it introduces biosphere-atmosphere interactive feedbacks and long-term memory in the model, which impact the simulation of energy fluxes variability and lead to improved climate extremes simulation. For example, the dynamic vegetation simulation shows a great improvement on how the model captures the number of hot days during the 1988 drought and its effect on the biosphere, as it is able to simulate the drought-stress effect on the plants.

Keywords: Dynamic vegetation, Regional modeling, Land-atmosphere interactions
Parallel Session

SCI-PS213.02 - CLASS application in western Africa

Diana Verseghy¹
¹Environment Canada, Toronto, Canada

This presentation will review the results of testing the Canadian Land Scheme, CLASS, within ALMIP2, the AMMA Land-surface Model Intercomparison Project. AMMA, the African Monsoon Multidisciplinary Analysis, ran from 2002 to 2010 and was aimed at improving knowledge and understanding of the West African Monsoon (WAM) variability, with the goal of providing improved predictions of the impacts of the WAM. It included a multi-year field campaign over west Africa and the tropical Atlantic, involving collaborators from Africa, France, UK, USA and EU. ALMIP2 focuses on three super-sites across the north-south transect of the WAM, located in Benin, Niger and Mali. Nineteen land surface models are participating in the intercomparison. The first phase involved regional offline runs over the three supersites at a resolution of 5 km, using atmospheric forcing from reanalyses and precipitation inputs from a dense network of rain gauges. The second phase involves point-scale testing of the models at seven tower flux sites located within the three supersites. This project presents an opportunity to test CLASS over a domain far removed from the cold, high-latitude areas for which it was originally designed, and to ascertain the robustness of its soil and vegetation parameterizations. CLASS has performed very well so far, but many of the vegetation and soil parameters were prescribed for the simulations on the basis of observed data. This presentation will investigate the sensitivity of CLASS to the prescribed values, and the effects when climatological background values are used instead.

Keywords: land surface, model intercomparison, ALMIP2, water cycle
Parallel Session

SCI-PS213.03 - Forecast uncertainty under different land-atmosphere coupling regimes

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The results of the GEWEX GLACE showed that coupling could directly affect a model’s ability to simulate climate predictability. The GLACE follow-on (GLACE-2) in turn demonstrated that realistic soil moisture initialization could improve sub-seasonal 2 m air temperature forecasts for limited areas. Both studies show the impact of coupling. However, neither elucidates the sign of the coupling feedback or its absolute sensitivity (i.e., of 2 m air temperature or precipitation to soil wetness), including its variability as a function of surface and atmospheric state. This leads us to question under what circumstances the skill of a coupled model is heavily dependent on realistic coupling. Under some conditions, a model may be forced into an unrealistic climate regime that does not allow coupling at all. For example, during dry-downs the CFSv2 land and atmosphere can become malaligned due to unchecked, inflated land evapotranspiration. In this study, we will apply WRF v3.5 to contrast short-term forecast skill during observationally defined wet-positive (rainfall on wet soil) coupling and dry-negative (rainfall suppressed on dry soil) coupling events over the southern Great Plains. Specifically, we will identify links in the modeled coupling process chain (i.e., direct land surface-PBL feedback, cumulus formation, convective triggering and fueling) with the greatest sensitivity to coupling regime. A key question is whether distinct coupling regimes correspond with a distinct uncertainty space. DOE ARM Best Estimate (ARMBE) data products (i.e., ARMBE-ATM: atmospheric surface and profile; ARMBE-CLD: cloud and radiative fluxes; and ARMBE-Land: land forcing) will serve as our comparison truth.

Keywords: forecast uncertainty, land-atmosphere coupling regimes, coupling process chain
Parallel Session

SCI-PS213.04 - Trends in summer rainfall over China associated with the Tibetan Plateau thermal forcing

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The impacts of the thermal forcing over the Tibetan Plateau (TP) in spring on changes in summer rainfall in China are investigated using historical records from the period between 1980 and 2008. The spring sensible heat (SH) flux and snow depth over the TP both decreased over this time period, although the trend in SH was more significant than that in snow depth. The similarity between patterns of precipitation trends over China and corresponding patterns of regression coefficients on the leading mode of spring SH change over the TP demonstrates the distinct contribution of changes in TP SH during spring. Enhanced precipitation in South China was accompanied by increases in heavy rainfall, precipitation intensity, and the frequency of precipitation events, while reduced precipitation in North China and Northeast China was primarily associated with decreases in the frequency of precipitation events. Further analysis using observational data and numerical simulations reveals that the reductions in SH over the TP have weakened the monsoon circulation and postponed the seasonal reversal of the land–sea thermal contrast in East Asia. In addition, the positive spring SH anomaly may generate a stronger summer atmospheric heat source over the TP due to the positive feedback between diabatic heating and local circulation.

Keywords: Trend, rainfall, China, Tibetan Plateau
Parallel Session

SCI-PS214.01 - Variability of tropical cyclone activity

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We will summarize the current state of the art for research on the link between tropical cyclones and climate at various time-scales, from sub-seasonal to decadal. Improvements in computational capabilities have enabled the representation of tropical cyclones in climate models to become much more realistic, primarily by increasing models’ horizontal resolution, although there remain deficiencies in storm intensity. We will discuss the capability of the current climate models to forecast tropical cyclone activity at sub-seasonal and seasonal time-scales. Recent results on tropical cyclogenesis during the Last Glacial Maximum and the mid-Holocene will be presented. The current challenges on this topics will be highlighted.

Keywords: tropical cyclones, climate
SCI-PS214.02 - Predictability of intraseasonal variability and tropical cyclogenesis in the Western North Pacific

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To examine predictability of intraseasonal variability (ISV) and tropical cyclogenesis which successively occurred in the north western Pacific in August 2004, we conducted 31 extended-range (30-day) forecasts initialized on each day of August 2004 using 14-km-mesh Nonhydrostatic Icosahedral Atmospheric Model (NICAM). The results are compared with those in the National Center for Environmental Prediction (NCEP) Global Ensemble Forecast System (GEFS) reforecast version 2. NICAM well simulated active convection and its northward migration associated with ISV in August and suppressed convection in September in the western north Pacific. On the other hand, in GEFS, convective activity in August tended to decay with time. In NICAM, TC genuses of Megi, Chaba, Aere, and Songda were predictable up to two weeks before their genuses. In GEFS, TC genuses of Chaba and Aere are predictable up to one week before their genuses, however, the others were less predictable. Large scale circulation around the location of Songda’s genesis was examined. In reanalysis data, monsoon trough extended beyond the date line and Songda was generated on the shear line associated with the trough. This eastward extension of monsoon trough was predicted up to two weeks prior to Songda’s genesis in NICAM, however, whereas it was not well predicted in GEFS even in one-week lead time. These results suggest that low predictability of monsoon trough in GEFS may result in missing Songda’s genesis.

**Keywords:** Tropical cyclogenesis, Intraseasonal variability, predictability, intermodel comparison
Parallel Session

SCI-PS214.03 – WITHDRAWN - Spiral rainbands in numerical simulations of tropical cyclones under vertical wind shear

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Previous studies have examined spiral rainbands in numerical simulations of tropical cyclones under idealized no-mean-flow conditions. However, more realistic large-scale environmental conditions surrounding tropical cyclones should include vertically sheared flows. This study examines spiral rainbands in numerical simulations of tropical cyclones embedded in vertically sheared flows. Results show that only the tropical cyclones simulated under vertical wind shear produce both radially outward- and inward-tilted rainbands documented in previous observations. Implications for secondary eyewall formation will be discussed.

Keywords: Tropical cyclones, Spiral rainbands, Secondary eyewall formation
The Madden-Julian Oscillation (MJO) has been documented in many previous studies to impact tropical cyclone (TC) activity for various TC basins around the globe. Strong modulations in Atlantic basin TC activity have also been demonstrated, with enhanced TC activity in the Atlantic Main Development Region (MDR) associated with convective enhancement over the Indian Ocean. Suppressed TC activity is typically observed in the Atlantic MDR when the convectively-enhanced phase of the MJO is over the tropical Pacific. These modulations in the Atlantic seem to be primarily driven by alterations in intraseasonal values of vertical wind shear. Many studies examining the MJO’s impacts utilize the Real-Time Multivariate MJO index which utilizes a combination of outgoing longwave radiation (OLR) and upper- and lower-level zonal winds. OLR is only available since 1974, and consequently, these studies only have 40 years of data with which to work. However, recently, Oliver and Thompson (2012) have developed an extended MJO dataset that goes back to 1905 using surface pressure reconstructions. A preliminary analysis of this dataset shows similar robust relationships between TC activity and MJO phase extending back to 1905. In addition, given the 100+ years of data available with this new dataset, relationships between MJO phase-TC activity and longer-period indices such as the Atlantic Multidecadal Oscillation and El Niño-Southern Oscillation can also be investigated. These results will be discussed in detail in this presentation.

Keywords: Madden-Julian Oscillation, Tropical Cyclone
SCI-POW1120 - Analysis of tropical high impact weather events using TIGGE data

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Forecasting high impact weather events in tropical regions and the possible ranges of intensity or evolution that can be supported by the large scale environmental conditions is essential. Important guidance for this can be obtained from ensemble forecasts. An empirical orthogonal function (EOF)- and fuzzy cluster analysis is performed to examine data from several THORPEX Interactive Grand Global Ensemble (TIGGE) ensemble prediction systems in order to examine the information contained within the models. In a case study of an intense African easterly wave (AEW) that caused major flooding in Ouagadougou, Burkina Faso, it is shown that this method can be used to identify distinct AEW scenarios that are contained in the ensemble data. The results indicate the possibility for the occurrence of heavy precipitation already four days in advance, and become the most likely scenario by two days before the event evolved. Examples for a variety of event types – including more recent intense precipitation events from 2012 and 2013 affecting West Africa in association with AEWs, and tropical cyclone Haruna (2013), which affected Madagascar – will be shown to illustrate how this coarse grid-resolution data can be used to identify these types of events, and to provide suggestions on how TIGGE data could be used for downscaling purposes.

\textbf{Keywords:} ensembles, tropical high impact weather
Parallel Session

SCI-PS215.01 - Adapting cities to climate change: a systemic modelling approach

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In response to the challenge of climate change, all states have not only to reduce their greenhouse gas emissions but also to adopt adaptation measures to limit the negative impacts of global warming on the population, the economy and the environment. The question arises especially for cities. Cities modify the local meteorology. A well know effect is the Urban Heat Island: by night cities can be 10°C warmer than the countryside. Recent rapid advances in the last 15 years allow to simulate these urban features in high-resolution research and NWP atmospheric models. Furthermore, because of complex interactions between climate change, and the evolution of cities and their inhabitants, studying adaptation strategies for cities requires a strong interdisciplinary approach involving urban planners, architects, meteorologists, building engineers, economists, and social scientists. A four-step methodology is presented. It consists firstly of defining interdisciplinary scenarios; secondly of simulating the long-term evolution of cities on the basis of socio-economic and land-use models; thirdly of calculating impacts with physical models (such as TEB), and finally of calculating the indicators that quantify the adaptation strategies. Urban planning strategies are revealed to have unexpected influence on city expansion in the long term. Another finding is that the urban heat island should be taken into account in operational estimations of building energy demands. Users’ practices seem to be an efficient lever for reducing energy consumption in buildings. Interdisciplinary systemic modelling appears well suited to the evaluation of several adaptation strategies for a very broad range of topics.

Keywords: Climate Change, Urban Heat Island, Modelling, City Expansion
Parallel Session

SCI-PS215.02 - Operational implementation and performance evaluation of a PM10 and PM2.5 model for Santiago de Chile

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This study shows the operational implementation and a systematic analysis of sources of error in a forecast model for air quality during the Santiago de Chile Critical Episode Management seasons (GEC) of 2011-2013, in order to add it as an operational tool for the use of the Chilean Weather Service (DMC) in its commitments to the national Ministry of Environment. Modeling system was transferred from the academia and then installed and tested in an operational fashion at DMC. The model is based on a tracer of carbon monoxide and it estimates the particulate matter (PM10 and PM2.5) concentrations based on the modeling of CO by a linear relationship for two of the more polluted stations in Santiago basin, that typically trigger measures that affect population, which are taken by environmental authorities, according to Chilean law. Performance evaluation was based on statistical metrics for air quality variables (CO, PM10 and PM2.5) and the analysis of some meteorological variables for the study period, along with a comparison for 2012 and 2013 with the official PM10 prediction model in use today. We also evaluate model performance using a multilinear regression using wood burning emissions using a different diurnal and spatial profile, as well as model performance degradation in terms of forecast window. The results show that the model has an acceptable performance in the prediction of particulate matter and allows reasonably anticipate management of critical events of air pollution with more ahead time than currently available tools.

Keywords: PM10 and PM2.5 forecast, WRF-Chem, CO tracer, Santiago de Chile
Parallel Session

SCI-PS215.03 - The Tokyo metropolitan area convection study for extreme weather resilient cities (TOMACS)

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An unprecedented dense observation campaign and relevant modeling and societal studies have been conducted since April 2010 by the National Research Institute for Earth Science and Disaster Prevention (NIED), Meteorological Research Institute (MRI), and more than 25 national institutions and universities in Japan that target local high-impact weather (LHIW) in the Tokyo metropolitan area. The objectives of the project, the Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities (TOMACS), include the 1) elucidation of the mechanism of LHIW in urban areas (e.g., local torrential rain, flash flood, strong wind, lightning), 2) improvement of nowcasting and forecasting techniques of LHIW, and 3) the implementation of high resolution weather information to end-users through social experiments. TOMACS was endorsed in 2013 as an international research and development project (RDP) of World Weather Research Programme (WWRP) of the World Meteorological Organization (WMO) with the international partners including the Environment Canada (Canada), Bureau of Meteorology (Australia), Sao Paulo University (Brazil), University of Hohenheim (Germany), Pukyong National University (Korea), University Paris-Est (France), National Center for Atmospheric Research (USA) and Colorado State University (USA).


Keywords: TOMACS, urban meteorology, local high impact weather, extreme weather
Parallel Session

SCI-PS215.04 - Coupling the Town Energy Balance (TEB) scheme to an operational limited area NWP model

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The Town Energy Balance (TEB) is implemented into a numerical weather prediction model running operationally at ~ 4 km resolution. The primary question addressed is the ability of TEB to function at relatively coarse resolution, and thus assessing its potential use in an operational configuration to improve sensible weather performance over Belgium. For this effort, simulations with and without TEB are first evaluated against 2m observations and wind above the urban canopy for two months (January and July 2010). The results show that promising improvements are achieved by introducing TEB. The 2m temperature and 2m relative humidity improve compared to measurements in urban areas. The comparison of wind speed and wind direction above the urban canopy indicate that the structure of the flow in urban areas is better reproduced with TEB. It was found that the implementation of TEB results in an increase of winter precipitation over urban areas and downwind from urban areas but during the summer TEB tend to cause rainfall to be locally concentrated and the total accumulated precipitation decreased obviously. Results from a 36-h case study during a high heat day with inland sea-breeze penetration (8 July 2010) indicate that the model captured satisfactorily the penetration of the sea breeze. In particular during the day, the TEB run shows a delay in the sea-breeze evolution compared to the operational run. During the night the results indicate that even at this coarse resolution, TEB is able to reproduce correctly the intensity of the observed UHI of Brussels.

Keywords: TEB, ALARO
SCI-PS216.01 - Multivariate chemical data assimilation and Chemistry-Dynamics Interaction

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An Ensemble Adjusted Kalman Filter (DART) system has been developed to assimilate simultaneously meteorological and chemical variables in the global scale chemistry-climate model CAM-Chem. Observations of long-lived chemical tracers such as carbon monoxide and ozone contain information that could potentially constrain meteorological fields (winds). In order to optimally integrate chemical measurements in the modeled atmospheric system, we will evaluate the impact of chemical data assimilation (Terra/MOPITT CO observations) on the meteorological state of the atmosphere, and conversely, the impact of meteorological assimilation on the chemical state of the atmosphere. Two processes will be quantified: to constrain a linked variable (e.g. winds and CO) using the data assimilation scheme using a multivariate covariance matrix, or only propagating the information using the model. Hence, the one way coupling in the assimilation scheme between meteorological assimilation and chemical assimilation will be discussed. The added value from the chemical observation on meteorological forecast skills will be also evaluated. The same methodology would be applied to investigate the impact between chemical variables, for example the impact of CO assimilation on other chemical species.

**Keywords:** Data assimilation, Chemistry, Meteorology
Parallel Session

SCI-PS216.02 - Do better aerosol forecasts improve weather forecasts? A regional modeling and assimilation study.

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Impact of aerosols on weather in the boundary layer is examined for short-term forecasts issued over eastern part of North America in summer 2012. The study employs WRF-Chem and Gridpoint Statistical Interpolation (GSI) for forecasting and 3D-Var simultaneous assimilation of standard meteorological observations and surface measurements of PM2.5 and PM10, and MODIS AOD. It is demonstrated that the assimilation of species leads to a significant improvement in prediction of aerosol concentrations. It is also shown that simulated aerosols have visible impact on weather in the boundary layer. While it is intuitively obvious that such impact should occur it is not apparent that quality of physical parameterizations is sufficient to improve weather forecasts. Verification statistics will be presented for a two-month-long period for simulations that do and do not account for aerosol feedback to radiation.


Keywords: aerosols, assimilation, weather, forecasting
Observational studies suggested that the Saharan Air Layer (SAL) may impose either negative or positive impacts on the evolution of Atlantic hurricanes. Hurricane Earl (2010) was influenced by SAL in the early development stage. The influence was studied in a numerical simulation and data assimilation experiment using the Weather Research and Forecasting model coupled with chemistry (WRF-Chem) and an ensemble Kalman filter (EnKF). In addition to the conventional observations, the Atmospheric Infrared Sounder (AIRS) temperature, specific humidity retrievals and Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depth that can represent the features of the SAL were assimilated into the WRF/EnKF system for a period of 4 days, followed by a 5-day ensemble forecasts. When only the conventional observations were assimilated, the storm failed to deepen and the tracks errors were large even at the beginning of the forecast. Assimilating AIRS observations significantly reduced the warm bias in the troposphere. The track and intensity analysis and forecasts were improved dramatically. Assimilating MODIS AOD has little impact on the hurricane development, probably due to the facts that the GOCART scheme used in the WRF-Chem only included the direct effect of dust and meteorological fields largely controlled Hurricane Earl’s development. The indirect effect of dust will be investigated in new data assimilation and forecast experiments.

**Keywords:** Saharan Air Layer, hurricane, WRF-Chem/EnKF
Parallel Session

SCI-PS216.04 - Experimenting with the LETKF in a dispersion model coupled with the Lorenz 96 model

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This work is framed in the general objective of testing the Local Ensemble Transform Kalman Filter (LETKF) as an assimilation technique to improve the representation of sources and sinks of atmospheric constituents. As a first step, this work focuses on two main objectives: a) to quantify the impact of the assimilation of concentrations and b) to investigate the ability of the LETKF to estimate model dispersion parameters (e.g. emission sources). In both cases OSSE experiments using a toy dispersion model based on the Lorenz 96 model have been done. For the first objective the LETKF ability to constrain concentration, when the dispersion model is coupled with the atmospheric model and when the dispersion model is uncoupled with the dispersion model, are investigated. The impact of the number of concentration observations has also been analyzed in both situations. We found that assimilation with the coupled model leads to better performance, particularly when a limited number of concentration observations are available. For the second objective, different emission scenarios (e.g. punctual sources with known location and sources with a priori unknown spatial distribution) as well as their temporal variability has been considered. Results show that a successful representation of concentration and dispersion parameters is possible and that a more accurate estimation of the parameters is achieved when they are estimated in a coupled system.

Keywords: LETKF, Dispersion toy model, Lorenz 96 model
Parallel Session

SCI-PS217.01 - Statistical Analysis of UK Convection and its representation in high resolution NWP Models

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Order 1km convection permitting models are now being used by a number of met services. With the prospect of moving to even higher resolutions in the future it is important to understand how they would represent convection. In the UK we have already routinely run a 300m version of the Unified Model (UM) for the Olympic sailing and 100m models have been used in several research contexts. Here we describe the DYMECS project (DYnamical and Microphysical Evolution of Convective Storms) which gathered statistics on 40 days of convective showers using the Chilbolton research radar in southern England. The modelling component of this project involved comparing the properties of convective showers with convection permitting versions of the UM with gridlengths from 4km down to 100m. We show that the key issue is the size of the convective cells and that the order 100m models have a tendency to produce too small convective cells, as measured by extent of cloud and rain, in cases where they should be larger although the behaviour is very sensitive to the subgrid mixing scheme employed. We also present some novel measurements of the vertical velocities in convective clouds and relate these to the cloud and rain data.

**Keywords:** Convection, Convection permitting models, High resolution models, Radar
The diurnal cycle of precipitation is considered to be one of the most important factors behind the variability of Indian summer monsoon (ISM). In this study, TRMM V7 3B42 rainfall, TRMM VIRS cloud congestus and MERRA reanalysis data are analysed to identify a possible mechanism between precipitation, associated cloud and dynamical processes over central India (CI) (which is the core ISM domain) in diurnal scale. We also have analyzed the rainfall and its associated features during active and break phases of ISM over CI. The 5 years of CFSv2 T126 and T382 models free run have been analysed to ascertain the model biases in diurnal scale. The study reveals that over CI, rainfall peaks at 1730 IST and the congestus maximizes at around 1300-1500 IST and the cloud liquid water maximizes at around 1430 IST keeping around a 3-hour lead with respect to rainfall maximum. Cloud ice attains a peak at 1730 IST being collocated with the rainfall maximum. The dynamical parameters also reach maximum in the early afternoon to afternoon hours over CI. The models fail to capture the time of maximum precipitation and cloud hydrometeors over CI. They also fail to reproduce the proper PDF of rainfall over CI region. These results indicate that both models possibly are unable to simulate diurnal scale physical processes. The model cloud parameterization scheme may need modification to better capture the diurnal scale process which eventually may improve its daily scale and subsequently the seasonal scale.


Keywords: Indian summer monsoon, Central India, CFSv2, cloud congestus
Parallel Session

SCI-PS217.03 - RELAMPAGO and SAME-PACE: Extreme storms that impact society in Southeastern South America

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RELAMPAGO (Remote sensing of Electrification, Lightning, And Meso-scale/micro-scale Processes with Adaptive Ground Observations) and ARM-DOE SAME-PACE (South American Multiscale Extreme Precipitation-Aerosol-Cloud Experiment) is proposed to be an international multi-agency field program to study the multi-scale aspects of convective storms that have extreme characteristics and impacts, produce an extreme precipitation climate, and have extreme impacts on the earth system. The convection in the lee of the Andes in Central Argentina and downstream into Uruguay, Paraguay and southern Brazil produces severe societal and economic impacts on this densely populated and key agricultural region. Reports of hail, strong straight line and tornadic winds, flooding, and dangerous lightning are common, but not as common as would be expected based on satellite proxies of convection and precipitation. In this data sparse, but modernizing region, we do not know much about aspects of these systems including what governs their structure, initiation and life cycle, extreme behavior, hydrometeorological impacts, connections with the earth system, as well as similarities and differences with severe weather-producing systems observed in the US and elsewhere. Models exert poor representation and predictability of these systems on nowcasting, synoptic-scale weather to climate timescales. The impacts of these storms on the global electric circuit, aerosol, IN, and CCN budgets, the water cycle, regional and global atmospheric composition and chemistry, and climate variability can be better constrained by detailed observations of the processes occurring in these extreme storms.

Keywords: hydrometeorology, severe weather, lightning, societal impact
Parallel Session

SCI-PS217.04 - Effects of high resolution land surface parameters on PBL and clouds in numerical modeling

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Land surface parameters such as orography and land use as well as soil characteristics influence the state of the PBL and the formation of clouds by determining the partitioning of the available energy into turbulent fluxes of sensible and latent heat. With the availability of more powerful computers the horizontal resolution in atmospheric models continues to increase. As horizontally better resolved land surface parameters become available as well, the question arises as to what extent the horizontal resolution of the land surface parameters influences the PBL and clouds. We run the COSMO model with 500 m grid distance. By varying the resolution of the underlying land surface parameters we investigate the effect on the atmosphere. The results are compared with data from the HOPE campaign, which took place in spring 2013 in Germany. HOPE provides comprehensive measurements of mean and turbulent PBL conditions with state of the art instrumentation. In the observations, for example, we can see a high variability of measured sensible heat fluxes in a small area. The use of better resolved land use fields results in a clear improvement in the variability of the surface sensible heat fluxes compared with standard land use data for COSMO. The influence of this variability on the statistics of the vertical velocity and other parameters will be shown.

Keywords: numerical-modelling, land surface, PBL
SCI-PS218.01 - Seasonal cycle of Rossby wave breaking events and their link to precipitation patterns

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Synoptic Rossby wave breaking events (RWB) in the upper troposphere are known for the interchange of subtropical and polar air masses, and for the exchange of tropospheric and stratospheric air on different timescales. Due to linked transport and mixing processes, these breaking events may have also an influence on regional weather situations. This study focuses on the seasonal cycle of RWBs in the Northern Hemisphere, and their accompanying winds in the troposphere and induced regional precipitation fields. The objective RWB algorithm by Gabriel and Peters (2008) is applied to ECMWF Reanalysis data. The algorithm distinguishes between four types of breaking events: anticyclonic and cyclonic breaking events are separated in poleward and equatorward. The climatological cyclonic distribution reveal two preferred regions: over the Labrador Sea and over the Gulf of Alaska. Further south, anticyclonic events are located central over both ocean basins with a southwest-northeast orientation to the adjacent continents. In particular, anticyclonic equatorward events dominate the breaking events. The events reveal a clear seasonal cycle with a minimum during summer and a maximum during winter. However, the seasonal cycle of the number behave in the opposite way. A composite study, for instance, shows that anticyclonic poleward events are associated with a jet formed in the upper troposphere north of the events and with a precipitation maximum south-east and north-west of these events. Over Northern Europe, the end of the formed jet streak mark a region of possible generation of inertia-gravity waves.


Keywords: Rossby wave breaking, climatology, seasonality, precipitation
Parallel Session

SCI-PS218.02 - The impact of tropical cyclones on midlatitude Rossby wave packets: a climatological perspective

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Tropical cyclones (TCs) that undergo extratropical transition (ET) have the ability to modify the synoptic-scale midlatitude flow. Recent case studies and numerical experiments identified physical key-processes and conditions that favor a downstream development after ET. While previous studies focused predominantly on specific cases, this study investigates the role of TCs in tropical-extratropical interactions from a climatological point of view. We identified Rossby Wave packets of synoptic-scale wavelength downstream of recurving TCs in the south Indian Ocean and western North Pacific for the period 1980-2010. This identification is based on a Hilbert-Transform of the upper-level meridional wind and a zonal wavenumber filter. In both basins, composite maps show a statistically significant increase of Rossby wave packet amplitude and occurrence frequency downstream of the TCs compared to the climatological mean. For the western North Pacific TCs, a statistically robust signal of an increase in amplitude and occurrence frequency extends from the western North Pacific to North America. We identified for these cases synoptic conditions that favor a downstream development. The results indicate that a precursor Rossby wave that emerges from the Asian continent provides favorable conditions for a downstream development. Composite maps of eddy-kinetic energy (EKE) budgets suggest that the strength of EKE production in the region between the TC's outflow and an approaching midlatitude trough is crucial for the further amplification of the midlatitude flow.

Keywords: Tropical Cyclones, Extratropical Transition, Rossby wave packet
Diabatic Rossby waves (DRWs) are low-tropospheric positive potential vorticity (PV) anomalies that are continuously regenerated through moist-diabatic processes, leading to a rapid propagation along a zone with increased baroclinicity. It has been shown that in some cases DRWs are important precursors for rapid cyclone development. So far, in addition to studies in idealized channel flows, a few real cases of Northern Hemisphere DRWs have been investigated, as well as a climatology of DRWs in the Northern Hemisphere (NH). This study presents a first Southern Hemisphere (SH) DRW climatology for the years 2001-2012 and a comparison with NH systems for the same period. DRWs can be found in both hemispheres, but in the SH they are less abundant and have a weaker seasonal cycle. In contrast to the higher number of strongly intensifying NH DRWs in the cold season, SH DRWs preferably intensify into cyclone bombs during the warm season, during which in both hemispheres most of the DRWs occur. Another inter-hemispheric difference occurs for the direction of DRW tracks. NH DRWs tend to follow a rather zonal track according to the direction of the baroclinic zone. In the SH, DRW tracks are more strongly bent towards the pole and they appear to follow the South Atlantic and South Pacific convergence zones. Eventually, typical DRW genesis situations are identified which include (i) a transformation of the low-tropospheric PV anomaly from another system, (ii) a splitting of the PV anomaly from a larger PV reservoir, and (iii) an in-situ diabatic PV generation.

**Keywords:** dynamics, diabatic processes, PV
Parallel Session

SCI-PS218.04 - Large-scale surface wind extremes in the Mediterranean

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Extreme wind and precipitation events in the Mediterranean are typically associated with the passage of cyclones and their attendant fronts, and often linked to particular topographic features (e.g., mistral, foehn, bora). The majority of previous studies analyze extremes locally, over a short time. However, large-scale (LS) extremes are of particular societal importance for the increased risk for extended flooding and prolonged exposure to strong gusts, potentially leading to severe damage. This study therefore focuses on LS extremes and addresses these unresolved aspects: 1) where and when do LS extremes occur? 2) what are the common precursors and dynamics of LS extremes? 3) how often do LS extremes in wind and precipitation co-occur? Here we study these questions focusing on LS surface wind gust extremes (scales of 500-1000 km, 3 days), by identifying events objectively using ERA-Interim data for 1979-2012. Key dynamical processes are shown in a composite analysis and with detailed investigation of a selected case study where extreme precipitation and wind co-occurred, using ERA-Interim data and mesoscale model (COSMO) simulations. We find that Mediterranean wind extremes are characterised by: 1) a strong anticyclonically curved jet along a stationary upper-level ridge during the 48 hours before the time of maximum surface wind; 2) rapid deepening of the surface cyclone with a shift in its location, creating strong pressure gradients and anomalously dry, cold northerly flow; 3) vertical alignment of upper- and lower-level circulation anomalies and weak static stability, facilitating momentum transfer to the surface. Moreover, topography may accelerate the flow.

Keywords: wind gust, extremes, Mediterranean, flood
Parallel Session

SCI-PS219.01 - Numerical techniques of cloud resolving model and Large Eddy Simulation on the future HPC system

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The climate/NWP model pursues the endless challenge for higher resolution with sophistication of each process. This demand is based on the philosophy that more principal method generates more realistic and true mechanics in meteorological phenomena. Now, the cloud resolving technique is used in any related research, even in the general circulation model. The next jump in numerics would be in Large Eddy Simulation. Ultimately, the global LES is a tentative goal, though it is still quite difficult from the current computational limitation. Computer technology seems to be in the rapid progress. However, the so-called Moore’s law is going to be saturated for limitation of semiconductor technology and available power cap. The saturation is true not only for the computational speed but also for memory speed. To make matter worse, our research field is an I/O intensive field. In this talk, based on the above situation, I will review my experience in large scale computations using global cloud-resolving model and discuss about what kind of study is feasible on the near future HPC.

Keywords: Climate / NWP Model, NWP Model, Eddy Simulation
Parallel Session

SCI-PS219.02 - The challenge of running operational Canadian NWP models on next generation supercomputers.

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Many NWP models are currently coded in Fortran using a mixture of MPI and OpenMP to parallelize the code and make the best usage of massively parallel supercomputers. As the cost of powering the very fast supercomputer chips increases with the square of the clock speed itself, it is becoming clearer now that the future of supercomputing will likely be in the sheer number of processors rather than in faster processors. This will unfortunately put a large burden on the programmers as most will have to work harder to achieve better scalability in order to use an increasing number of processors on a fixed size problem. Inter processor communications, data locality and even mathematical algorithms will likely have to be revisited yet again. The current operational NWP model at the Canadian Meteorological Centre is the Canadian GEM model. This model integrates the basic Euler equations on the sphere using finite differences on latitude-longitude grid. Load imbalance related to the clustering of grid points near the poles has recently been lifted with the introduction of the quasi uniform Yin-Yang method. We will discuss scalability issues related to that model and outline our plan to address aspects of running very large problems on a very large numbers of cores. We will also discuss the need for mathematical/algorithmic changes that may pave the way to an entirely new model. We are currently investigating novel time stepping schemes including exponential integration methods on an icosahedral grid system which is showing very promising scalability properties.

Keywords: Scalability, Supercomputer
Parallel Session

SCI-PS219.03 - Scalability initiative at ECMWF

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The challenges of highly parallel computing have been recognized for some time at ECMWF and areas such as observational data pre-processing and data assimilation have been identified as being critical in the near future. Work on other areas such as the development of the future model dynamical core has also been initiated. It is further evident that alternatives to CPUs will become part of future HPC architectures but that it is not clear to date in which configuration this will happen. In addition to MPI and OpenMP, a 3rd strand of on-processor parallelism through accelerators has to be built in. In how far this will be supported by future code design and compilers also remains open. In this context, ECMWF has founded a dedicated scalability project. The objectives are (1) to develop the future forecasting system combining a flexible framework for scientific choices to be made with maximum achievable parallelism, (2) to prepare for expected future technologies and their implications on code structure ensuring efficiency and code readability, (3) to develop environment/metrics for quantitative scalability assessment. The project will strongly involve external partners from ECMWF Member States, regional consortia, HPC centres, and vendors. The paper gives an overview of scalability challenges in NWP and the ECMWF project.

**Keywords:** scalability, weather prediction, high performance computing
Parallel Session

SCI-PS219.04 - An efficient time integration scheme for high-order non-hydrostatic atmospheric models

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The High-Order Method Modeling Environment (HOMME) is a dynamical core developed at the National Center for Atmospheric Research for investigating continuous or discontinuous Galerkin (DG) methods to build scalable and high-order accurate atmospheric models. The main issue of extending HOMME to the non-hydrostatic (NH) scale is the stringent restriction on explicit time-step size, due to the fast-moving acoustic waves together with a high aspect ratio between the horizontal and vertical spatial discretization. We consider a time integrator which employs so-called ‘horizontally explicit and vertically implicit’ (HEVI) approach through a dimensional-split procedure for the DG discretization, so that the explicit time-step size is only limited by the horizontal grid spacing. The HEVI scheme is investigated in a two-dimensional NH model based on compressible Euler/Navier-Stokes equations and the terrain-following height-based z-vertical coordinates (HEVI-DG). The vertical one-dimensional aspect of the dynamics is solved implicitly, while the horizontal part (where dx or dy >> dz) is solved explicitly. The HEVI-DG model is successfully tested for a variety of NH benchmark tests, and results are compared against the explicit DG-NH model. The HEVI approach is being incorporated into the NH formulation of HOMME, and has the potential to maintain the petascale capability of the HOMME framework.

Keywords: Dimensional time-split methods, Non-hydrostatic atmospheric models, discontinuous Galerkin Methods, High-order
SCI-PS220.01 - Revisiting predictability of the strongest storms that hit France over the past 30 years.

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Improving early detection of extreme weather events is of crucial importance for the national meteorological services. It could greatly help authorities to take preventive protective actions to reduce lives and property losses caused by those devastating events. Yet, providing reliable forecasts of intense weather events three or four days ahead is still challenging. In most cases such events have low predictability and, although they have considerably improved in the last decades, NWP systems can still have difficulty to predict, beyond 48h, the intensity and the trajectory of the strongest storms and High Precipitation Events (HPE). The development, until 20 years, of Ensemble Forecasting Systems (EFS) has allowed progress in evaluating forecast uncertainty. However, as severe events are infrequent, the ability of EFS to anticipate for such events has been poorly documented. Here, we propose to evaluate the capacity of the Météo-France EFS, PEARP, to detect such severe weather events. A reforecast dataset, covering autumn and winter periods of the last 32 years, has been developed to document the model climate of PEARP. It is used to calibrate PEARP and to compute forecast indexes such as the Extreme Forecast Index and the Shift Of Tails index (all developed at ECMWF to measure the abnormality of a weather forecast). Evaluation is done against the most extreme wind and 24-h rainfall events that have hit France over the past 30 years (including storms such as Lothar, Martin, Klaus, the 1987 great storm ...).

Keywords: EFI, short-range predictability, extreme events
In this work, the main characteristics of COSMO-LEPS, the Limited-area Ensemble Prediction System developed by ARPA-SIMC in the framework of the Consortium for Small-scale Modelling, are presented. The present status of the system, running on an operational basis since 2003, is shown with the description of the main upgrades which took place during its years of activity. The performance of COSMO-LEPS for the probabilistic prediction of the main surface fields is assessed in terms of both time-series and seasonal scores over a 10-year period. A fixed number of stations is selected and observations are compared to short and early-medium-range forecasts. Different verification indices are used to assess the skill of COSMO-LEPS and to identify the impact of system modifications on forecast skill. Particular attention is also paid to the ensemble-size reduction, performed via a clustering-selection technique, which enables the identification of the Representative Members of ECMWF ENS and their provision as initial and boundary conditions to COSMO-LEPS integrations. Modifications to the present methodology are tested and their impact is assessed in terms of spread/skill relation for surface and upper-air variables. The optimal way to select a subset of initial conditions from a largely-populated ensemble and its dependence on the application is finally emphasized.

**Keywords:** LAM ensemble, clustering, ensemble verification
Parallel Session

SCI-PS220.03 - Optimizing the COSMO-DE Ensemble towards renewable energies

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The last years have witnessed a significant increase in the proportion of renewables in the German power supply. The weather-dependent nature of wind and solar power plants creates a direct link between weather and power production. The high variability of weather results in fluctuations in power output, which pose great challenges to the power grid. Therefore, reliable and accurate weather forecasts are required for ensuring energy security and minimizing costs of grid development and maintenance. The German Weather Service has started two projects to optimize its weather forecasts for power production variables. These projects, titled EWeLiNE and ORKA, are funded by the Federal Ministry for the Environment. For a close connection to the renewable energy community the ORKA project works together with energy and meteo systems, while the EWeLiNE project is a collaboration with the Fraunhofer IWES. Both companies are providers of power production forecasts. In addition both projects cooperate with German transmission system operators. ORKA aims to optimize ensemble forecasts for renewable energies for the very short time range, which is especially relevant for network security issues. In the course of the project, ensemble power forecasts are analyzed to identify critical weather situations. The performance of COSMO-DE-EPS in these situations is investigated by modifying the physical parameterizations and changing initialization schemes. Particular attention will be paid to simulating atmospheric conditions at hub height, e.g. by improving the physics parameterization for the boundary layer. This presentation will show results of numerical experiments with the COSMO-DE deterministic and ensemble models.

Keywords: Ensemble prediction systems, renewable energie, COSMO
Parallel Session

SCI-PS220.04 - Multi-model EPS – GLAMEPS: configuration and performance for polar lows and the Sochi Olympics

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Grand Limited Area Model Ensemble Prediction System (GLAMEPS) is an operational pan-European, short-range ensemble prediction system developed by HIRLAM and some ALADIN countries. It is a combination of 4 equally sized sub-ensembles. Two of the sub-ensembles use HIRLAM physics and one use ALARO physics in addition to a subset of IFS ENS. The total ensemble size is 54, horizontal resolution ~11 km and the forecast is made twice a day. The surface is perturbed by running separate surface data assimilation for the members. Extensive validation of GLAMEPS will be shown for two distinctly different regions and applications: for possible detection of polar lows over ocean areas in high latitudes and for the sub-tropical climate of Sochi with it’s complex topography. For the Sochi area a dense network of observations were available during the Olympics, and these were used for calibrating GLAMEPS at venues. Results from calibrated GLAMEPS forecasts will be shown together with uncalibrated GLAMEPS, and also with results from an experimental convection-permitting EPS based on Arome model (HarmonEPS) at 2.5 km. Both GLAMEPS and HarmonEPS were part of the FROST-2014 project. During spring 2014 GLAMEPS will go through a major configuration change: one more ALARO sub-ensemble will replace ECMWF ENS members, the horizontal resolution will increase to ~8 km and GLAMEPS forecast will be produced 4 times a day. From comparing results of different GLAMEPS configurations the effect of multi-model vs single model EPS can be examined, as well as the effect of lagging and ensemble size etc.

Keywords: Ensemble prediction, multi-model, polar lows, FROST-2014
Parallel Session

SCI-PS221.01 - The effects of surface friction over land on the general circulation

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Several studies have shown that large-scale models generally have more mixing in stably stratified conditions than what turbulence theory or boundary-layer observations suggest. Thus, the parameterizations for surface exchange and boundary-layer turbulence utilize various forms of so-called long-tail formulations in stable conditions, i.e. enhanced mixing, and have no critical Richardson number. The consequences are too deep boundary layers, too weak diurnal cycles in wind speed and not enough wind turning. Other parameterizations than the one describing the boundary-layer effects also exert drag on the flow in the troposphere. A global model has a gravity wave drag parameterization and maybe another formulation for effects of sub-grid scale orographic features on the flow. The distribution of where in the atmosphere and how much drag that should be exerting is not easily derived from observation and there are unknown constants in these parameterizations. In this presentation, a suite of experiments with the NCAR CESM (CAM5), where changes in the boundary-layer parameterization and other sub-grid scale parameterizations, are discussed. The analysis is done both with respect to boundary-layer performance and the effects on large-scale circulation features such as storm track positions and blocking frequencies.

Keywords: planetary boundary layer, blocking frequency, sub-grid scale drag, momentum budget
Parallel Session

SCI-PS221.02 - Adaptation of a parametrisation to the gray zone of turbulence

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The gray zone of turbulence is the range of scales for which the model grid length is closed to the size of the largest boundary-layer structures. With increasing computational power the operational models are now able to run at these resolutions. In order to characterize the subgrid turbulence in the gray zone, Large-Eddy Simulation (LES) fields are averaged to obtain resolved fields of reference at coarser resolutions. This method allows to quantify the defaults of the models. Turbulence schemes are not adapted to represent the characteristics of the subgrid turbulence in the gray zone. Especially, convective boundary-layer (BL) thermals are partly resolved but remains mainly subgrid scale, which is not correctly simulated by traditional mass-flux scheme. A mass-flux scheme is adapted to produce subgrid thermals smaller than those of mesoscale scheme. The mass-flux scheme is only used in case of shallow convection. However, in the gray zone, the models have to move from a unidirectional (mesoscale) to a tridimensional (LES) turbulence scheme. So the shear driven production of turbulence has also to be modified. A shear driven neutral BL is studied. The gray zone of turbulence spreads from 25 m to 800m. The horizontal movements cannot be neglected, so a tri-dimensional turbulence scheme is required. However, the turbulence is not consistently isotropic, as assumed in LES. In convective BL, the horizontal turbulent movements must be taken into account at resolutions finer than 1 km resolution.

Keywords: turbulence, boundary layer, sub-kilometric scale, parameterization
Model uncertainty at horizontal resolutions of O(1km) to O(10km) - sometimes called 'grey zone' - varies drastically because convection is treated by a shifting interplay of parameterized and resolved transports. Within the German research project HD(CP)² (high definition cloud and precipitation for advancing climate prediction) the ICON weather and climate model is extended to run at large-eddy resolutions of O(100m) for large domains with realistic conditions. The model uncertainty of ICON in the grey zone is investigated by comparison of ICON at LES and GCM resolutions. Particular focus is put on the simulation of clouds and precipitation in the continental diurnal cycle. For that purpose, the deep and shallow convective parameterization of Bechtold et al, 2014 and Neggers, Köhler, Beljaars, 2009 are implemented in ICON and compared with the default ICON pre-operational setup. Preliminary results with ICON confirm that the Bechtold et al parameterization shifts the phase of precipitation. Yet a more realistic diurnal cycle of convection is achieved with ICON at convection resolving resolutions.

**Keywords**: convection parameterization, grey zone, uncertainty
Parallel Session

SCI-PS221.04 - Resolution dependence of cumulus statistics in radiative-convective equilibrium

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In numerical modeling of atmospheric processes on global and mesoscales it is necessary to parameterize the effects of moist convection as they cannot be adequately represented by the resolved-scale motions. With the Plant-Craig stochastic parameterization for deep convection the theoretical basis is given by statistics of equilibrium fluctuations of a cumulus cloud ensemble under homogeneous large-scale forcing. It was derived by Craig and Cohen (2006) that in the limit of non-interacting convective cells, statistics of the convective fluctuations can be written in terms of the large-scale, externally constrained properties of the system and that the probability density function of individual cloud mass fluxes is exponential. This theory was validated at a horizontal resolution of 2 km and the distribution was observed to be insensitive to changes in the magnitude of forcing. However, at this horizontal resolution convective cells are only partially resolved and mostly collapse to the grid-scale. In our project we reproduced the exponential distribution at 2 km horizontal resolution for horizontally homogeneous forcings from -2 K/day to -12 K/day on a 128 km x 128 km x 20 km domain. Increasing horizontal resolution to 1 km and 500 m revealed a trend towards clouds occurring with a size and mass flux larger than predicted by the theoretical distributions. Further evaluation showed these large clouds to be made up of several smaller clouds which suggests an increasing trend of clouds to develop in near-cloud environments. Convergence of these preliminary results will be investigated by further increasing horizontal resolution.

**Keywords:** Cloud-Resolving Simulations, Convection, Radiative-Convective Equilibrium
SCI-PS222.01 - The skeleton and muscle of tropical intraseasonal oscillations

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Multiscale Multicloud modeling of the MJO is reviewed here. The stochastic “skeleton” model is a simplified model for the MJO involving moisture and the planetary envelope of synoptic scale activity coupled to a Matsuno-Gill model. This model does not include any active instabilities on planetary scales yet it is able to capture the fundamental features of the MJO such as the intermittent growth and demise of MJO wave trains, the MJO propagation speed, quadrupole vortex structure, etc. Idealized GCM simulations with a prototype GCM parametrization based on the multicloud model validate the skeleton model concept. Multicloud Multiscale models are then reviewed which point to the important “muscle” from Convective Momentum Transport in some MJO’s such as those from TOGA-COARE, for example Convective Momentum Transport resulting from interactions with shear and the moist background state with both synoptic scale convectively coupled waves and mesoscale convective systems.

Keywords: Multiscale Multicloud, MJO, TOGA-COARE, Convective Momentum Transport
Parallel Session

SCI-PS222.02 - Identifying the skeleton of the Madden-Julian oscillation in observational data

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The MJO skeleton model is a nonlinear oscillator model for the basic planetary, intraseasonal features of the Madden-Julian Oscillation (MJO). As such, it predicts a particular structure of the MJO in terms of its winds, temperature, moisture, and convective activity. The goals of this study are (i) to identify this theoretical structure in observational and reanalysis data, and (ii) to examine and assess its variability. To this end, potential surrogates were examined for the MJO skeleton variables, with particular focus on the lower-tropospheric water vapor, Q, and the convective activity, A. A main question is, To what extent is there agreement between the structure of the theoretical MJO skeleton and the structure of the MJO in nature? Case studies will be presented of well-known MJO (and non-MJO) events, and statistics of MJO skeleton variability are also used to assess these questions.


Keywords: Madden-Julian Oscillation, Tropical Intraseasonal Oscillation, Convection
Parallel Session

SCI-PS222.03 - Linkages between the Madden Julian Oscillation, process-level diagnostics and GCM parameterization behavior in YOTC simulations

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The simulation of the Madden Julian Oscillation (MJO) remains a significant challenge in climate models. The primary difficulty lies in relating MJO skill to parameterized physical processes - the main access point for model development. One theory of the MJO relies on scale-interactions from small to large scales. The expectation is that GCMs should reproduce the correct relationships at the smallest resolved scales and this will translate through increasing scales and lead to a skillful simulation of the MJO. So-called 'process-based' diagnostics have recently been applied to simple model fields in order to relate accurate simulation of the MJO to accurate, small-scale process-level relationships (Kim et al., 2014). In this presentation we will take this technique further to provide greater insight into how the underlying physical parameterizations in the Community Atmosphere Model (CAM) conspire to provide the process-level responses in the model, particularly as it relates to precipitation and humidity dependent processes. This provides the potential for a range of dependencies between parameterization tendencies and MJO skill. Furthermore, these dependencies are examined to quantify the effect of model biases. This entails performing the same process-level analysis on simply initialized and nudged CAM simulations that make use of YOTC analysis. These techniques enable diagnosis of the relationship between degrading model simulation (basic state and MJO) and changes in the parameterized response at the process level. In summary, this talk will show the most promising relationships between MJO simulation performance and the fidelity with which the parameterized physics produce observed process-scale relationships.


Keywords: MJO, processes, parameterizations, forecasts
The Madden-Julian Oscillation (MJO) is the most dominant intraseasonal variability in the tropics. Yang and Ingersoll (2013, J. Atmos. Sci.) propose that the MJO is a large-scale, long-lasting envelope of high-frequency inertia-gravity (IG) waves. They then seek the minimum recipe of the MJO and present a novel 1D β-plane model that successfully simulates key features of the MJO (2014, Geophys. Res. Lett.). Using this 1D model, they derive a scaling for the MJO zonal wavenumber $k \sim (S_c/c)^{1/2}$, where $S_c$ is the spatial-temporal frequency of convection events and $c$ is the Kelvin wave speed. This scaling predicts stronger and larger MJOs in a warmer climate, in which convective events become more vigorous. To test the Yang and Ingersoll dynamical paradigm, we test its scaling predictions against the explicitly simulated MJO across a wide range of climates, in which $c$, $S_c$, and other parameters will vary accordingly. This is achieved by using the aquaplanet super-parameterized (SP) community atmosphere model (CAM) forced by uniform sea surface temperatures (SSTs). Our simulation results show that the MJO becomes stronger and larger when the SST increases from 1degC to 35degC monotonically. We will present how $c$, $S_c$, and the strength of convection events vary with SST. Then we examine their relation to the MJO zonal wavenumber and strength. It is the first time that the MJO dynamics have been explored across such a wide range of climates. Our study sets new benchmarks for developing and testing MJO theories.


Keywords: The Madden-Julian Oscillation, Moist convection, Climate change, Equatorial Waves
Parallel Session

SCI-PS223.01 - Improved understanding of and techniques for decision-making - making effective decisions from uncertain forecasts

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Weather forecasts and warnings are useless unless people base decisions on them, but forecasts are fundamentally uncertain. A common response to uncertainty is “...I just need a decision”. Decision making is easier with categorical yes/no forecasts, and allows the user to pass full responsibility to forecasters. Conversely, modern forecasting systems which include sophisticated estimates of uncertainty, provide opportunities for much better decision-making based on risks – risk being a combination of Probability and Impact. Since the same weather or climate event may have very different impacts on different users, a single “best-guess” forecast cannot be tuned to the needs of all users. Probabilistic forecasts are more flexible, but risk-based decision-making requires understanding of user impacts, and some responsibility for decisions gets passed back from forecaster to user. Many forecast providers are trying to move beyond forecasting weather or climate hazards to forecasting societal impact, but this is a huge challenge involving the crossover between physical and social science. Many research projects have expressed ambitions to address societal impact, but while huge progress has been made in probabilistic hazard prediction, progress with impacts has been relatively modest. Impact modelling requires a deep understanding of the user’s business, and cost/loss decision rules rarely reflect real world complexity – users make multiple decisions at different lead-times and levels of risk. The presentation will include illustrations of risk-based warning systems, the use of advisers embedded with users, and will also discuss how the WMO SWFDP project helps establish effective warnings in developing countries.

Keywords: Uncertainty, Decision, Risk, Forecast
Parallel Session

SCI-PS223.02 - Using Geographic Information Systems to bridge communication gaps among users of NWS weather forecast information

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The National Weather Service (NWS) issues mission-critical weather forecast information via its watch, warning, advisory, and forecast products. These potentially life-saving products are delivered over traditional communication platforms. More modern communications systems have diversified the flow of that information. Geographic information systems (GIS) is an enabling technology that bridges the gap in delivering and communicating weather information between disciplines—among research scientists, forecasters, service providers, and users. The provision of NWS weather information in GIS-ready formats allows for more effective communication of the spatial and temporal aspects of the underlying weather information. GIS technology allows NWS meteorologists to maintain focus on accurately forecasting the evolution of upcoming weather events, while serving that information via GIS technology allows each and every user the ability to consume that information in a way that is most useful to them, by enabling each user to filter and subset the information to meet their specific needs. This presentation will describe how NWS forecasts are translated from their native formats to a GIS server environment. Displays of this information, on forecast time scales from months to minutes before an event, will be shown as examples of how NWS weather information can be filtered, queried, and displayed to allow users to focus on more precise aspects of the overall weather information being offered. Successes and challenges associated with communicating weather impacts using geospatial tools will be discussed.

Keywords: GIS, NWS, Communication, Users
Switzerland counts about 60 lakes and aerodromes for which warnings are issued in case of high probability of wind gusts exceeding 25 knot. Mitigating actions can then be triggered accordingly, on a local basis. These warnings being not automated, forecasters are required, beside their main duties, to pay attention round-the-clock to the local weather evolution at these many specific locations. Not surprisingly, quality assessment demonstrates low efficiency, with frequent missed events. This project is aimed at implementing a semi-automatic gale warning system based on an evolutionary algorithm, also called genetic programming, initially developed in collaboration with the Artificial Intelligence Laboratory of the University of Zurich. The system delivers precursory proposals for gale warnings, supporting forecasters in their ongoing weather surveillance. Working on a predictor set specific to each lake or aerodrome (in each case, 4-year data of relevant observations and short-term forecasts from the 2-km numerical weather model COSMO-2 run by the Swiss National Weather Service MeteoSwiss), the evolutionary algorithm constructs, evaluates, selects and improves algorithmic expressions - indeed Java methods - aimed at forecasting maximal gust intensity within the next hour. 20 such evolution runs are performed, leading to an ensemble of 20 methods specific to each warning object (lake or aerodrome). In operational practice, the 20 methods of each warning object are evaluated every 10 minutes and deliver probabilities of gale occurrence that are displayed as warning suggestions if exceeding a pre-defined threshold. The forecaster must at the end either confirm or reject the alarm.

Keywords: Gale Warning, Genetic Programming
Heavy and very heavy rainfall events lead to hydro-meteorological hazards like floods and landslides. As not only property is destroyed but also human lives are lost. These hazards occur frequently over India during southwest monsoon (June-September). An analysis of occurrence of heavy rainfall events over different regions of India has been made in order to understand vulnerability of these regions. They include (a) North East India (b) West Coast of India (c) The hilly regions in western Himalayas (d) Central India. Daily rainfall data for five monsoon seasons (2009-2013) have been analyzed to study the incidence of heavy (>=64.5mm) and very heavy (>=124.5mm) rainfall. The study has found that heavy rainfall events occur on 40-50 percent of days over Western Himalayan regions and Central India. Whereas over northeast India and west coast of India such incidences are 60-75 percent of days. Continued spells of heavy rainfall which have more serious implications on the vulnerable regions were generally found not to exceed two days; and the inter-annual and spatial variability of such spells was also found to be high. Analysis of spatial distribution show that west coast of India is more prone to fairly wide spread heavy rainfall compared to other sub-divisions. Comparison of the predictions based on two Atmospheric General Circulation Models models (UKMO and GFS) with observations has also been made to estimate biases in model forecasts in predicting heavy rainfall events in 1-7 days in advance to help operational forecasters make their decision about heavy rainfall warnings.

Keywords: UKMO: Unified Model, GFS: Global Forecast System
Wednesday, 20 August 2014

UAS-PA408 - Panel Discussion

Special Joint Panel on the Future of the Weather Enterprise

Enhancing Weather Community Collaboration to Meet Shared Goals for the Weather Enterprise

This special joint panel on Enhancing Weather Community Collaboration is the final in a series of three designed to advance dialogue on the collaboration of private, public and academic elements of the weather enterprise—the first two explore important issues and problems while the final panel is oriented towards finding solutions. Panel discussion will consider ideas where improved collaboration is needed to improve infrastructure and services. What areas offer the most potential for collaboration producing measurable service improvement? What factors that prevent or inhibit collaboration provide realistic goals for future collaboration? What next steps would start the weather community down the path? How could collaboration accelerate needed infrastructure improvement in developing and least developed countries worldwide? How could collaboration accelerate exploitation of improved service capabilities by developing and least developed countries worldwide?

Chair: Jack Hayes

UAS-PA408.01 - Panel Participant

Harinder Ahluwalia

1 Canadian Meteorological and Oceanographic Society, Ottawa, Canada

The quality of meteorological forecasts and nowcasts is vital for safety of life and property and for economic growth and it, requiring dense monitoring networks, advanced science, bright ideas and strong investment. With the world’s tight economic conditions, no single entity – Governments, Private Sector and Universities – can generate sufficient value to achieve the desired results. A strong inter and intra collaboration between the three sectors can achieve superior results than any entity by itself could. The type of collaboration will be discussed, followed by examples of successful partnerships. Moreover, the role of WMO and National Meteorological Societies in acting as the glue and facilitator will also be discussed.
Linking researchers and practitioners through problem-focused collaboration

Around the world, extreme weather events cost thousands of lives and billions of dollars in damage each year. The indirect losses that stem from missed opportunities may be greater still. It can be a challenge to bring together the academic, public, and private realms in ways that can reduce the impact of weather extremes on society. However, if we are serious about saving lives and livelihoods, we must invest our shared resources and expertise so that decision makers are better equipped to make the right decisions at the right times. At UCAR, we have worked to build dynamic collaborations among public, private, and university researchers on well-defined topics that range from the causes of regional air pollution to the impact of weather on highway safety. Through NCAR, we are also the home of a research-oriented version of the Weather Research and Forecasting model, a powerful tool that is freely available to universities yet widely adaptable for use in the commercial realm. Our hope is to extend this model of cross-sector collaboration to include international partners.

The Hydro-Meteorological Equipment Industry (HMEI) was started over 10 years ago at the request of the World Meteorological Organization (WMO). One of the significant goals of HMEI is to promote and contribute to worldwide standardization in the fields of meteorology and hydrology. It is the areas of specifications, standards, system maintenance and lifecycle management that represent the most significant impediments to the success of the weather enterprise over the next decade. It is here, where the public, private and academic communities need to focus by working closely together in the development of worldwide standards that will insure worldwide consistency and quality of data.

The Role of Scientific and Professional Societies in the Enterprise

The enterprise is generally thought to be composed of three sectors: academic, public, and private. Scientific and professional societies represent a critical fourth element. These societies can act as an intermediary between the three traditional sectors, smoothing and enhancing the interactions to the benefit of the enterprise. In the US, the American Meteorological Society (AMS) played a central role in developing today’s close sector collaboration. This was accomplished through a number of mechanisms, including active participation of all sectors in AMS leadership and meetings focused on sector interactions. The enterprises of different nations and regions vary in their needs, but societies play an important role in enterprise evolution.
Serving the public good and achieving economic growth and development in a changing world characterized by extremes in weather and climate will need new ways of collaboration, engagement, planning and solutions orientation. Frameworks that catalyze. Co-design, co-planning and co-delivery may yield the desired outcome of a safe planet for all building on existing strengths and minimizing weaknesses and recognize building on existing strengths. Various roles and responsibilities are already well defined in the current context, e.g., instruments manufacturers (with some exceptions of NMHSs that are also producers of instruments), super-computer building and leasing, broadcasting, product and service development, etc. Different players wield power different but complementary power that needs to be harnessed for the greater good. The World Meteorological Organization, as the institution bringing together the best meteorological and climate scientists from all over the world, is uniquely positioned to promote a synthesis of public, academic and private sector interests. It can do this by brokering ongoing dialogue between the two sectors and by integrating this dialogue in practical projects that incorporate agreed principles. The GFCS and its User Interface Platform provide but one example where these principles are being put into practice.

Goal Building

NOAA’s Weather-Ready Nation (WRN) is about building community resilience to extreme weather and water events. The WRN concept is based on impact-based decision support services based primarily on linking forecasts and warnings directly to decision-makers to build responsive, resilient communities. NWS is shifting toward Impact-based Decision Support Services, or IDSS - from fine-tuning the weather forecast to communicating the impact of weather and water events. Furthermore, NWS is infusing social science to improve products and services while ensuring consistency across NWS. This discussion will focus on the partnerships required, including the private sector, throughout the climate, water, weather enterprises to ensure we can attain a Weather-Ready Nation.
Parallel Session

UAS-PS329.01 - Developing effective warning systems for hazards: Lessons for weather from volcano warnings in New Zealand

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Communicating scientific information to stakeholders is a critical component of an effective early warning system for natural hazards. Scales are often used to communicate complex scientific information in a simple form. Communication tools need to meet the requirements of a wide range of end-users, who use the information for response decision-making. These tools also need to be effective for scientists who determine levels based on observations and interpretation, requiring consideration of the constraints and uncertainties involved. In order to consider these needs when developing effective warning systems, qualitative social science methodologies can be used. New Zealand’s 20-year-old Volcanic Alert Level (VAL) system, which is used to communicate the status of volcanic activity, was recently explored. The use of the International Civil Aviation Organization Aviation Colour Code used by Volcanic Ash Advisory Centres was also investigated. For the first time globally a qualitative ethnographic methodology was utilised in the development of a VAL system, involving interviews with scientists and end-users, observations over three years of scientists who determine the VAL, and document analysis. A new VAL system that meets the requirements of all parties was developed, and is currently being implemented for New Zealand. This methodology can be transferred to develop effective early warning systems for other hazards, such as extreme weather events. By sharing experiences and methodologies between weather and volcanic hazards, and physical and social science fields, the presentation of this transdisciplinary research aims to stimulate discussion and draw upon lessons learned from weather warnings.

**Keywords:** Early warning systems, communication, volcanic alert level, aviation colour code
Parallel Session

UAS-PS329.02 - How "communication overload" and, in particular warning fatigue, can impact decision-making under uncertainty.

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The uncertainties inherent in weather-prediction mean that disaster scenarios such as floods and bushfires often necessitate repeated warning messages in the absence of the actual event. Government and emergency management agencies have a two-fold problem because they want to avoid the accusation of panicking the public whilst running the risk of under-preparing them at the same time. As a result they may be tempted to err on the side of caution, downplay the severity of a potential disaster or delay issuing a warning because they are worried the public may get tired of the message. The taken-for-granted phenomenon known as ‘cry wolf’ or ‘warning fatigue’ describes the cynicism and apathy that can result from repeated warnings. Regarded by disaster theorists to be a ‘disaster myth’, it nonetheless continues to be blamed by some for reduced vigilance, inadequate preparation and flawed decision-making. A case study from the Australian bushfire context established that warning fatigue is a multifaceted construct, and can influence risk perception in the context of uncertainty. The results from a warning fatigue measure (BWFM-R) conducted once a month over a 6 month period by residents of bushfire-prone Victoria, Australia enabled an operationalisation of warning fatigue and showed that five variables combine in a unique way to produce ‘warning fatigue’. This paper suggests that if emergency and disaster agencies understand the complexities of warning fatigue and tailor their warnings accordingly, disaster risk communication will become more effective, increasing public engagement and improving disaster response.

Keywords: Warning Fatigue, Uncertainty, Risk Communication., Warnings
Parallel Session

UAS-PS329.03 - An analytical framework and preliminary results of an evaluation of weather warning systems in Quebec-Canada

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We present an analytical framework for evaluating weather warning systems (WWS), and the preliminary results of a study that used it to analyze the quality of the current WWS in place in Quebec (Canada) and its impact on the decision making process of the organizations involved in civil protection and emergency management. The analytical framework proposes a logic model outlining the main effects of the development of WWS. According to this model, investments in WWS should improve the quality of risk assessment, the accuracy of weather forecasts and the relevance of information disseminated. The provision of reliable weather information that corresponds to users' needs should then help the organizations involved in civil protection and emergency management to improve their understanding of their territorial vulnerabilities and therefore, to engage in the capacity building needed to protect the population from threatening events. In addition, the emission of weather warnings should keep user organizations well informed on extreme events and therefore, enable them to react efficiently. Preliminary results of the utilization of this framework to evaluate the WWS in Quebec will also be presented. More specifically, the results of an online survey of the personnel in charge of civil protection and emergency management in health organizations and municipalities will be reported. The focus will be put on the users’ assessment of the reliability and the relevance of weather warning messages and their impacts on the decision making process of those organizations.

Keywords: weather warning system, analytical framework, evaluation, effects
Parallel Session

UAS-PS329.04 - Prepare now to survive the next tornado

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They are the most violent atmospheric phenomenon on our planet. Their wind speeds can reach 300 miles per hour. They strike with little warning. They are tornadoes. Tornadoes can occur at any time of the year and have occurred in all 50 U.S. states and across Canada. However, are citizens really prepared? Do they know the difference between a tornado watch and a tornado warning? More importantly, do they care? No matter where you live...if you are ever in the path of nature's most destructive phenomena, you need to know what to do to keep you safe. I will discuss where you should take cover if you are inside a building, outside without shelter, or in a vehicle. Tornado myths will be discussed so you can test your own disaster preparedness knowledge. I will also touch on the role social media plays in tornado safety and preparedness. Despite advancement in the science allowing meteorologists to forecast tornadoes more accurately with greater lead time, citizens will always be at risk and must be educated and prepared to ultimately save lives.

\textbf{Keywords:} tornado, preparedness, safety, survive
Cusco is located in the Southeast area of Peruvian Andes. Rainfall patterns in this region have a long dry season from May to September and a rainy season from December to March (summer season). Rainfalls occurred in Cusco between January and March 2010 have caused losses of over 700 million soles, U.S.$ 254 million approximately. The intensity had not overcome the historical ranges unlike the frequency (Waldo Lavado et al.). According to the National Meteorological and Hydrological Service of Peru (SENAMHI), it rained more than 400 liters per square meter during January. The hydrometeorological peak anomaly occurred during the 22, 23 and 24 January. About 5000 houses were destroyed and 16 200 hectares of crops were lost. The railway that leads to Machu Picchu, Peru's main tourist attraction, was damaged on a significant stretch. A total of 21 bridges became unusable and others were affected (National Institute for Civil Defense, 2012). The flooding of the Vilcanota River, its tributaries in Cusco and the damage to different access routes to Machu Picchu, forced the main attraction to remain closed for weeks.

This event has made government to improve the emergency, rehabilitation and reconstruction phase as well as the early warning system. Flooding in general, has become more frequent each rainy season in Peru, for that reason people think climate change has to do with it but is not scientifically proved yet.

**Keywords:** Cusco, flood, Machu Picchu
Inland flooding, whether from tropical cyclones (TCs) or other related extreme rainfall events, causes significant economic losses in the United States. Yet, little is known about the relationship between floods and economic losses. Difficulties on establishing this link partially arise from the fact that current flood hazard estimation methods are based on flood data collected in a limited number of locations; therefore they fail on spatially characterizing flood extent and magnitude. In this study, we apply a spatially distributed and parsimonious hydrological model to simulate floods across the entire river network. We use a normalized index called flood ratio (FR) to characterize flood magnitudes across a large range of scales. To demonstrate our methodology, we simulate four extreme flood events that caused serious damages on the Delaware River Basin. We then perform hazard to loss flood risk assessment by empirically linking the FR to registered insurance claims held by the National Flood Insurance Program. We demonstrate that simulated FR accurately captures the location and the spatial extend of floods/claims, and can be used to estimate expected flood losses. These results highlight the technological capabilities that can lead to a better integrated risk assessment of extreme floods. This capacity will be of tremendous value to a number of public and private sector stakeholders dealing with flood disaster preparedness.

**Keywords:** inland flood, natural disaster losses, simulated flood ratio
Parallel Session

UAS-PS330.03 - Flash flooding and the Global Environmental Change perspective: Toward an integrated strategy for disaster reduction

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How do people answer to heavy precipitation and flood warnings? How do they adapt their daily schedule and activity to fast evolving environmental circumstances? More generally, how do social processes interact with physical ones? Such questions address the dynamical interactions between hydro-meteorological variables, human environmental perception, and actual behavioral responses. These questions, relevant for both social and physical scientists, relate to scales and hierarchy issues through seamless interactions between smaller and larger scales. They are more and more pertinently addressed in the Global Environmental Change perspective through the concepts of Coupled Human And Natural Systems (CHANS), resilience or panarchy developed in the context of interdisciplinary collaborations. Nevertheless those concepts are complex and not easy to handle, specially when facing with operational goals. The proposed presentation illustrates two key difficulties of such integrated approaches about flash-floods in the Mediterranean area: i) the access to empirical data informing the processes at various scales. In fact, if physical and social processes are well studied by distinct disciplines, they are rarely jointly explored within similar spatial and temporal resolutions. Such coupled observation and analysis poses methodological challenges, specially when dealing with responses to short-fuse and extreme weather events where finer resolution data for the study of human-nature interactions are sparse. ii) the need to produce comparable analysis on different case studies where social, physical and even cultural contexts vary. Generic and robust framework for data collection, modeling and analysis are needed to allow cross and deeper understanding of the processes across scales.


Keywords: social dynamics, Space-time scales, Coupled Human and Natural Systems, Heavy precipitation event
The skill of tropical-cyclone (TC) track forecasts has steadily improved over the past decades, as has the understanding of TC risk in coastal regions. However, there is still much to be learned about the TC risk in inland regions, which is complicated by the presence of coastal evacuees, and includes hazards such as inland flash flooding and tornadoes. This was exemplified by Hurricane Ivan (2004), which spawned 118 tornadoes and produced significant rainfall amounts contributing to flooding inland. Ivan was responsible for 25 deaths in the U.S. and $18.8 billion (2004 USD) in damages. As part of a larger effort to improve the decision support tools available to emergency managers, this project seeks to map the inland U.S. hazards associated with TCs in the Atlantic Basin. The specific hazards of TC-associated flash flooding (TCFF) and tornadoes (TCT) are assessed over approximately the last two decades using geographical information systems (ArcGIS v. 10.1) software. The highest TCFF hazard is indicated in southern Mississippi, Alabama, North Carolina and the Mid Atlantic Region, and TCT hazard is highest in the same region as TCFF, including Florida; stream-gauge data additionally show that the highest TC-flood potential is in southern Florida. The TCFF and TCT data are smoothed at a county/parish level and then combined with a quantification of the social vulnerability of the exposed populations to derive a hurricane disaster risk index. The disaster risk index will also be used in experiments with agent based modeling to assess evacuation behavior.

**Keywords:** Hurricane hazards, Hurricane Risk, Social Vulnerability, Tropical cyclone tornadoes
Parallel Session

SCI-PS224.01 - Challenges for numerical weather prediction in the tropics

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Tropics and its associated circulations and disturbances play a very important role in the global climate system and in weather regimes in the Tropics and beyond. Deep convective cloud systems in the Tropics are the primary mechanism of transport of energy out of the Tropics to higher latitude and of energy distribution in tropical troposphere. The fact that local and mesoscale effects are more dominant than synoptic influences makes prediction in Tropics quite challenging. In addition to the lack of total understanding of processes and misrepresentation ok key processes in environmental prediction systems, the current operational World Weather Watch over the tropical latitudes exhibits large data gaps, particularly over continental Africa. The AMMA (African Monsoon Multidisciplinary Analyses) programme is a long-term programme that focus on Continental Africa. Its first phases provided unprecedented measures and diagnostics and has successfully addressed the goals i) to improve our understanding of the West African Monsoon (WAM) and its influence on environment regionally and globally; ii) to provide the underpinning science that relates WAM variability to related societal issues. The ongoing AMMA second phase aims to incorporate research outcomes in relevant monitoring and prediction strategies. In particular, a large effort is being achieved in the last decade to better document and understand intraseasonal variability of the WAM and to improve predictictability of the West African Monsoon at the medium range and at intraseasonal timescales.

Keywords: Tropics, Weather prediction, West Africa, African Monsoon Multidisciplinary Analyses
East Africa receives some of the most severe storms in the world, often resulting in damaged infrastructure and loss of life. Flooding and landslides can cause disruption across large regions; whilst outflows from storms are often strong enough to capsize boats and lightning strikes ignite bush fires or directly kill people and livestock. Good predictions of storms and convection are therefore important for both safety and economic development. The Met Office has recently expanded its operational 4km limited area model to cover the whole of East Africa. The model domain is from Ethiopia to south of Malawi, covering or partially covering 16 countries in total, forecasting weather conditions out to 48 hours. The model is run twice daily and is initialised from the global Unified Model. Information from the model is disseminated freely to National Meteorological Services within East Africa as part of the WMO Severe Weather Forecast Demonstration Project (SWFDP). Met Office forecasters have been working in partnership with African Met Services to improve severe weather guidance and forecasting practices across the region. Here we will address the capability of the expanded 4km model, discussing initial results from case studies collected by the forecasters, from a science perspective. The aim is to assess whether the new NWP model is fit-for-purpose and to address and begin to quantify the improvement in weather prediction for the East Africa region.

**Keywords:** Tropical meteorology, High resolution modeling, Africa, Severe storms
The onset of the West African Monsoon (WAM) marks a key date for both the local and regional climate. There is however no consensus on what is meant by monsoon onset, with over seventeen definitions in publication. Onset definitions can be broadly categorized as regional or local. Regional definitions generally consider the annual shift of the ITCZ and associated changes in precipitation or OLR patterns within the zonally averaged monsoon region portraying large-scale shifts in regional climate dynamics. Local onset definitions consider symptom data (precipitation, frequency of rainy days etc.) at individual data cells. The work presented here shows the wide disparity between different onset definitions in observational datasets. The onset of the WAM has been computed using six definitions in five datasets for the period 1998-2012. Different regional onsets are compared and discussed and their correlation with local onsets is shown. Regional onsets show little inter-annual variability with mean onset date in late June. Local onsets have high inter-annual and spatial variability with onset dates often varying by over a month. It is found that there is little to no correlation between the large-scale shift of the ITCZ and local triggering of onset. An alternative large-scale trigger for the localized onset across West Africa has been identified, which shows good correlation with local onset anomalies and has a lead-time of over two weeks prior to local onsets. The representation of this trigger has been explored in the GloSea5 hindcast, to evaluate potential skill in forecasting local onset dates.

Keywords: West Africa, Monsoon onsets, Seasonal Predictability, Observational Uncertainty
Parallel Session

SCI-PS224.04 - The challenge of modeling the meteorology of dust emission: Results from the Desert Storms project

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As the dominant aerosol type by mass, mineral dust plays an important role in the Earth system. However, a reliable quantification of the global dust budget is still not possible due to a lack of observations and simplifications of relevant processes in state-of-the-art Earth system models. Four years ago, the Desert Storms project set out to (1) improve the understanding of key physical mechanisms of peak wind generation in dust emission regions, (2) assess their relative importance, (3) evaluate their representation in models, (4) determine model sensitivities with respect to resolution and model physics, and (5) explore the usefulness of new approaches for model improvements. The focus of this project is on the world’s largest dust source northern Africa. This talk aims to give an overview of some of the most significant findings from this project: (1) The morning breakdown of nocturnal low-level jets is an important emission mechanism, but details depend crucially on nighttime stability, which is often badly handled by models. (2) Convective cold pools are a key control on summertime dust emission over northern Africa, directly and through their influence on the heat low; they are severely misrepresented by models using convective parameterizations. (3) The lack of sufficient observations leads to a considerable uncertainty in (re)analysis products. (4) Variations in vegetation-related surface roughness can create small-scale wind variability and support long-term dust trends in semi-arid areas. (5) Due to dry convection dust emission frequency shows a clear peak during daytime with an uncertain contribution from dust devils.


Keywords: mineral dust, northern Africa, aerosol, wind
Parallel Session

SCI-PS225.01 - Urban-scale forecasting system for the 2015 PanAm Games in Toronto

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A Sub-kilometer atmospheric modeling system with grid-spacings of 1 km and 250 m and including urban processes is currently being developed at the Meteorological Service of Canada (MSC) in order to provide more accurate weather forecasts at the city scale. In this study, the development of a real-time forecasting system over the Greater Toronto Area (GTA) will be presented. This system will be devoted to help issuing alerts during the Pan-American and para-Pan-American games in Toronto during July and August 2015 (Panam 2015). As typical summertime features, the region is concerned with localized heavy rainfall due to convective precipitations, and with human discomfort during heat waves. In this system, surface physical processes are represented with the Town Energy Balance (TEB) model for the built-up covers and with the Interactions between the Surface, Biosphere, and Atmosphere (ISBA) land surface model for the natural covers. In order to provide more accurate urban and land surface variables initialization, output from the external high-resolution GEM-Surf model and including a long spin-up period is specified to the system. For the Lakes existing over the region, surface temperature is prescribed using 2-km hourly output from an ocean model, and aerodynamic roughness length is prescribed using a wave model. Results from a few case studies will be presented. In particular, simulations are conducted for the case of 8 July 2013 when exceptional localized rainfalls were recorded.

Keywords: urban meteorology, real-time forecasting, lake breeze, extreme weather
Parallel Session

SCI-PS225.02 - Modelling London with high resolution versions of the Unified Model

Humphrey Lean

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With operational weather forecast models reaching km scale in many operational centres they can start to represent, albeit crudely, urban effects in larger cities. Research in the Met Office has already moved on to investigate higher resolution versions of the Unified Model (UM) down to 100m gridlength for specific situations (e.g. cold pooling in small valleys and convection). Such high resolution models of cities would potentially provide benefits for short term environmental prediction as well as studies of longer term effects of possible future changes. For many such applications the high resolution models would need to be coupled to other models such as urban hydrology and air quality models as well as including more sophisticated surface schemes. However, for now, there is a long way to go towards understanding the basic behaviour of the models at these gridlengths. Here we describe work on models of London with gridlengths of 500m, 333m and 100m. We describe some experiments with these models and comparisons with observations which point out what the benefits, as well as the potential problems, with these models might be. These include the representation of the convective boundary layer and of some small scale effects such as orographic flows.

Keywords: Urban Modelling, boundary layer, High resolution models
In summer 2015, Environment Canada will showcase the development of their nested high-resolution air quality model (GEM-MACH) and the objective analysis tool for making predictions of the Air Quality Health Index (AQHI) at sporting venues across the Greater Toronto Area. We describe here progress and developments towards this goal. This version of GEM-MACH, based on the newest version of GEM, EC’s operational weather forecast model, will use a 240,000 km² grid centered on Toronto, with a grid-spacing of 2.5 km. Efforts are underway to incorporate feedbacks between chemistry and the double-moment bulk microphysics scheme of this model. Tests are underway for a new bottom-up approach to generating on-road mobile emissions based on a traffic-flow model for Toronto, to provide part of the emissions inputs for the model. These model improvements will be evaluated against the surface network of air quality observations across Canada and the US, but also a unique air quality data set generated from a mobile laboratory that sampled from different neighbourhoods across Toronto. Preliminary evaluation results with a coarser-resolution version of GEM-MACH show a significant positive O3 bias for southern Ontario, but improved bias and correlation for NO2.

**Keywords:** GEM-MACH, Air Quality Health Index, Mobile Emissions, Objective Analysis
Urban effect on precipitation and its mechanism is still unclear because of its complexity and the lack of effective observation data. We investigate the horizontal distribution of frequency of precipitation for \( \geq 5\text{mm/hour} \) and \( \geq 20\text{mm/hour} \) in and around the Tokyo-area using "Radar/Raingauge-Analyzed Precipitation" which is C-band radar rain gauge adjusted quantitatively by the high density ground-based rain gauge network. The horizontal- and time-resolution of the data are 1-km and 30-minute, respectively, and the analyzed period is from April to October in 2008-2012. The data is provided by Ministry of Land, Infrastructure, Transport and Tourism in Japan. The distribution of frequency of precipitation is inhomogeneous even in the inside of the urban area. It is high near major arterial roads, office- and bustling-areas, while it is low around large green spaces. Furthermore, hourly and monthly distributions show different patterns. The results indicate that anthropogenic heat and heat conductivity of urban structure have different effect on reinforcement of precipitation. We conducted numerical experiments using the Weather Research and Forecasting (WRF) Model for case studies. In the experiments, urban areas are set in three classes and applied combinations of anthropogenic heat intensities. Considering anthropogenic heat from crowded arterial road and buildings, the maximum value of anthropogenic heat is set to 300W/m². The results of experiments suggest that anthropogenic heat clearly intensify precipitation in and on the leeward of urban areas; the reproducibility of distribution of precipitation become much similar to the radar observation than the experiment without anthropogenic heat.

**Keywords:** Urban Meteorology, Precipitation, Radar, Regional Climate Model
The Climate Forecast System Reanalysis (CFSR) was developed at the Environmental Modeling Center at NCEP. It is the first partially coupled reanalysis of its kind in the world, using a background first guess from a fully coupled model representing the interaction between the Earth's atmosphere, oceans, land and sea-ice. In this presentation, we will review the specific reasons for the decision to partially couple the reanalysis, such as the relationship between precipitation and sea surface temperature over warm oceans, etc., as well as the technical decisions regarding how the coupling was done. We will also discuss our future plans. We propose to assemble and test an ensemble based climate data assimilation system with coupled land-atmosphere-ocean-ice-aerosol assimilation/forecast components, as a proof of concept as well as a potential development direction for an operational CFSv3 system. We would start from a CFSR framework and build an ensemble processing infrastructure, similar to that of the NCEP EnKF GFS assimilation/forecast system, in which the five physical models are integrated together with a coupling component to create ensembles of first guess forecasts. These assimilation components will run independently from the ensemble first guesses. All the major components, including the EnKF software, needed for the initial build of the proposed system already exist. Technically, this would be a big step closer to a fully coupled analysis, but it will only pay off if the covariances are substantial. The EnKF approach may be more robust in dealing with the unavoidable data inhomogeneities when 1979-present is reanalysed.


Keywords: Coupled Data Assimilation, Reanalyses, Coupled Models
The Japan Meteorological Agency (JMA) conducted the second Japanese global atmospheric reanalysis JRA-55. It covers the period starting in 1958, when regular radiosonde observations began on a global basis. JRA-55 is the first comprehensive reanalysis that has covered the last half century since the ERA-40 reanalysis, and is the first one to apply four-dimensional variational data assimilation (4D-Var) to this period. The main objectives were to address issues found in previous reanalyses and to produce a comprehensive atmospheric dataset suitable for studies of climate change and multidecadal variability. The observations, data assimilation system and forecast model used to produce JRA-55 as well as the basic characteristics of the JRA-55 products are introduced. JRA-55 has been produced with the TL319 version of JMA's operational data assimilation system as of December 2009, which was extensively improved since the JRA-25 reanalysis. It also uses many newly available and improved past observations. The resulting reanalysis products are considerably better than the JRA-25 products. Two major problems of JRA-25 were a cold bias in the lower stratosphere, which has been diminished, and a dry bias in the Amazon basin, which has been mitigated. The temporal consistency of temperature analysis has also been considerably improved. Our initial quality evaluation revealed problems such as excessive precipitation over the tropics, and unrealistic trends in analyzed tropical cyclone strength. This presentation also assesses the impacts of model biases and changes in the observing system.

**Keywords:** reanalysis, data assimilation, meteorological observation, numerical weather prediction
Parallel Session

SCI-PS226.03 - ERA-CLIM: Developing reanalyses of the coupled climate system

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ERA-CLIM and ERA-CLIM2 are two successive EU-funded research projects in the area of climate reanalysis, part of a large effort to build tools, information systems and services in the area of climate change. The ERA-CLIM projects are developing input observations, data assimilation methods, and processing systems needed to compute consistent reanalyses of the coupled climate system (atmosphere, ocean, sea ice and land surface) that extend back in time by 100 years or more. We will outline the approach taken in these projects, present some of the results obtained so far, and discuss our plans for the next few years.

Keywords: Climate, Reanalysis, Observations
Parallel Session

SCI-PS226.04 - Regional reanalysis at the Met Office

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As part of the EURO4M project (European Reanalysis and Observations For Monitoring), a regional reanalysis system for the atmosphere has been developed. It uses 4DVar to assimilate conventional and satellite data, and also cloud and visibility from surface stations. It relies on the ECMWF ERA-Interim global reanalysis for boundary conditions and for observation data. The reanalysis has been run for a 2-year period and validated against observations and against other reanalysis datasets. The reanalysis system and results from the validation are presented here. The system will now be extended, adding an ensemble to give estimates of uncertainty (the UERRA project), and adapting it to run in other regions. Planned and possible future developments are outlined.

Keyword: reanalysis
Parallel Session

SCI-PS227.01 - User-oriented weather information for disaster risk reduction and associated science-based technology in Japan

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The Japan Meteorological Agency (JMA) has been making continuous efforts in improving disaster-prevention information such as strengthening of its observation system, improvement of forecast performance and enhancement of the warning system, based on the lessons learnt from a wide variety of disasters that Japan experiences every year. Especially, JMA make efforts to develop and provide the disaster-prevention weather information which would facilitate the judgment of stages in disaster management, such as evacuation order by local governments. In the presentation, the JMA’s recent efforts will be presented such as (1) introduction of weather warnings and advisories for each municipality, (2) development of disaster-related special indices calculated with rainfall amount for the information on the risk of flood and land-slide, and (3) launch of the Emergency Warning System to support against extreme events once every few decades. The presentation will also include the future plan of improvement of prediction skills, including Numerical Weather Prediction, to support the above-mentioned efforts.

Keywords: disaster risk reduction, numerical weather prediction, user-oriented weather information
Parallel Session

SCI-PS227.02 - Impact and risk of coastal-related hazard on lives, livelihood, property and economy

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Decision-makers and the public growingly need to know impact and risk of coastal-related hazard on lives, livelihood, property and economy. The World Meteorological Organization (WMO) implements the Coastal Inundation Forecasting Demonstration Project (CIFDP) to provide an example of cooperative work for building improved operational forecasting and warning capability for coastal inundation, combing extreme waves, surges, tides and river flooding. By developing a cross-cutting cooperation between different scientific disciplines and user communities the project aims to demonstrate the benefits of this approach in reducing the impacts of natural hazards on coastal communities. This paper describes the scientific and technical processes that are needed to provide an efficient coastal inundation forecasting and warning service by using available and operational technologies, the importance of bridging the gap between science and the user communities, the value of integrated forecasting products to address potential impacts and risks, and the need for specialised training for operators, forecasters and disaster managers. The paper will particularly discuss on the interactions between weather, marine and coastal related science in order to provide advice that quantifies impacts using both deterministic and probabilistic methods.

Keywords: Coastal Hazards, Risk
PARALLEL SESSION

SCI-PS227.03 - An event-based methodology for verifying rainstorm and thunderstorm warnings

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For the purpose of disaster mitigation, a rainstorm warning system is in place in Hong Kong to alert the public of the impact of severe weathers. To support the warning system, the Hong Kong Observatory has been operating a fully automated rainstorm nowcasting system named SWIRLS (Short-range Warning of Intense Rainstorms in Localized Systems). By tracking and extrapolating radar echoes, SWIRLS generates nowcast products of severe weather for use by weather forecasters. The performance of SWIRLS in providing alerts on possible rainstorms and thunderstorms is assessed by a novel predominantly event-based verification scheme that has been in real-time use since 2012. The verification scheme is so designed to handle situations such as a forecast spans over multiple actual events of occurrence, or conversely an actual event continues into multiple forecasts. Being event-based, the scheme yields results in the form of conventional metrics such as probability of detection and false alarm ratio that can be conveniently interpreted. This paper describes the verification methodology, illustrates with examples and discusses its performance in 2012 and 2013. Potential future developments, including the proper handling of close calls, are also explored.

Keywords: verification, event-based, rainstorm, thunderstorm
Atmospheric turbulence causes most weather-related aircraft incidents. Commercial aircraft encounter moderate-or-greater turbulence tens of thousands of times each year worldwide, injuring probably hundreds of passengers (occasionally fatally), costing airlines tens of millions of dollars and causing structural damage to planes. Clear-air turbulence is especially difficult to avoid, because it cannot be seen by pilots or detected by satellites or on-board radar. Clear-air turbulence is linked to atmospheric jet streams, which are projected to be strengthened by anthropogenic climate change. However, the response of clear-air turbulence to projected climate change has not previously been studied. Here we show using climate model simulations that clear-air turbulence changes significantly within the transatlantic flight corridor when the concentration of carbon dioxide in the atmosphere is doubled. At cruise altitudes within 50–75°N and 10–60°W in winter, most clear-air turbulence measures show a 10–40% increase in the median strength of turbulence and a 40–170% increase in the frequency of occurrence of moderate-or-greater turbulence. Our results suggest that climate change will lead to bumpier transatlantic flights by the middle of this century. Journey times may lengthen and fuel consumption and emissions may increase. Aviation is partly responsible for changing the climate, but our findings show for the first time how climate change could affect aviation.


Keywords: turbulence, flights, planes, climate change
The first HyMeX field campaign took place in the Mediterranean in fall 2012 with the aim of better understanding the mechanisms which lead to heavy precipitation events. Two such events occurred on the 24th (IOP6) and 26th (IOP7b) of September over south-eastern France. IOP6 was characterized by moderate to weak low-level flow which led to heavy and concentrated convective rainfall over the plains near the coast, while IOP7a had strong low-level flow and consisted of a convective line over the mountainous regions further north. Firstly, an ensemble was constructed for each IOP using analysis files from the AROME, AROME-WMED, ARPEGE and ECMWF operational models as initial (IC) and boundary conditions (BC) for the research model Meso-NH (2.5km resolution). A high level of model skill was obtained for IOP7a, with a lower level of agreement with the observations for IOP6. Using the most accurate member of this ensemble as a control simulation, three further ensembles were constructed to address uncertainties related to cloud physical and turbulence parameterizations. Perturbations were introduced by perturbing the time tendencies of the warm and cold microphysical and turbulence processes. An ensemble where all three sources of uncertainty were perturbed gave the greatest degree of dispersion in the surface rainfall for both IOPs. Comparing the level of dispersion to that of the ICBC ensemble demonstrated that when model skill is low (high) and low-level flow is weak to moderate (strong), the level of dispersion of the ICBC and physical perturbation ensembles is (is not) comparable.


Keywords: HyMeX, precipitation, ensemble forecast, parameterization uncertainty
Parallel Session

SCI-PS228.02 - A systematic approach to identifying and characterizing atmospheric bores and other fine-line features during IHOP_2002

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The evolution of gust fronts, bores, drylines, and other boundaries was investigated using surface data and radar fine-lines from 1600 to 0600 LST during the International H2O Project (15 May – 25 June 2002 over the Southern Great Plains). Our analysis revealed atmospheric bores were common; 143 individual fine-lines were observed in the radar mosaic with 66 identified as bores. The bores were predominantly observed in the Texas-Oklahoma panhandle and across the Kansas-Oklahoma border and emanated from outflows surging ahead of convective systems. The statistics of the observed evolution was generally consistent with the hydrodynamic concept of a gust front moving into stable layer, triggering a bore, which can subsequently evolve into undular bore. However, our analysis also revealed that the duration of these bores varied from ~ 1 to 10 hrs suggesting wide differences in the effectiveness of wave ducting. The relationship between convective, bores and gust fronts also appeared to vary over the region as the precipitation maximum was found in the SE portions of the domain where surging gust fronts and bores were evidently less common. Current work is attempting to determine if these variations can be explained by the dynamical arguments of Rotunno et al. (1988) and French and Parker (2010). Bores and density currents also demonstrated a proclivity for clockwise rotation with time as could be expected from coriolis. However, our preliminary analysis also suggests that rotation is favored when as fine lines move across air mass boundaries, such as the dryline.


Keywords: IHOP_2002, bore, convection, observation
Parallel Session

SCI-PS228.03 - Amplification of high precipitation in the Western Mediterranean by Corsica island flow and convection

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The influence of mountainous islands, in particular of Corsica, on deep island convection and downstream effects on high precipitation at the Ligurian and French coasts is investigated using observations with the KITcube observation facility, the instrumented Dornier 128 aircraft, and COSMO modelling. Within case studies it is investigated, under which circumstances moist convection occurred over Corsica (and Sardinia) and which factors decided on the severity of the island on the precipitation. Model sensitivity runs elucidating the relative importance of the land–sea contrast, the atmospheric stratification and the importance of PV anomalies. This provides into the partly competing effects of different physical processes, such as of island precipitation that increases by superposition of the sea breeze and upslope flow. The KITcube measurements at sites at the eastern coast and inland (Corte) provided strong evidence, that the convergent inflow of moist air from the surrounding seas is most important for inland convection and that the wave systems developing over Corsica may critically effect flow and uprising flow on scales much larger than the island itself.


Keywords: convection, precipitation, orography, prediction
This study investigates a long-duration mesoscale convective system (MCS) with extreme rainfall (451 mm in 16 hours) over west coastal Guangdong on 10 May 2013 during the Southern China Monsoon Rainfall Experiment (SCMREX) that is a WMO/WWRP Research & Development Project. The environmental conditions are characterized by little convective inhibition, moderate convective available potential energy, moderate precipitable water, low lifting condensation level, and lack of low-level jets from the tropical ocean. Repeated convective back-building and subsequent northeastward "echo training" of convective cells are found during the MCS’s early development and mature stages. However, the earlier and later stages possess distinctive initiation/maintenance factors and organization of convection. During the earlier stage (0000-0900 Beijing Standard Time; BST=UTC+8h), convective cell is continuously initiated when weak (<5 m s⁻¹) southeasterly/southerly flows near the surface impinge on the east sides of Mts. Longgao and Ehuangzhang (highest peak of approximately 800 and 1300 m), respectively, and moves northeastward, leading to formation of two quasi-stationary rainbands. During the mature stage (0900-1430 BST), new convection is repeatedly triggered along a storm-generated cold pool boundary, resulting in formation of several rainbands that are quasi-stationary before 1130 BST and move eastward in later times. Individual rainbands during the MCS’ life period similarly consist of northeastward training of convective cells and a stratiform region to the northeast. While the MCS begins to dissipate, a stronger squall line moves into the region from the west and passes over within about 3.5 hours, contributing about 10%-15% to the total rainfall amount.

Keywords: extreme rainfall, convective maintenance, orographic lifting, cold pool
Parallel Session

SCI-PS229.01 - How do atmospheric rivers form?

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The term atmospheric river is used to describe the instantaneous position of filaments of enhanced water vapour in the troposphere. They are often observed in satellite imagery extending from the subtropics to the extra tropics. The precipitation associated with these filaments of enhanced water vapour can lead to high impact flooding events in the US and Europe. However, there remains some debate as to how these filaments form. In this paper we analyse the spatial distribution and transport of water vapour within a climatology of wintertime north Atlantic extratropical cyclones. The water vapour budget is calculated for each of the cyclones in the climatology and an average cyclone evolution presented. Analysis shows that as the cold front catches up with the warm front it sweeps up water vapour in the warm sector, causing a narrow band of high water vapour content to form ahead of the cold front at the base of the warm conveyor belt airflow. Non-local convergence of water vapour into the cyclone is small in comparison to local convergence. Thus, local sources of water vapour in the warm sector close to the cyclone centre, and not long-distance transport of water vapour from the subtropics, are responsible the generation of filaments of high water vapour content seen in the satellite imagery. These filamentary structures represent the trails left behind as cyclones channel atmospheric moisture into narrow bands as they travel polewards from their origins in the subtropics.

Keywords: water vapour budget, extratropical cyclone, moisture flux
Parallel Session

SCI-PS229.02 - A climatology of extreme cyclone growth processes in the North Atlantic Basin

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The purpose of this research is to analyze historically extreme cyclogenesis cases in the context of synthesizing crucial dynamic and thermodynamic processes occurring on planetary-, synoptic-, and mesoscales. Our analysis includes diagnoses from both the classical Sutcliffe quasi-geostrophic, and the potential vorticity perspectives. The particular foundational analysis is that of an historical analysis of moist baroclinic growth rates, and their relationships to extreme cases of North Atlantic dynamic tropopause jets, to extreme flanking polar and subtropical air masses, and to extreme cases of explosive cyclogenesis. A climatology of these moist baroclinic growth rates is presented for each of the four seasons for the period from 1950 through early 2014. Finally, we focus on the most recent winter (December-January-February) of 2013-14, in which the North Atlantic basin had a particularly active storm track. The areal coverage of strong growth rates was anomalously large through most of this cold season. Our analysis includes the diagnosis of the North Atlantic jet, and the dynamic-thermodynamic processes associated with the development of planetary-scale circulation features in the poleward and equatorward environments of this jet stream.

**Keywords:** Atmospheric dynamics, Oceanic cyclogenesis
SCI-PS229.03 - Sub-seasonal clustering of extreme precipitation events

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Temporal clustering of extreme precipitation events on sub-seasonal time-scales is of crucial importance for the formation of large-scale flood events. Recent examples are the severe floods in central Europe in summer 2013 and the floods in England in winter of this year. Here we study the temporal clustering of extreme precipitation events in Southern Switzerland, which is relevant for the flooding of lakes in southern Switzerland and Northern Italy. We are first interested in the question if temporal clustering is present and second in the dynamics that are responsible for the clustering. We use an observation-based gridded precipitation data set of daily rainfall sums and ECMWF reanalysis data sets. First two statistical methods are introduced that can be used to characterize temporal clustering on sub-seasonal timescales and to determine the statistical significance of the clustering. Significant clustering of precipitation extremes in the 20- to 30-day time range is found during the fall season. Then four high-impact clustering episodes are selected and the dynamics responsible for the clustering are identified. During the four cluster episodes all heavy precipitation events were associated with an upper-level breaking wave upstream over Western Europe. During two clustering episode this wave breaking was supported by atmospheric blocking located downstream over Eastern Europe. During one clustering periods several events of extratropical transition of hurricanes contributed to the formation of high-amplitude ridges over the Atlantic basin and downstream wave breaking.

Keywords: extreme precipitation, Rossby wave breaking, sub-seasonal clustering
Parallel Session

SCI-PS229.04 - Novel measure for Baroclinicity and its tendency: Theory, case study and climatology

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The position, strength and variability of midlatitude storm tracks are dictated by the availability and spatial distribution of baroclinicity. This linkage is well understood in terms of eddy-mean-flow interactions and related storm-track diagnostics. However, these more traditional measures are not always straightforward to associate with object-based features, such as cyclones detected from sea level pressure. Here, we propose a novel diagnostic to quantify tropospheric baroclinicity based on the slope of isentropic surfaces. In this framework we present the contribution of diabatic and dynamic processes to the tendency of baroclinicity. Its usefulness for the dynamical understanding of extratropical cyclones is demonstrated in the context of the severe winter storm Dagmar, which hit Norway in December 2011. We present evidence that two major events of generation of baroclinicity by diabatic processes preceded the intensification of the storm. We also present a thirty-year climatology of tropospheric baroclinicity and its tendencies using the ERA-Interim dataset. We pinpoint the balance of consumption and production of baroclinicity in the storm track, where consumption is driven by baroclinic conversion in extratropical cyclones, while production is dominated by diabatic processes also directly associated with extratropical cyclones. Furthermore, our results show that kinematic frontogenesis and the advective flux of baroclinicity have only minor contributions. This indicates that a major part of the baroclinicity consumed by cyclones is generated locally by the cyclones themselves.

Keywords: Baroclinicity, Jet Stream, Cyclones, Energy Conversion
Parallel Session

SCI-PS230.01 - Advancing the frontiers of tropical cyclone modeling with the Variable-Resolution General Circulation Model CAM-SE

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A statically-nested, variable-mesh option has recently been introduced into the cubed-sphere Spectral Element (SE) dynamical core of the Community Atmosphere Model (CAM) which is under development at various U.S. Department of Energy laboratories and the National Center for Atmospheric Research (NCAR). It allows for global simulations with grid spacings as small as 12 km. At these resolutions, GCMs are able to capture key features of tropical cyclones. The paper gives an overview of the variable-resolution mesh approach, and evaluates its scientific properties. In particular, we will discuss the characteristics of tropical cyclone simulations in a variety of modeling frameworks. They include the representation of tropical cyclones in aqua-planet experiments, and showcase short-term and multi-decadal tropical cyclone simulations in CAM-SE when driven with prescribed sea surface temperatures. Special attention is paid to the characteristics of tropical cyclones in the grid transition regions, and the comparison of variable- and uniform-resolution experiments. It is shown that the variable-resolution CAM-SE model has the potential to become a future tool for regional climate assessments and short-term weather assessments. In addition, we assess the performance of the CAM4 and CAM5 physical parameterization packages in variable-resolution aqua-planet simulations. In particular, we discuss the question whether current physics packages are scale-aware and whether or not the addition of increased resolution patches adds bias to key climate metrics such as rainfall and cloud fraction at the regional level.


\textbf{Keywords:} Variable-resolution grid, Tropical cyclones, Scale-aware parameterizations, Seamless GCM
Parallel Session

SCI-PS230.02 - Global ocean-atmosphere modeling on unstructured meshes

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A 10-plus year effort at the NOAA Earth System Research Lab to develop an atmospheric prediction model using an icosahedral grid in combination with a predominantly isentropic vertical coordinate is described. Owing to its intended use as a biweekly to intraseasonal prediction tool, the model relies on the hydrostatic approximation with a targeted mesh size of 10 - 30km. Versions of the model, which has been named FIM, have undergone real-time testing for several years now on meshes ranging from 15 to 30km. Current efforts focus on (a) reducing long-term cloud coverage/radiation biases in the column physics package obtained from the U.S. Weather Service, and (b) coupling FIM to an icosahedral version of the ocean model HYCOM. While the ocean model is currently being tested on a 120km mesh in multi-decadal runs, it will eventually share the grid with a 30-km version of FIM and at that stage be eddy-permitting. The focus of this talk is on numerical issues encountered when combining an unstructured (icosahedral) horizontal mesh with an adaptive vertical coordinate (quasi-isentropic in the atmosphere, quasi-isopycnic in the ocean). The free choice of vertical discretization allows us to run isentropic- and sigma-coordinate versions of FIM side by side, thereby shedding light on the cold bias found in conventional AGCMs. We also discuss the apparent tendency of both FIM and the U.S. Weather Service’s GFS to overpredict atmospheric blocking near the end of the 14-day prediction interval.

Keywords: isentropic coordinates, icosahedral mesh, coupled ocean-atmosphere model
SCI-PS230.03 - Non-hydrostatic dynamical core for the Russian SL-AV model: overview and first results

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In the Hydrometeorological Centre of Russia the global weather forecast is carried out with the model SL-AV [1] based on the equations of hydrothermodynamics for the incompressible hydrostatically equilibrium atmosphere. We discuss the new version of the dynamical core which perhaps will be included into the SL-AV model. The core is based on non-hydrostatic equations of the compressible atmosphere described in [2]. The equations are solved using the finite-difference semi-implicit scheme with semi-lagrangian treatment of advective terms. The non-hydrostatic core was tested against classical solutions covering various mountain-wave regimes for continuously stratified flows.


Keywords: numerical weather prediction, dynamical core, non-hydrostatic
During recent decades, the Arctic region has experienced greater-than-global surface warming and dramatic sea ice loss. The multi-scale, atmosphere-ocean-cryosphere interactions within this changing environment are not fully understood. Here we investigate the role that upper-atmospheric circulations play in the coupled climate system, with a focus on coherent circulation features called tropopause polar vortices (TPVs). Historically, two established classes of numerical weather prediction models are coarse global circulation models (GCMs) and higher resolution limited area models (LAMs). GCMs are inhibited by their inability to resolve important smaller-scale features, while LAM forecasts are sensitive to the larger-scale, downscaled initial and boundary conditions. The nonhydrostatic atmospheric core of the Model for Prediction Across Scales (MPAS-A) falls into a new class of models bridging this gap. Local horizontal refinement allows for desired resolution in regions of interest, while a smooth transition to a relatively coarse global mesh reduces the numerical complications that typically arise from nesting approaches. Understanding the benefits and limitations of this new class of models is fundamental. Towards this understanding, we isolate the dynamical components of MPAS-A by comparing to WRF-ARW and GFS using the same respective physics parameterizations. Historical simulations from summer 2006, summer 2007, and winter 2014 represent conditions of high summer sea ice extent, low summer sea ice extent, and winter Arctic-lower latitude interactions, respectively. Evaluations based on both climatological means and individual TPV evolutions reveal characteristics for each class of models. Signatures for boundary numerics, scale-dependence, and Arctic-lower latitude interactions are discussed.

Keywords: Model for Prediction Across Scales, tropopause polar vortex, Arctic, sea ice
Parallel Session

SCI-PS231.01 - Recovering the multivariate dependencies of statistically post-processed ensemble forecasts with ensemble copula coupling

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In recent years, weather prediction has been transformed through the implementation of ensemble forecasts consisting of multiple runs of numerical weather prediction models which differ in the boundary conditions and/or the numerical representation of the atmosphere, thereby addressing the two major sources of forecast uncertainty. However, even the state of the art ensemble systems are biased and lack calibration which requires statistical post-processing of the model output. The statistical post-processing method ought to provide a probabilistic forecast, for instance in the form of a full predictive distribution, and depend on the ensemble forecast in a coherent manner. In this talk, we will discuss the current challenge of obtaining physically realistic probabilistic forecasts of space-time trajectories. For this, we propose a general multi-stage procedure called ensemble copula coupling which draws on the multivariate correlation structure of the original ensemble.


Keywords: ensemble prediction, statistical postprocessing, multivariate modelling
Parallel Session

SCI-PS231.02 - Statistical postprocessing for TIGGE

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Ensemble prediction systems typically are biased and uncalibrated and, thus, can benefit from statistical postprocessing. Various methods have been proposed for doing this, with Bayesian model averaging (BMA) and heterogeneous regression being state of the art approaches. Here, we focus on techniques tailored to probabilistic temperature forecasts with TIGGE. Among the many challenges that arise with TIGGE, we are particularly interested in modeling physically realistic spatial dependence structures in the postprocessed global forecast fields. For this task we use ensemble copula coupling (ECC) as a reference standard. In a more sophisticated approach, we use Gaussian random fields to represent the forecast error fields, where we fit spatially heterogeneous covariance functions on the globe that account for land-water differentials in predictive ability and correlation length. In a case study, we demonstrate improvements in forecast skill and illustrate the importance of spatial modeling.

Keywords: probabilistic forecasting, Gaussian process, spherical covariance function, ensemble prediction system
Parallel Session

SCI-PS231.03 - Bayesian weighting for short-range lagged ensemble forecasting at convective scale

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Ensemble prediction systems at convective scale are often under-dispersive. In order to alleviate this problem, a time-lagged ensemble can be created from ensemble forecasts initialized at different production times. While an equal-weight combination of lagged forecasts generally provides competitive results, this presentation will introduce and discuss the efficiency of an objective weighting. The proposed approach is based on nonlinear Bayesian filtering, and the weights are determined online for each member according to the observations likelihood. The method is illustrated with short-range ensemble forecasts provided by the cloud-resolving AROME-France model. A time-lagged ensemble is then constructed from the current ensemble forecasts combined with older ensemble forecasts started 6h and 12h earlier. It is first shown that the weighting scheme provides reasonable results, in particular it is able to detect differences in forecast quality due to different production times. The question whether these unequal flow-dependent weights can be successfully applied to the members of the time-lagged ensemble is then examined. Results indicate that the weighting does not lead to a noticeable gain in forecast quality. Possible reasons for this limited impact will be discussed.

Keywords: Ensemble prediction, Time-lagging, Particle filtering
Parallel Session

SCI-PS231.04 - Are we still lacking spread in medium-range ensemble forecasts?

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Since the beginning of operational medium-range weather ensemble forecasting in the 1990’s it has been considered that these forecasts are generally under-dispersive, i.e. spread is generally smaller than the ensemble mean error. This has direct implication for the users since the produced probabilistic forecasts were therefore overconfident due to this discrepancy. Several ways to increase forecast spread were developed like the stochastic perturbations of the model physics, the stochastic kinetic energy back-scattering or the multi-model approach. A couple of decades later, does the problem persist? Based on a recent sub-set of the North American Ensemble Forecasting System (NAEFS) dataset, we will look at the current balance between ensemble mean error and the ensemble spread in the Canadian (GEPS) and American (GEFS) global ensemble forecasting systems. The combination of the two operational systems will also be studied. Using observations as a reference, the dispersion score (Candille et al. 2007) which takes into account the observational error will be presented and compared with the more user oriented reliability diagram. Different fields in the troposphere and near the surface will be examined for different regions over the globe.


Keywords: ensemble, forecast, spread
Parallel Session

SCI-PS232.01 - Ocean model parameterizations relevant to weather prediction

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Ocean model “parameterizations” come in many flavors, ranging from truncated physics with well understood and acceptable limitations, to complicated schemes of dubious universal fidelity. Solar absorption and overflows are given as respective examples. The focus will then turn to other parameterizations that are likely to be more relevant to the overarching theme of the OSC: “....... Prediction of the Earth System: from minutes to months.” They link the upper ocean to the overlying atmosphere through the surface temperatures and currents that are the ocean parameters appearing in the surface flux parameterizations. Therefore, most attention will be given to the representation of boundary layer turbulence, including the entrainment of denser thermocline water and the formation of sub-grid-scale diurnal boundary layers. Turbulent mixing from three energy sources will be discussed separately; the surface fluxes of momentum and heat, the surface wave field including breaking and Langmuir turbulence and both remote and local dissipation of the barotropic tide, especially along the coast. Less attention will be given to the parameterization of heat and salt effects of ocean eddies, because the mesoscale is becoming more commonly resolved, the sub-mesoscale is not yet a robust parameterization, and both are more indirectly linked to the surface ocean and hence to the atmosphere. Finally, different approaches to satisfying both physical and numerical requirements for viscosity will be discussed.

**Keywords:** Parameterization, Ocean Model, Weather Prediction
Parallel Session

SCI-PS232.02 - Parameterizing Richardson number hysteresis in the boundary layer

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Turbulence in the planetary boundary layer (PBL) transports heat, momentum and moisture in eddies that are not resolvable by current NWP systems. The PBL parameterization scheme employed in this study uses a higher-order closure that incorporates a predictive equation for the turbulent kinetic energy (TKE). For a stably-stratified fluid, the growth and decay of TKE is largely controlled by the dynamic stability of the flow as represented by the gradient Richardson number (Ri). Although the existence of a critical Ri (Ric) that uniquely separates turbulent and laminar regimes is predicted by linear theory and perturbation analysis, observational evidence and total energy arguments suggest that its value is highly uncertain, if Ric exists at all. Some of the disparity between predicted and observed Ric estimates can be explained by the apparent presence of regime-dependent critical values, a property known as "Richardson number hysteresis". In this study, a parameterization of Richardson number hysteresis for use in a TKE-based PBL scheme is proposed. It is shown that accounting for a hysteretic loop in the TKE equation improves guidance for a canonical freezing rain event by reducing the diffusive elimination of the warm nose aloft, thus improving the model's representation of PBL profiles. Enhancements in predictive skill are also found in the assimilation cycle, suggesting that accounting for Richardson number hysteresis in PBL schemes using higher-order closures has the potential to yield important and physically relevant improvements in forecast quality.

Keywords: boundary layer, physical parameterization, operational NWP
Parallel Session

SCI-PS320.03 - An economical, scale-aware PDF-Based turbulence closure model

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Global models parameterize the effects of subgrid-scale processes. Current global forecast models use grid spacings of a few tens of kilometers. In the next few years, the grid size is expected to be less than ten kilometers. Such models will resolve mesoscale circulations and the largest deep convective clouds. However, smaller clouds such as shallow cumuli will not be even partially resolved in the foreseeable future. We have developed an economical PDF-based SGS turbulence and cloudiness scheme that unifies the representation of turbulence and SGS cloud processes, and that is scale-aware: it does not require any explicit grid-size information. SHOC (Simplified Higher-Order Closure, Bogenschutz and Krueger 2013) integrates a prognostic SGS TKE equation, the assumed joint PDF method, a diagnostic second- and third-moment closure, and a turbulence length scale related to the subgrid-scale turbulence kinetic energy and eddy length scales. Our turbulence closure requires only one prognostic equation. This makes it economical, portable, and well-behaved. Our closure also uses a novel turbulence length scale that produces excellent scalability with horizontal resolution. We implemented SHOC in a cloud-resolving model (CRM) and tested it against large-eddy simulation (LES) results. We also implemented it in a global model based on the Multiscale Modeling Framework (MMF) and evaluated the results using global observations. Our evaluations indicate that SHOC can realistically represent many boundary layer cloud regimes in coarse-grid CRMs, while in the global model, shallow cumulus and subtropical stratocumulus were both improved.


Keyword: turbulence closure model
Parallel Session

SCI-PS232.04 - Anticipating some future challenges for operational parameterizations in high resolution Numerical Weather Prediction

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When making the operational Numerical Weather Prediction model ALADIN (Aire Limitee Adaptation dynamique Developpement INernational) progress to higher resolutions, some problems and/or dilemmas of parameterization must be anticipated in the development of evolving and/or new schemes. We are thinking here of grey zone issues, but not only. We shall present some concrete examples of our related trade off ideas within the development strategy of the so-called Alaro version. We will also give indications about first concrete realizations and show specific results, concerning the following parameterization issues. High spatial and temporal pairing of microphysics and radiation becomes possible thanks to new and computational-cost-aware intermittency choices in the radiative calculations. Compromise between scientific complexity, brought in by recent advancements in turbulence and thermodynamics theories, and practical numerical solutions enables having a new approach to the parameterization of moist turbulence. It includes third order moment terms and coordinated prognostic equations for turbulent kinetic energy, for turbulent total energy and for a moist turbulent length scale. There are also implications of this new turbulence parameterization for the shallow convection closure and for associated properties of the cloudiness scheme. Finally, the flexibility of an existing “convection permitting” scheme for the multi-scale parameterization of precipitating convection (3MT = Modular, Multi-scale Microphysics-Transport) is further enhanced, in order to get qualitatively very homogeneous results across the grey zone grid-mesh sizes. Better links with the cloud-cover issues are, here also, important, e.g. for getting an improved diurnal cycle of simulated deep convection.

\textbf{Keywords:} grey-zone, radiative-intermittency, moist-turbulence, convection-permitting
The Madden-Julian Oscillation (MJO) is the major mode of subseasonal variability in the tropics. It represents a major source of predictability on timescales out to a month, not only in the tropics, but also, through the Rossby waves it excites the extra-tropics. Its role in the development of El Nino events makes it an important component of seasonal prediction. However, General Circulation Models used for weather and climate prediction have long standing weaknesses in their simulation of the MJO, typically with weak amplitudes and poor propagation characteristics. Many theories for the MJO rely on the detailed structure of the diabatic heating and moistening processes associated with the convection and as such are sensitive to the representation of convection. This talk will describe results from two projects motivated and facilitated by the Year of Tropical Convection (YoTC). The first is an intercomparison of the state of the art weather and climate models for two observed MJO events during YoTC characterizing diabatic process in the models. Relationships between the quality of the simulation and the structure of the diabatic process will be presented to identify key characteristics of the diabatic processes associated with a successful simulation of the MJO. The second project uses cloud system resolving simulations of a YoTC MJO event. Analysis of the diabatic processes highlight differences in the variation of heating profiles for explicit and parametrized convection and markedly different evolution of the organized convection associated with the MJO.

**Keywords:** Madden-Julian Oscillation, Diabatic Processes
Parallel Session

SCI-PS233.02 - Sensitivity of the superparameterized Madden-Julian Oscillation to extreme climate variation on a uniform temperature aquaplanet

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The moisture mode dynamical paradigm of the MJO emphasizes the importance of convective self-aggregation thermodynamic feedbacks for maintaining MJO amplitude and “self-advection” of moist static energy anomalies by its gyres for MJO propagation. From this view, MJO amplitude should be sensitive to the efficiency of self-aggregation feedbacks, which RCE cloud resolving simulations suggest are in turn quite sensitive to surface temperature (indicating a critical SST ~ 25°C). Likewise from this view, the MJO phase speed is linked to the sharpness of the background SST gradient, such that the MJO should travel more slowly when that is relaxed. To test these ideas, the Super-Parameterized (SP) Community Atmosphere Model – (SPCAM) v. 3.0 – which is known to produce a convincing MJO in real-geography simulations – is run in an extremely idealized configuration with uniform SSTs across an extreme range of temperatures. The expectation from the above view is a strong damping of the MJO as temperatures are reduced beneath 25°C. Surprisingly, an MJO signal is detected down to temperatures as low as 15°C. A moist static energy budget analysis is presented to examine the simulated MJO’s thermodynamic balances and their sensitivity to extreme climate variation.

Keywords: Madden Julian Oscillation, dynamics, tropical meteorology, multi-scale simulation
Parallel Session

SCI-PS233.03 - Process-oriented MJO simulation diagnostic: moisture sensitivity of simulated convection

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Process-oriented diagnostics for Madden-Julian oscillation (MJO) simulations are being developed to facilitate improvements in the representation of the MJO in weather and climate models. These process-oriented diagnostics are expected to provide insights into how parameterizations of physical processes in climate models should be improved for a better MJO simulation. In this paper, we propose one such process-oriented diagnostic, which is designed to represent sensitivity of simulated convection to environmental moisture: composites of the relative humidity (RH) profile for precipitation percentiles. The ability of the RH composite diagnostic to represent the diversity of MJO simulation skill is demonstrated using a group of climate model simulations participating in the Coupled Model Intercomparison Project Phase 3 (CMIP3) and CMIP5. A set of scalar process metrics that capture the key physical attributes of the RH diagnostic is derived and their statistical relationship with indices that quantify the fidelity of the MJO simulation is tested. We found that a process metric that represents the amount of lower-tropospheric humidity increase required for a transition from weak to strong rain regimes has a robust statistical relationship with MJO simulation skill. Our results suggest that moisture sensitivity of convection is closely related to a GCM’s ability to simulate the MJO.

Keywords: Process-oriented Diagnostic, MJO (Madden-Julian oscillation) simulation, Moisture sensitivity of convection
Parallel Session

SCI-PS233.04 - Gross moist stability in weak temperature gradient simulations

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The weak temperature gradient (WTG) approximation is an important tool for understanding the properties of tropical convection on scales smaller than typically resolved by GCMs. Understanding these properties can lead to improvements in convective parameterizations. The gross moist stability (GMS)—defined as the ratio of moist entropy export to moisture import—governs precipitation rate and may be a key diagnostic for improving parameterizations of deep convection. Small values of GMS result in large precipitation rates, while larger values correspond to smaller rain rates. Regions of suppressed convection associated with strong descent can export both moist entropy and moisture and lead to negative values of GMS. We can investigate the relationship between precipitation rate and GMS using the WTG approximation in limited domain simulations which explicitly resolve convective systems. In WTG, gravity waves redistribute buoyancy anomalies, which horizontally homogenizes the vertical temperature profile. The model accomplishes this by creating a vertical velocity that counteracts diabatic heating. This vertical velocity governs the lateral import/export of moist entropy and moisture via mass continuity, and consequently determines the GMS and the resulting precipitation rates. Different choices in the implementation of WTG can affect details of the convection—including values of GMS and precipitation rate—but may do so in a way that preserves the relationship between the two. Here, we report on the sensitivity of the relationship between rain rate and GMS to choices in WTG implementation.

Keywords: weak temperature gradient, gross moist stability, tropical convection
Parallel Session

SCI-PS234.01 - A review of the technologies and algorithms used to couple Earth System model components

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Model coupling is essential for realizing multi-physics simulations based on two or more computing applications. An Earth System Model is a quintessential example of a coupled model, which involves several interacting components e.g. the atmosphere, ocean, land, and sea ice. Although their implementations differ vastly, the different coupling technologies used in the geophysical community to link these model components typically carry out similar functions, such as managing data transfer between two or more components, interpolating the coupling data between different grids, and coordinating the execution of the constituent models. In general, coupling data must be regridded and passed between the components subject to different constraints such as conservation of physical quantities, stability of the flux exchange numerics, consistency with physical processes occurring near the component surface, etc. In addition, computational efficiency of the coupling on parallel hardware is of course required. This presentation will review the main coupling technologies (i.e. how the coupling is technically realized) currently used to couple the numerical codes representing the different components of the Earth System and will discuss the design characteristics of the different approaches. It will also provide an overview of the coupling algorithms (i.e. what are the physical quantities exchanged between the components and in what sequence) implemented in different groups to respect the different physical and numerical constraints existing at the component interfaces.


Keywords: Coupling technologies, Coupling algorithms, Earth System models
Parallel Session

SCI-PS234.02 - Coupling sub-systems at NCEP

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The modeling suite for the National Centers for Environmental Prediction (NCEP) consists of short- and medium-range weather forecasts out to extended-range and seasonal climate prediction, deterministic as well as ensemble forecasts, includes hurricane modeling, as well as a number of "downstream" connections to ocean/sea-ice/waves, dust and aerosols, air quality, and high temporal/spatial resolution for severe weather and aviation needs. In working toward streamlining the interaction of the NCEP analysis, forecast, and post-processing systems, development of a common modeling framework called the NOAA Environmental Modeling System (NEMS) has been underway for several years, with the Earth System Modeling Framework (ESMF) as the foundation of the NEMS architecture. NEMS therefore provides a means of unifying an increasing number of operational systems within NCEP as well as the opportunity to expedite the exchange of various systems within NOAA and with the general research community. This is important as NOAA moves towards an earth system prediction capability, with additional components such as land-hydrology/river-routing, and biogeochemistry and ecosystems. NCEP model upgrades require a thorough evaluation with comprehensive and efficient model development procedures, following a "simple first then more complex" approach, from individual component "simulators" first (e.g. land-only) and ultimately to fully-coupled regional and global forecasts, where a series of "benchmark" tests must be passed before moving to increasingly more complex modeling systems.

Keywords: coupling sub-systems, coupled models, forecast models
Parallel Session

SCI-PS234.03 - Integrated modeling of aerosol, cloud, precipitation and land processes at satellite-resolved scales

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The primary objective of the NASA Unified WRF project is the development and application of an observation-driven integrated modeling system that represents aerosol, cloud, precipitation and land processes at satellite-resolved scales. This project is led by NASA’s Goddard Space Flight Center, in collaboration with NASA’s Marshall Space Flight Center and the Johns Hopkins University. We define “satellite-resolved” scales as being within a typical mesoscale atmospheric modeling grid (roughly 1-25 km), although this work is designed to bridge the continuum between local (microscale), regional (mesoscale) and global (synoptic) processes. NU-WRF is a superset of the standard NCAR Advanced Research WRF model, achieved by fully integrating the GSFC Land Information System (LIS, already coupled to WRF), the WRF/Chem enabled version of the GOddard Chemistry Aerosols Radiation Transport (GOCART) model, the Goddard Satellite Data Simulation Unit (SDSU), and boundary/initial condition preprocessors for MERRA and GEOS-5 into a single software release (with source code available by agreement with NASA/GSFC). We will show examples where the full coupling between aerosol, cloud, precipitation and land processes is critical for predicting local, regional, and global water and energy cycles, including some high-impact phenomena such as floods, hurricanes, mesoscale convective systems, droughts, and monsoons.


Keywords: modeling, aerosol, cloud, land
Parallel Session

UAS-PS331.01 - Modelling support for canadian air quality regulations and policy

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The REQA unit (unité de Réponse aux Enjeux de Qualité de l’Air), within the Air Quality Modeling and Application Section (AQMAS) of Environment Canada, is responsible for providing regulatory guidance to policy-makers on air quality. The REQA team is involved in many science and policy development studies both nationally and internationally. In order to provide such guidance, air-quality model scenarios analysis are the most common means used to estimate the impact of emission changes on atmospheric pollutant concentrations. This presentation will give an overview of the methodologies used in air quality emission scenario analysis, the latest 2010 REQA modelling platform used to create baselines and projected scenarios as well as an overview of past realizations, current and future projects.

Keywords: regulation, modelling, air, quality
Parallel Session

UAS-PS331.02 – WITHDRAWN - Bioclimatic extreme and population health in the coastal cities of Benin (West Africa)

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This study aims to increase knowledge about the evolution of extreme bioclimatic in the coastal cities of Benin and their effects on populations. To do so, this study was conducted using the methods of descriptive statistics and bioclimatic index calculation. The data used are of two major types of data: weather (rain, temperature, relative humidity, sunshine and wind) and Statistics epidemiological conditions. The results of this study that the month characterized by the most discomfort are the months of April, May and June. These months, characterized by heat stress, are also the months with high relative humidity in the study area. In contrast, the harmattan months (January December February) are the months characterized by a certain comfort. Meanwhile, 71% of respondents estimated that the weather is bad or very bad throughout the year. It is noted that the development of bioclimatic atmospheres follow the same rhythm as changing rainfall regimes along the coast. These periods are also be periods of occurrence of diseases such as malaria (55%), ARI (11%) and diarrheal diseases (34%) in the cities of Benin coast.

Keywords: Cities of Benin coast, UTCI, extreme bioclimatic atmospheres, health
Recent studies have revealed the importance of weather information as a key factor in travel planning and the travel experience for leisure activities. A survey of 1,948 Ontario (Canada) skiers/snowboarders and snowmobilers are the empirical basis for the paper. To deepen our knowledge about how winter recreationists are both similar to and different from the general public with respect to weather information, this article explores how weather information is sourced, perceived and used for the discretionary and weather-dependent winter activities of skiing, snowboarding and snowmobiling. Results show that virtually all (≥97%) of skiers/snowboarders and snowmobilers use weather forecasts when planning an outing, which are primarily (≥95%) sourced through internet and mobile devices. Significant differences were found between skiers/snowboarders and snowmobilers, reflecting activity-specific outdoor clothing, weather parameters that affect how 'good' the conditions are for the particular activity, and flexibility in the choice of location for the outdoor activity. The odds of cancelling travel for these activities were also modelled as a function of forecast and ambient conditions of different types. The results underscore both the high degree of weather-sensitivity among this sub-population and shows how outdoor recreationists piece together weather information from multiple sources to meet their context-specific decision-making needs. This suggests that there would be both demand for and value in providing tailored and integrated weather products for the various winter recreationist communities.

**Keywords:** winter recreation, tourism, weather forecast
In November 2006, the World Meteorological Organization (WMO) launched the demonstration phase of the SWFDP (Severe Weather Forecasting Demonstration Project) with five developing countries in Southern Africa supported by a regional and three global meteorological centres. SWFDP was a new initiative to enhance the early warning capability of developing countries against severe weather hazards with a lead time of up to five days, using the latest available forecasting technology from the global weather centres that was previously not available to forecasters in these countries. A second main objective of SWFDP was to develop the relationships between the weather forecasters, and disaster managers and the media in their countries. The success of the SWFDP system of cascading of information prompted the subsequent roll out of activities to 16 countries in Southern Africa as a daily operational early warning service. It also led to the establishment of similar SWFDP sub-projects in four other regions in the world. Forecasters in developing countries on a daily basis now utilize products from ensemble prediction systems to issue warnings when needed to disaster management with a lead time of up to five days. The successful application of increased forecasting capabilities in developing countries and intra-regional collaboration will be discussed and demonstrated, using case studies of Tropical Cyclone Favio in 2007, and Tropical Cyclone Irina in 2012.

Keywords: Early warning, Developing countries
Parallel Session

UAS-PS332.02 – WITHDRAWN - The effect of climate change adaptation on rural community livelihoods

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Background: This study explores the opportunities for linking social protection, CCA and DRR in the context of rain fed crop production, establishing whether these three approaches would help enhance resilience. Methods: The study reviewed the conceptual and policy-related similarities and differences between the three disciplines. Case studies where climate change and resilient social protection approaches were collected and an adaptive social protection framework that highlighted opportunities was developed. Results: With climate change, the magnitude and frequency of stresses and shocks is changing and approaches such as social protection, disaster risk reduction (DRR) and climate change adaptation (CCA) will be needed to bolster local resilience and supplement people’s experience. Social protection and DRR measures designed to limit damages from shocks and stresses may not be sufficient in the longer term. For social protection to be resilient to climate change impacts, it will need to consider how reducing dependence on climate sensitive livelihood activities can be part of adaptive strategies. Conclusion: Climate Change Adaptation and Disaster Risk Reduction cannot effectively address the root causes of poverty and vulnerability without taking a differentiated view of poverty, integration with social protection can solve the problem.

Keywords: Effect, Climate Change Adaptation, Rural Community, Livelihoods
How can urban communities become more resilient in the face of increasingly extreme weather events and climate change? Multiple and overlapping legal and policy jurisdictions intersect in Canadian urban communities, complicating those communities’ preemptive reduction and responsive management of weather and climate-related disasters. To address this inherently political problem, this paper begins by developing a framework for the critical assessment of urban community-based climate governance and policy that accounts for both the bio-geophysical and socio-legal dimensions of community-based ecological infrastructure and policy. The paper then proceeds to apply this critical framework to a series of urban community case studies in Canada – drawn primarily from the provinces of British Columbia and Ontario, and focusing in particular on the weather and climate change planning process presently underway in the urban community of Thunder Bay, Ontario – to illustrate how community participation in DRM may be improved in a context of complex interactions among multiple levels of actors and interests. In particular, this paper contends that the coordination problems besetting urban community and environment planners cannot be analyzed within the exclusively scientific and/or technocratic framework that characterizes much research into the assessment of weather and climate change impacts and adaptation, which tends to ignore the jurisdictional problems posed by competing policy objectives and political interests. Rather, improving urban community-based DRM depends, not only on collaboration across the biophysical and social sciences, but also on the development of a framework that foregrounds and seeks to overcome the political constraints operating on urban communities.


Keywords: integrated community participation, ecological infrastructure and policy, climate change and extreme weather events, risk management
Parallel Session

UAS-PS332.03 – NEW - Weather Knowledge and Disaster Management in Canada

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Content Not Provided for Book of Abstracts
Parallel Session

UAS-PS332.04 - Integrated research on disaster risk

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Why is it that, despite the marked growth over recent decades in our knowledge and understanding of natural hazards, losses associated with environmental disasters have also risen during the same period at a seemingly exponential rate? The Integrated Research on Disaster Risk (IRDR) program is a decade long program, co-sponsored by the International Council for Science (ICSU), the International Social Science Council (ISSC), and the United Nations International Strategy for Disaster Reduction (UNISDR) that looks to answer this question. The complexity of the task requires nothing less than the full integration of research expertise from natural, socio-economic, health and engineering sciences, coupled with socio-economic analysis, understanding the role of communications, and public and political response to reduce risk. Although approaches in the sciences vary, IRDR is not only multi-disciplinary but will also approach issues of natural and human-induced hazards and disasters from several perspectives – from hazards to disasters and also from human exposures and vulnerabilities back to hazards. This coordinated approach takes IRDR beyond approaches that have traditionally been undertaken. The IRDR programme has three research objectives:  • characterization of hazards, vulnerability and risk  • understanding decision-making in complex and changing risk contexts  • reducing risk and curbing losses through knowledge-based actions.


Keywords: Disaster Risk, Integrated research
WW-JPL06.01 - Research Needs for Better Health Resilience to Weather Hazards

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Investing in operational research on health resilience is essential for the management of risks linked to weather hazards. Not only will it provide a better understanding of exposure/ vulnerability determinants but it will also refine alert thresholds and help identifying most efficient and early response interventions. Current trends on research show a focus on space and time scales: small (local) to understand the complexity of epidemiological factors or broad (regional or national) to lead towards operational guidelines. Scales on time predictions with different degrees of certainty involves different operational actors from emergency units up to long term planners. The scope of information required for decision making purpose can change a lot. The author illustrates these space and time scale issues from some experiences on research networks focusing on weather sensitive epidemics: the Global Leptospirosis Environment Action Network (GLEAN) and the Meningitis Environment Research Information Technologies (MERIT). In this context of rapid and evolving weather information and communication technologies, the author raises key interconnected questions for further discussions with Conference participants: who should be involved in the design and development of research project, how to develop sustained cooperation between meteorological office, research institutions and public Health related services and how to overcome difficulties to work with various disciplines and different actors/ authorities.

Keywords: Research, Health Resilience, Weather Hazards
High Performance Computing (HPC) is the foundation of much of the NCAR’s scientific work. Currently the climate and climate communities are exploiting trans-petascale resources in HPC, for the most part using homogeneous multicore platforms. Driven by the ever pressing need for more computational power and looming prohibitive utility costs, these communities will need to identify ways to effectively use heterogeneous platforms that contain both conventional multicore and disruptive many core co-processors. Additionally, “Big Data”, – large, diverse, distributed and heterogeneous data sets are becoming impractical to deal with because they are too large or too complex, and this growing problem for the Earth science communities is now limiting the rate of production of science. NCAR has embarked on a reexamination of the traditional workflows as one of the ways to move forward with major upgrades in our portfolio of data capabilities. This presentation will offer insight into the technical efforts for transforming atmospheric sciences at NCAR for use of enhanced computing and information systems.

**Keywords:** Climate & Weather Simulations, NCAR, HPC, BIG Data
Parallel Session

SCI-PS237.01 - Boundary layers and clouds in interaction with the surface in polar regions

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Sub-grid scale processes, such as boundary layer turbulence and clouds, important for weather and climate in the polar regions are less well captured in models than they usually are at mid-latitudes. This has an effect on the predictability on all time scales in polar regions which are characterized by a very large annual, but small diurnal, cycle. Special conditions for these regions include stably stratified long-lived boundary layers, optically thin clouds and surfaces covered with snow and ice. These types of surfaces react readily to small changes in energy fluxes caused by any changes in stability and consequent turbulence levels and/or cloudiness through their impact on radiation. Any surface temperature change in turn is coupled back to the turbulence intensity and cloudiness. For large regions and long periods, there are no diurnal cycles that "resets" the system so biases may act for long times. Another consequence of the highly coupled system in persistent conditions is that a model bias in one process easily may be either compensated or enhanced by another model bias. Analysis of global model results of various near-surface parameters, vertical structure, stability, cloudiness and airmass transformations will be presented. The analyzed parameters are closely related to the performance of the parameterizations of sub-grid scale processes of boundary layers turbulence, clouds and radiation, and their interactions. Consequences of this coupling for model development and observational needs will also be discussed.

Keywords: boundary layer, polar, clouds, surface interaction
Parallel Session

SCI-PS237.02 - GABLS4: An intercomparison case to study the Stable Boundary Layer on the Antarctic Plateau

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Within GABLS (GEWEX Atmospheric Boundary Layer Study), inter-comparison studies are carried on for boundary layer parameterizations schemes in use by numerical weather prediction and climate models. Under stable stratifications, models still have large biases, which depend on the parameterizations used for boundary layer and for surface (Holtslag et al, 2013, BAMS). The first three GABLS inter-comparison studies dealt only with moderate stable conditions. In the next GABLS4 case, we aim to study the interaction of a boundary layer with strong stability with a snow surface (having a low conductivity and a high cooling potential). Such a case is explored using observations at the Antarctic Plateau at Dome-C. One difficulty was to find a “ideal or golden” day with all measurements available and validated during at least 24h with a clear sky, low wind, a high Richardson number and with a large diurnal cycle. On D day, a specific 4Dvar re-analysis has been made with the stretched global model ARPEGE (10km on the Antarctic Plateau). Moreover, an improved boundary layer analysis using all the vertical levels (every 2m) from the radio-sounding was implemented to provide better initial and lateral boundary conditions to the non-hydrostatic model (2.5km) used to compute the forcing term (advection, geostrophic wind) for 1D models. Finally, the set-up of the GABLS4 inter-comparison for the 1D model will be explained and the first preliminary results will be presented.

Keywords: GABLS, Stable Boundary Layer, Antarctic, intercomarison
Evaporation from the Arctic Ocean has implications for the cloud and water vapor feedbacks, Arctic amplification, and ablation of sea ice. Accurately estimating the evaporation continues to be problematic due to the quality of the input data and model parameterizations. To improve evaporation estimates, this paper compares the Atmospheric Infrared Sounder, Version 6 (AIRS V6) and the ECMWF’s ERA-Interim reanalysis input data as well as our recent moisture flux scheme (BMF13) and the ERA-Interim scheme. Improvements were made between AIRS V5 and V6 data products, reducing the error in the moisture flux by 2%. Skin temperature and 2-m specific humidity (q2m) from AIRS V6 and ERA-Interim were compared with a variety of in situ data. Skin temperatures from ERA-Interim showed a warm bias over sea ice and a cold bias over open seas. ERA-Interim skin temperature had twice as large an error compared to AIRS, but had smaller errors in q2m. Due to these differences, surface latent heat fluxes in the open water in the Beaufort - East Siberian Seas region in September 2007 were up to 55 W m⁻² less than those produced with AIRS V6 and the BMF13 scheme. Since such large errors exist in ERA-Interim's skin temperature product in the Arctic, it is suggested that using AIRS V6 input data would produce more realistic results. To produce more accurate moisture flux estimates in the Arctic, reanalyses like ERA-Interim should also update their parameterizations to such ones that are based on observations from the Arctic.


Keywords: Moisture Flux, AIRS, ERA-Interim, Sea Ice
Taylor (QJRMS, 1971, vol.97, pp.326-329) noted limitations on the standard assumptions about the log + linear form of the velocity and temperature profiles in stably stratified constant flux layers. This was in a situation where the surface heat flux and a wind speed measurement were specified, plus an assumed roughness length, z0. The resulting equation for the Obukhov length, L, is a cubic which will sometimes have two real positive roots but may not. At York University we run a weather station on which we measure wind at 10m and the temperature difference, ΔT, between 1m and 9m. Atmospheric chemistry studies use the weather station data to assess atmospheric stability which plays an important role in determining the temporal evolution of HONO concentration. Assuming a known z0 plus measured U and ΔT, in stable stratification we have a quadratic equation for L which again may or may not have real roots. When estimating the potential Annual Energy Production for a proposed wind farm one relies heavily on one or more years of wind measurements at the site. These are often from 60-m or 80-m masts while wind turbines have hub heights of 100m or more. Extrapolation to100m is usually done with logarithmic or power-law profiles. Occasionally ΔT measurements are available in addition to wind speeds, typically at three levels. We are exploring ways in which extrapolation uncertainty can be reduced if stability can be characterized quantitatively. Methodologies are being tested using data from the Cabouw tower.

**Keywords:** Obukhov Length, Stable Atmospheric Boundary Layer
NOAA’s high resolution operational HWRF model implemented for the 2013 hurricane season has demonstrated significant improvements in hurricane intensity forecast guidance for forecasters at NHC and JTWC. This leap-step advancement is achieved through implementation of several major upgrades including assimilation of real-time Tail Doppler Radar data when available. Track forecast skills from HWRF were found comparable with highly skillful GFS model. This talk will focus on describing the progress accomplished at NCEP/EMC in advancing the high-resolution hurricane modeling capabilities through an unprecedented retrospective testing and evaluation of model upgrades using HFIP’s dedicated computing facilities in Boulder. This presentation will also provide highlights on the performance of the operational HWRF model for other oceanic basins including North Western Pacific and North Indian Ocean regions. 2013 typhoon season was dominated by strong storms with several rapid intensification events, and the HWRF model showed impressive performance with more than 23% POD and very little FAR. Starting in January 2014, HWRF team at EMC started providing real-time forecasts for the Southern Hemispheric oceanic basins as well, making the HWRF model unique global tropical cyclone model for operational needs. Ongoing model development plans for 2014 HWRF implementation include increased vertical resolution, assimilation of more inner core observations, advanced physics options for land surface, radiation and microphysics and coupling to high-resolution ocean model. Future developments will have a state-of-the-art air-sea-wave-land-surge-inundation coupled modeling system with high-resolution ensembles for addressing the genesis, rapid intensity changes and long-range (7-day) track forecasts using the global to local scale modeling approach.

**Keywords:** Tropical Cyclone Forecasts, Operational Prediction, High resolution numerical modeling, Hurricane Forecasting
Parallel Session

SCI-PS238.02 - The global to local scale hurricane weather research and forecasting (HWRF) system

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More than 80-90% of the deaths due to Tropical Cyclones (TCs) are caused by fresh water flooding and storm surge. Although the operational Hurricane Weather Research and Forecasting (HWRF) system is starting to show some exceptional skills in intensity forecasting, TCs such as Irene (2011), Isaac (2012) and Sandy (2012) have all illustrated the importance of providing accurate track, intensity and structure predictions at land fall. The current operational HWRF system is storm centric and single nested, not ideal for representing multi-scale interactions or for post landfall applications, and is greatly limited in extending forecast lead times beyond 5 days. Supported by NOAA’s Hurricane Forecast Improvement Project, the Hurricane Research Division of the Atlantic Oceanographic and Meteorological Laboratory with its partners at National Centers for Environmental Prediction have created the next generation of the HWRF system that can operate with multiple moving nests spanning at resolution down to 3 km within a regional domain that covers Atlantic and East Pacific Basins. The basin-scale HWRF was run for the 2013 hurricane season and also in a retrospective mode for the 2011-2012 seasons. Some significant improvements in prediction skills for cases including Hurricane Sandy will be reported. The primary goal of NOAA’s next generation, High Impact Weather Prediction Project’s (HiWPP) is to accelerate the development of operational global non-hydrostatic weather prediction systems capable of running at ~3-km resolution by late in this decade. Transition of the basin scale HWRF to a global modeling framework is underway and will also be discussed.

Keywords: Tropical Cyclone Predictions, Next Generation HWRF System, Global non-hydrostatic weather prediction systems, Hurricane Sandy
SCI-PS238.03 - Advancing microphysics parameterizations in the Hurricane Weather Research and Forecasting (HWRF) System

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One of the main goals of the Developmental Testbed Center (DTC) is the advancement of modeling for hurricanes, with its primary focus on the HWRF model -- a coupled atmosphere-ocean system with hybrid-ensemble-variational data assimilation, vortex initialization, and postprocessing components. Its 27/9/3km horizontal grid spacing allows it to take advantage of advanced physics schemes. The current operational configuration of the HWRF employs the Ferrier microphysics scheme, a single-moment parameterization, and the GFDL radiation scheme as a part of its physics suite. With the latest HWRF release came the capability to choose the Thompson microphysics scheme, a partial double moment scheme. The newest HWRF release also contains a coupled version of the Rapid Radiative Transfer Model (RRTMG) parameterization that takes advantage of the effective radius of atmospheric particles calculated by the Thompson microphysics scheme to compute cloud optical depth. Case studies of Hurricane Sandy and TS Debby in the Atlantic using HWRF with the Thompson/RRTMG schemes indicated that a better representation of the physics at the HWRF grid scales led to improved track and intensity forecasts. The DTC and the Environmental Modeling Center have conducted extensive HWRF tests with Thompson/RRTMG physics options, which indicate that the experimental physics suite has reduced track and intensity error for the Atlantic storms, but surprisingly the results are not as promising in the Eastern North Pacific basin. A detailed analysis of the Thompson/RRTMG test and its effect on hurricane forecasts in each of the basins will be the focus of this presentation.

Keywords: Microphysics, Hurricanes, Forecasting, Thompson
In late October 2012, Storm Sandy made landfall near Brigantine, New Jersey, devastating surrounding areas and causing tremendous economic loss and hundreds of fatalities (Blake et al., 2013). Central questions to be addressed include (1) to what extent the lead time of severe storm prediction such as Sandy can be extended; and (2) whether a high-resolution global model can help effectively illustrate the complicated physical processes that may contribute to the improvement of high-impact storm predictions. In this study, we investigate the predictability of Sandy with a global mesoscale model and focus on short-term (or extended-range) genesis prediction as the first step toward the goal of understanding the relationship between extreme events, such as Sandy, and the current climate. We first present 10 track and intensity forecasts of Sandy initialized at 00Z and 12Z October 22-26, 2012, realistically producing its movement with a northwestward turn prior to its landfall. We then show that three experiments initialized at 00Z October 16-18 captured the genesis of Sandy with a lead time of up to six days and simulated reasonable track and intensity in the next two-day period of 18Z October 21-23. Results suggest that the extended lead time of formation prediction is achieved by realistic simulations of multi-scale processes, including (1) the interaction between an easterly wave and a low-level westerly wind belt (WWB); (2) the appearance of the upper-level trough at 200-hPa to Sandy’s northwest. The low-level WWB and upper-level trough are likely associated with a Madden-Julian Oscillation.


Keywords: Genesis Prediction, Hurricane Sandy, Global mesoscale model, Multiscale interactions
Parallel Session

SCI-PS239.01 - Sensitivity analysis of aerosol feedbacks on chemistry and weather at urban and regional scales

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Ambient aerosols are important air pollutants with direct impacts on human health and on the Earth’s weather and climate systems through their interactions with radiation and clouds. Their role is dependent on their size, number, phase and composition distributions, which vary significantly in space and time. There remain large uncertainties in simulated aerosol distributions due to uncertainties in emission estimates and in chemical and physical processes associated with their formation and removal. These uncertainties in aerosol distributions lead to large uncertainties in weather and air quality modeling and in estimates of health and climate change impacts. Despite these uncertainties and challenges regional-scale coupled chemistry-meteorological models such as WRF-Chem have significant capabilities in predicting aerosol distributions and explaining aerosol-weather interactions. In this paper a fully-coupled meteorology-chemistry-aerosol model (WRF-Chem) is used to assess the impacts of black carbon and other aerosols on radiative forcing, weather and atmospheric chemistry. A series of simulations from different aerosol-cloud environments ranging from heavily polluted cities in East (Beijing) and South (Delhi) Asia to relatively clean coastal areas with permanent cloud cover (VOCALS experiment off the west coast of Chile/Peru) are simulated. General findings emerging from these studies regarding the impact of aerosols on air quality and weather prediction are presented.

Keywords: air pollution modeling, aerosol weather interaction, urban analysis, feedbacks at urban scales
Parallel Session

SCI-PS239.02 - Ensemble based probabilistic forecasting of meteorology and air quality in Oslo, Norway

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An ensemble based probabilistic forecasting system for Oslo, Norway is presented, providing probabilistic forecasts of hourly average meteorology and air quality (NOx, NO2 and PM10) in grid and receptor points (currently re-forecasts over a half year period in 2010-2011). To achieve this, a model chain is set up using output from the ECMWF synoptic scale weather forecasting ensemble (up to 50 members) as input to a meteorological downscaling model (TAPM), which in turn provides meteorological fields as input to an urban and local scale air quality model (EPISODE). Additional input to this model system includes urban and local emissions and background concentrations (boundary conditions) of NO, NO2, O3 and PM10 provided by the MACC (Monitoring Atmospheric Composition and Climate) ensemble of regional scale air quality models. Recently improved calibration results with the system is presented, and are encouraging in that the ensemble predictions of meteorology and air quality compares well with available observations in the city. A probabilistic model evaluation of the system is shown using rank histograms, sharpness plots and combined numerical measures such as the Continuous Ranked Probability Score (CRPS).


Keywords: air quality, ensemble, probabilistic, forecasting
UN Intergovernmental Panel on Climate Change (IPCC) states that “global warming of the climate system is unequivocal and the increase in the global temperature will have devastating effects such as diseases, species extinction, and extreme weather. The effects of climate change are already being felt in many Korean communities year by year. Hence, the paradigm of urban planning and management are challenging and the needs for efficient weather information system for instant weather forecasting to protect life of the public people. The aim of Weather Information Service Engine (WISE) project is developing an integrated weather service and management system for long term planning and instant response to extreme weather. The climate Analysis Seoul (CAS)* is the climate analysis and management system to produce many kinds of high resolution maps such as thermal energy, wind, pollutant distribution in complex urban settings. WISE will improve CAS to diagnose and manage the climate climatically vulnerable areas such as heat wave using the analysis of heat, wind, and air quality. CAS will integrated with other neighbored technologies to support policy administration’s decision making or city level systemic urban resource planning, design, and management. CAS supported adaptation measures will change the paradigm of urban planning and management and WISE have a plan to implement CAS system across cities and countries in Korea. It will be shared by the stakeholders around the WISE platform and realize the added value of the urban climate information.

References: *CAS : Climate Analysis Seoul, This system is developed by National Institute Meteorological Research of Korea and Technical University of Berlin.

Keywords: Urban climate analysis, Urban climate map
Parallel Session

SCI-PS239.04 - Experiments with a scale- and aerosol-aware convective parameterization on regional and global scales

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A convective parameterization suitable for use in high-resolution non-hydrostatic mesoscale models as well as in modeling systems with unstructured varying grid resolutions and for convection-aware simulations is applied and evaluated. This scheme is based on a stochastic approach originally implemented by Grell and Devenyi (2002) and described in more detail in Grell and Freitas (2014, ACPD). Interactions with aerosols have been implemented through a CCN-dependent autoconversion of cloud water to rain as well as an aerosol-dependent evaporation of cloud drops. Initial tests with this newly implemented aerosol approach showed plausible results with a decrease in predicted precipitation in some areas, caused by the changed autoconversion mechanism. Other areas experience an increase of precipitation, most likely due to strengthened downdrafts. Here we test the dependence of the results on various tunable parameters. The parameterization is further generalized to be able to handle CCN distributions provided by WRF-Chem forecasts as well as CCN distributions provided from AOD initial fields. Evaluation is performed with regional non-hydrostatic models as well as with a hydrostatic icosahedral global model.

Keywords: numerical modeling, integrated environmental modeling, Aerosol interactions
The European Centre for Medium Range Weather Forecasts (ECMWF) is currently developing a coupled data assimilation system for reanalysis purposes. This system has been called CERA (Coupled ECMWF ReAnalysis) and uses the ECMWF coupled model where the atmospheric component is the ECMWF Integrated Forecast System and the oceanic component is the NEMO model. The ultimate purpose is to generate a self-consistent atmosphere-ocean state by assimilating both atmospheric and oceanic observations within the coupled model. The CERA system is based on a variational approach where the coupled model is used to compute the misfits with ocean and atmospheric observations in the outer loop. The ocean and the atmosphere share a common 24-hour assimilation window but still run separate inner loops yielding to the computation of two increments. This framework is aimed at being flexible enough to adapt to the coupled initialisation of medium range, monthly and seasonal forecasting activities. This presentation will describe the CERA system and its validation. Focus will be put on the impact of the coupled initialisation on the medium range predictability.

Keywords: Coupled assimilation, Reanalysis, Atmosphere-ocean state, Coupled initialisation
Parallel Session

SCI-PS240.02 - Towards coupled atmosphere-ocean assimilation via skin SST analysis in NASA GEOS DAS

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The skin sea surface temperature (SST) is an important variable because it is used for the computation of upper-air temperature and air-sea fluxes. Bulk retrieved SST does not provide an accurate representation of the skin SST, as it does not resolve near sea-surface stratification in temperature brought about by diurnal warming, wind stress and surface currents. As a first step towards the development of an ocean-atmosphere coupled data assimilation system (DAS), the NASA-GMAO atmospheric DAS has been extended to model and analyze skin SST using a simple air-sea interface layer. This layer modifies the bulk SST to include near-surface effects, such as diurnal warming due to solar insolation and cool-skin, that were previously not felt by the atmosphere. Impact of surface waves is parametrized in this initial version of interface layer. By directly assimilating infrared and microwave satellite radiance observations that include SST sensitive channels and in-situ data from ships and buoys, using the Gridpoint Statistical Interpolation (co-developed with NCEP) we are able to estimate a realistic diurnally varying skin SST. Using this infrastructure, we quantify the impact of satellite radiances and in-situ observations on the estimation of the skin SST through statistics of Observation-Minus-Background and Analysis. This presentation will focus on evaluation metrics that include: forecast skill scores, air-sea flux validation with respect to observations, coupling between SST and surface wind speed in regions of strong ocean currents, and two-way interaction with aerosol analysis.


Keywords: Coupled Assimilation, Sea Surface Temperature, Satellite Radiance, Air-Sea Fluxes
Parallel Session

SCI-PS240.03 - Exploring coupled atmosphere-ocean data assimilation strategies with an EnKF, low-order model and CMIP5 data

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Strategies in fully coupled data assimilation (DA) are considered in an idealized low-dimensional analogue of the coupled atmosphere-ocean North Atlantic climate system, featuring the Atlantic meridional overturning circulation (AMOC). The ability to initialize the multi-frequency AMOC with an ensemble Kalman filter (EnKF) is assessed over a range of experiments with varying levels of observations available for assimilation (atmosphere, upper and deep ocean). A multiscale DA scheme assimilating the raw, high-frequency and/or time-averaged observations is proposed, along with a simplification involving climatological covariances estimated from a single long model simulation rather than the traditional approach requiring cycling of an ensemble of model trajectories. This simplification is tested using a low-order coupled model, while the multiscale approach is characterized using CMIP5 data from a comprehensive coupled atmosphere-ocean global climate model. Results suggest that the simplified DA approach is a viable more economical alternative, while a clear benefit of multiscale assimilation is found for initializing the fast and slow components of the AMOC.

Keywords: Data assimilation, atmosphere-ocean, initialization, AMOC
Parallel Session

SCI-PS240.04 - A coupled ensemble data assimilation system for seasonal prediction

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A coupled ensemble-based ocean assimilation system called the POAMA Ensemble Coupled Data Assimilation System (PECDAS) has been developed. PECDAS is an approximate form of ensemble Kalman filter system, its approximations being necessary to reduce its computational cost. It is based on the multivariate ensemble optimum interpolation of Oke et al (2005), but uses covariances from a time evolving model ensemble. The first version of the system is weakly coupled, only ocean observations are assimilated into the coupled model and the atmospheric component is nudged towards pre-existing atmospheric analyses. A re-analysis from 1980 to present has been completed with this system. Both in situ temperature and salinity observations are assimilated, and current corrections are generated based on the ensemble covariances. The comparisons of the PECDAS reanalysis to a non-coupled re-analysis and other state-of-the-art international reanalyses are presented, with a particular focus on the representations of the main modes of climate variability. The impact of the coupled assimilation on seasonal forecasts will also be presented, including the impact of the ensemble characteristics of the initial conditions on forecast spread.

Keywords: Coupled, assimilation, seasonal prediction
Parallel Session

SCI-PS241.01 - A coupled Arctic Ocean/sea ice reanalysis

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Ocean state estimation has been used over many years to provide a dynamically consistent description of the time-varying ocean circulation. Efforts are now underway to expand those efforts to cover the coupled ocean/sea ice system of the Arctic. The talk will summarize the data sets available, and will discuss the sensitivities of sea ice to various forcing parameters as they emerge from an adjoint modeling effort. The talk will subsequently address first coupled ocean/sea ice assimilation efforts, describe first results and will also summarize problems encountered.

\textbf{Keyword:} Data Assimilation
Parallel Session

SCI-PS241.02 - Sensitivity of Arctic sea-ice to surface atmospheric forcings in a coupled ocean-sea ice state estimate

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Arctic sea ice cover is highly sensitive to surface atmospheric boundary conditions at the air-ice interface and air-sea fluxes in adjacent ice-free regions. An assessment of radiative fluxes, surface air temperatures and wind fields from several atmospheric reanalysis products reveal large, and in some cases systematic differences between the products considered. A coupled ocean sea-ice model, which serves as basis for dynamical interpolation of diverse observations, is forced with atmospheric boundary conditions from the ERA-Interim and JRA-25 products, and with different values of sea ice albedo within acceptable observed range. We demonstrate how systematic differences in radiative forcings and air temperature lead to large discrepancies in simulated sea ice compared to observed satellite ice cover and thickness over the period 1992--2011. As part of the Estimating the Circulation and Climate of the Ocean (ECCO) framework, results from global and regional adjoint-based state estimates show that small systematic adjustments to these atmospheric variables can bring the sea ice state into consistency with observations. These corrections are well within the range of uncertainty of the variables considered. They highlight (a) strong feedbacks between ice cover and atmospheric boundary conditions, (b) the need for more accurate polar atmospheric measurements and associated uncertainty estimates, and (c) the need for their assimilation into numerical models for hindcasts and forecasts.


Keywords: sea-ice, forcings, sensitivity, Arctic
Parallel Session

SCI-PS241.03 - Recent advances in the Mercator-Ocean reanalysis system: Application to an Arctic configuration

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In the framework of the European project MyOcean, Mercator Ocean, the French operational oceanography center, is in charge of the development and of the production of real time analysis and forecasts and reanalysis for the global ocean at the resolution of 1/12°. The operational systems are all based on the ocean and sea ice model NEMO and the multivariate data assimilation system SAM2 (Système d'Assimilation Mercator V2). The assimilation method is a reduced order Kalman filter based on SEEK formulation with bias correction scheme for temperature and salinity and an Incremental Analysis Update. The strong need of a realistic description of the mean state and variability of the rapid changing Arctic Ocean and its adjacent seas over the last decades motivated the use of the Canadian Arctic Ocean and Nordic seas configuration (CREG). This dedicated configuration at 1/12° developed by the Canadian research teams has been coupled to the multivariate data assimilation system SAM2. The objectives of this Arctic platform is both to improve the sea ice assimilation method used in the Mercator Ocean and Canadian analysis and forecasting systems and to produce reanalysis over recent periods at lower numerical cost in order to prepare global higher resolution reanalysis. After a description of this Arctic reanalysis system, we present first results on the abilities of this configuration to reproduce sea ice extent and volume interannual variability without assimilation over the last decades and, secondly, the impact of assimilating sea ice data on the sea ice cover with short hindcasts experiments.

Keywords: data assimilation, sea ice concentration, reanalysis
Parallel Session

SCI-PS241.04 - The global ocean forecasting initiative GODAE OceanView

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The GODAE Ocean View (GOV) Science Team gathers both academic and operational groups focusing on daily-to-weekly ocean forecasting capabilities, and the ways to build and improve it. The enhancement of the observing, modelling, and end-to-end service capacity are key issues, together with sustainability concerns, with strong similarities with the WWRP work plan and targets. The GOV Science Team is driven by task teams for intercomparison and validation of operational systems, observing system evaluation, coastal ocean and shelf seas, coupled (ocean-atmosphere-wave-sea ice) initialisation and prediction, and marine ecosystem prediction. The goals and structure of the GODAE OceanView Program (www.godae-oceanview.org) will be presented along with a general view of their operational ocean forecasting systems. Today's operational GODAE OceanView systems include global and regional domains resolved with very high spatial resolution. Examples of the development of ocean data assimilation methods as well as applications will be shown, including sensitivity studies of the ocean analysis to investigate the relative importance of in situ data and remote sensing data.

Keywords: ocean observing system, data assimilation, ocean forecasting, applications of ocean forecasting
Parallel Session

SCI-PS242.01 - High-latitude influences on mid-latitude weather

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The amplification of climate change in the Arctic has led to an increased interest in the polar regions along with their possible influence on the weather and climate of the mid-latitudes. Here, results from a set of forecasts experiments with the ECMWF model with and without relaxation of the polar regions towards analysis data is described. These experiments are used to provide insight into high-latitude influences on mid-latitude weather and its predictability. It is shown that the strongest links occur over Eurasia and North America; relatively weak links are found for the North Atlantic and the North Pacific. Furthermore, it is shown that high-latitude influences on mid-latitude weather are strongly flow-dependent and undergo substantial seasonal changes.

Keywords: teleconnections, predictability
Cold air outbreaks (CAO) are severe weather events in polar latitudes, which greatly affect turbulent heat fluxes from the ocean, but also have strong dynamical impacts, as they provide a favorable environment for the genesis of polar lows. We present a novel, Lagrangian climatology of CAOs in the South Pacific. The Lagrangian approach allows to trace the evolution of thermodynamic and dynamic quantities along trajectories associated with the formation of a CAO. The origin of the air constituting these CAOs is investigated and it is shown that in the Ross Sea sector about 50% of the air has descended from the Antarctic continent, mostly via the Ross ice shelf corridor. Furthermore, about 80% of the CAOs are caused by the northward advection of cold air on the rearward side of extratropical cyclones. Sensible and latent heat fluxes from the ocean into the atmosphere are tremendously enhanced within CAOs, and in winter their interannual variability is mainly determined by the frequency of CAOs. Also between 60% to 90% of the events of extreme (below 5th percentile) turbulent heat fluxes occur in CAOs. Evaporation associated with cyclone induced CAOs largely compensates for a large portion of the additional input of freshwater due to cyclone precipitation in the Amundsen Sea. This has implications for the understanding of the variability of oceanic freshwater fluxes over the high latitude Southern Ocean, which are crucial for the formation of water masses.

**Keywords:** Lagrangian climatology, extratropical cyclones, turbulent heat flux
Parallel Session

SCI-PS242.03 - Dynamics and predictability of atmospheric response to reduced Arctic sea ice through ensemble sensitivity analysis

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Substantial changes have been observed in the Arctic climate system over the last few decades, including a rapid decline of sea ice extent over the Arctic Ocean. Sea ice plays an important role in the climate system by altering the surface roughness, albedo, and fluxes of heat and moisture between the ocean and atmosphere. Previous studies have found that reduced Arctic sea ice extent can influence the atmosphere both within and beyond the Arctic. As the sea ice is projected to continue to shrink, there is a growing research interest in bettering our understanding of the complex sea ice—atmosphere interactions. This study examines the impact of Arctic sea ice on the atmosphere on intra-annual to interannual time scales with a focus on weather patterns in mid-latitudes on the Northern Hemisphere.

Using a global atmospheric model, a large ensemble of simulations with different sea ice extents is carried out to investigate the atmospheric response to varying sea ice anomalies in the Arctic. We quantify uncertainties in the mean response from the ensemble spread and identify regions and atmospheric variables that are particularly sensitive to a reduced Arctic sea ice extent. The results show a large variability among ensemble members and between different years after the initial perturbation has been introduced, suggesting that the atmospheric response to Arctic sea ice anomalies largely depends on the underlying atmospheric circulation. An ensemble sensitivity analysis is performed to investigate the dynamics that link the Arctic sea ice to weather in mid-latitudes.

Keywords: Arctic, sea ice, weather patterns, ensemble sensitivity
Parallel Session

SCI-PS242.04 - WRF simulation of changes to characteristics of tropopause polar vortices due to sea ice loss

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Substantial reductions of Arctic sea ice during the summer are leaving increasingly large areas of open water during the autumn and early winter. Greater amounts of heat and moisture have the potential to alter the unique conditions that enable Tropopause Polar Vortices (TPVs) to be maintained over the Arctic by reducing their radiative intensification mechanism. Since TPVs are important dynamical predecessors to surface cyclones, changes in their characteristics due to changing sea ice may be a key to understanding changes to surface low locations and intensity in the future. We present two high-resolution numerically simulated climatologies to examine the impact of reducing sea ice on TPV characteristics and the resulting effects on surface lows. Results show a substantial change in TPV tracks during this time period change, however their most frequent location over northern Canada remains largely unchanged. This result is consistent with the characteristic of TPVs where limited latent heating rates are essential for their maintenance. Changes in surface cyclone tracks are seen as a local response from different locations in which TPVs flow over low-level baroclinic zones rather than the advection of surface cyclones into the Arctic. In particular, baroclinic zones along the Arctic coastline due to the lack of sea ice promotes an increase in frequency of surface cyclones and a decrease in lifetimes of TPVs. The increase in surface cyclones over the Arctic furthermore results in an increase in precipitation throughout much of the Arctic.

Keywords: TPV, Sea Ice
Many of the atmospheric phenomena with the greatest potential impact in future warmer climates are inherently multiscale. Such meteorological systems include hurricanes and tropical cyclones, atmospheric rivers, and other types of hydrometeorological extremes. These phenomena are challenging to simulate in conventional climate models due to the relatively coarse uniform model resolutions relative to the native nonhydrostatic scales of the phenomenological dynamics. To enable studies of these systems with sufficient local resolution for the multiscale dynamics yet with sufficient speed for climate-change studies, we have adapted existing adaptive mesh dynamics for the Community Atmosphere Model (CAM). In this talk, we present an adaptive, conservative finite volume approach for moist non-hydrostatic atmospheric dynamics. The approach is based on the compressible Euler equations on 3D thin spherical shells, where the radial direction is treated implicitly (using a fourth-order Runge-Kutta IMEX scheme) to eliminate time step constraints from vertical acoustic waves. Refinement is performed only in the horizontal directions. The spatial discretization is the equiangular cubed-sphere mapping, with a fourth-order accurate discretization to compute flux averages on faces. By using both space-and time-adaptive mesh refinement, the solver allocates computational effort only where greater accuracy is needed. The resulting method is demonstrated to be fourth-order accurate for model problems, and robust at solution discontinuities and stable for large aspect ratios. We present comparisons using a simplified physics package for dycore comparisons of moist physics.

**Keywords:** adaptive mesh, dynamical core, multiscale methods
Parallel Session

SCI-PS243.02 - Does high order and dynamic adaptive mesh refinement improve the efficiency of atmospheric simulations?

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Even with today's supercomputers it is still impossible to explicitly represent all scales involved in weather prediction. A large number of different numerical methods have been developed for improving the efficiency of atmospheric simulations. Among those methods are Spectral Element and Discontinuous Galerkin methods which allow arbitrary high order for the spatial discretization and have shown very good scalability on large supercomputers. Another promising method for reducing the computational effort of simulations is given by dynamic adaptive mesh refinement (AMR) which allows the adaptation of the spatial resolution to local properties of the atmosphere. So far not much work has been done for quantifying the benefit of these methods in terms of efficiency. The authors are developing the dynamical core NUMA which is used for the next generation weather prediction model NEPTUNE of the US Navy. NUMA incorporates many recent developments like the above mentioned Spectral Element and Discontinuous Galerkin methods as well as in its 2D version dynamic adaptive mesh refinement. In this talk a comparison between the different methods implemented in NUMA is presented. This comparison is done for a rising thermal bubble test case. The spatial discretization order ranges from 3 up to 11. The results demonstrate that with increasing resolution high order simulations as well as AMR simulations show a significantly improved efficiency. Furthermore the authors implemented a simple Kessler parameterization in NUMA and used the model for a squall line simulation. Spectral Elements as well as Discontinuous Galerkin methods performed very well in this simulation.

Keywords: numerical methods, adaptive mesh refinement, efficiency, Discontinuous Galerkin
SCI-POW1115 - Modeling of Sea Ice: Non-linearity, numerics and convergence at high resolution

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Current numerical sea ice models struggle when dealing with high resolution simulations. It is hypothesized that the strong velocity gradients present in fracture zones slow down the convergence of numerical solvers by accentuating the non-linearity in the sea ice momentum equation. This results in increased computational time, often preventing models from reaching properly refined solutions. Errors in the sea ice velocity field impact both ice cover and thickness and can in turn propagate to significantly affect weather forecasts. In order to address this issue, new numerical solvers are being considered for the sea ice momentum equation. The use of a Jacobian free version of Newton’s method has allowed models to solve the equation for a velocity field more rapidly, but its convergence also suffers at high resolutions. In this presentation, the analytical Jacobian of the sea ice momentum equation is introduced and the insights it provides into the convergence issue will be discussed. Preliminary results using the analytical Jacobian with Newton’s method for the modelization of sea ice will also be described.

Keywords: Sea Ice, High Resolution, Numerics, Jacobian
Parallel Session

SCI-PS243.04 - An accurate and efficient numerical framework for adaptive numerical weather prediction

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We have introduced an accurate and efficient discretization approach for the shallow water equations on the sphere (extending the technique proposed in Tumolo et al. JCP 2013), as well as for the non-hydrostatic Euler equations on a vertical slice, that can be effectively applied to all geophysical scale flows. We combine a semi-Lagrangian approach with a novel TR-BDF2 based semi-implicit time integrator and with a spatial discretization based on adaptive discontinuous finite elements on hierarchical bases. The resulting method is unconditionally stable and has full second order accuracy in time, thus improving standard off-centered trapezoidal rule discretizations without any major increase of the computational cost nor loss in stability, while allowing the use of time steps up to 50 times larger than those required by stability for explicit methods applied to corresponding DG discretizations. The method also has arbitrarily high order accuracy in space and can effectively adapt the number of degrees of freedom employed in each element in order to balance accuracy and computational cost. The p-adaptivity approach employed does not require remeshing and hence is especially suitable for NWP applications, where a large number of physical quantities has to be reconstructed on the mesh from the available data. Furthermore the p-adaptivity approach can cure the pole problem by reducing the polynomial degree in polar elements, yielding a reduction in the computational cost comparable to that achieved with reduced Gaussian grids. Numerical simulations of classical shallow water and non-hydrostatic benchmarks validate the method and demonstrate its accuracy and efficiency.


Keywords: Discontinuous Galerkin methods, semi-implicit discretizations, semi-Lagrangian discretizations, p-adaptivity
Multi-model ensemble forecasts of tropical cyclones (TCs) using THORPEX Interactive Grand Global Ensemble (TIGGE) are presented, mainly focusing on the North Atlantic and the western North Pacific basins. The presentation starts with a brief introduction of TIGGE and benefits of using this data set by giving some examples of TC prediction cases. Then ensemble TC track predictions using TIGGE are examined with the aim to investigate the relative benefits of a multi-centre grand ensemble (MCGE) over a single-model ensemble (SME) from both deterministic and probabilistic perspectives. Moreover evaluation results on TC genesis predictions on a medium-range timescale using ensemble predictions from the European Centre for Medium-Range Weather Forecasts (ECMWF), the Japan Meteorological Agency (JMA), the National Centers for Environmental Prediction (NCEP), and the UK Met Office (UKMO) are presented. In the end of my presentation, ensemble predictions for recent severe, high-impact TCs including Hurricane Sandy (2012), Cyclone Phailin (2013) and Typhoon Haiyan (2013) are also shown. Various research and forecasting demonstration projects have been conducted in order to explore the utility of TIGGE products and to promote them for operational forecasting. Those include the North Western Pacific Tropical Cyclone Ensemble Forecast Project (NWP-TCEFP), which is a joint project by the World Meteorological Organization (WMO) Tropical Cyclone Programme (TCP) and the World Weather Research Programme (WWRP), and the WMO Severe Weather Forecasting Demonstration Project (SWFDP). The activities of those projects are briefly introduced.


Keywords: THORPEX, TIGGE, Tropical cyclone, Ensemble Prediction System
Parallel Session

SCI-PS244.02 - Probabilistic verification of global and mesoscale ensemble forecasts of tropical cyclogenesis

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Probabilistic forecasts of tropical cyclogenesis have been evaluated for two samples: a near-homogeneous sample of ECMWF and WRF/EnKF ensemble forecasts during the NSF PREDICT field campaign (15 August – 30 September 2010); and ECMWF ensemble forecasts during the 2010-2012 Atlantic hurricane seasons. Quantitative criteria for a tropical cyclone (TC) were first determined from model analyses based on threshold values of lower-tropospheric circulation, local thickness anomaly and minimum sea level pressure. A dichotomous verification was then performed for all ensemble forecasts with initial tropical disturbances. During the PREDICT period, the ECMWF and WRF/EnKF ensembles had similar verification statistics, with reliability diagrams of positive slope flatter than unitary, and Relative Operating Characteristic (ROC) curves that demonstrate skill. For the 2010-2012 ECMWF ensemble forecasts, the Equitable Threat Score was small and positive, with skill mostly lost after 5 days. The reliability diagrams for 1-5 day forecasts were monotonic increasing, though an overly large number of short-range ensemble forecasts predicted a low probability of a TC when a TC verified. The ROC curves exhibited similar skill for forecasts out to 5 days. The reliability curves were sensitive to parameters such as time tolerance and threshold values, and insensitive to cases that originated from African Easterly Waves versus those that did not. Qualitative investigations revealed case-to-case variability in the probabilistic predictions. While the sample size is limited, the ensembles show potential for probabilistic prediction out to 5 days, though it appears that the model struggles with developing a warm core in the short-range forecast.

Keywords: Tropical Cyclones, Ensemble, TIGGE, ECMWF
Parallel Session

SCI-PS244.03 - Characteristics of TIGGE in representing forecast variability associated with extratropical transition

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The characteristics of the extratropical transition (ET) of tropical cyclones and its impact on the midlatitude flow are examined in the THORPEX Interactive Grand Global Ensemble (TIGGE) multimodel ensemble prediction system (EPS). Ten ensemble forecasts initialized prior to ET for five tropical cyclones in 2008 are investigated using an empirical orthogonal function analysis and fuzzy clustering methodology. Each forecast contains 231 members from eight different global EPS. The EPS contributing to TIGGE differ in their spread and their contributions to the different scenarios. Some of the individual EPS are generally confined to only a few scenarios, whereas others contribute regularly to almost all. TIGGE contains more development scenarios than European Centre for Medium Range Weather Forecast (ECMWF) EPS but the full range of development scenarios is only found with the ECMWF included in the multimodel EPS. By comparing the development scenarios with the corresponding analysis it can be shown that in some of the cases the multimodel approach is necessary to get the analysed development included in the ensemble forecast.


Keywords: TIGGE, extratropical transition, forecast variability, EOF and clustering
Ensemble forecasting is a numerical approach that is used to provide a discrete estimate of the predicted probability density function of the atmosphere. Such a system must take into account initial errors by using different initial conditions. Model error is represented through stochastic physic, or different formulations of a forecast model or several models. The TIGGE (Thorpex Interactive Grand Global Ensemble) database gives access to several global ensembles. An other application of ensemble forecasting is to provide sensitivity of an aspect of the forecast to initial conditions. Although the propagator is here based of non-linear integrations of numerical models that include subgrid scale processes, the approach is intrinsically linear. The purpose here, is to extend the sensitivity computation with ensembles to threshold mechanisms by the means of a novel approach based on Factorial discriminant analysis. High impact weather such as heavy precipitation in the Mediterranean area and windstorms will be addressed using TIGGE.

Keywords: sensitivity to initial conditions, TIGGE, high-impact weather
We present a cursory analysis of the details of simulation of the Indian Summer Monsoon (ISM) by the superparameterized NCEP CFS version 2 (SP-CFS). The GCM here is the NCEP CFSv2 in T62 resolution superparameterized by the System for Atmospheric Modelling (SAM) which is a cloud resolving model (CRM). The incorporation of the superparameterization technique has resulted in the reduction of a few systematic biases observed in the traditional convection parametrized CFSv2 model; the highlights are the reduction of the cold tropospheric temperature bias, dry bias of ISM precipitation and underestimation of the synoptic scale variance. Undoubtedly, more detailed analysis of longer climate simulations are surely needed to attain more robust and confident conclusions, but nevertheless the results of this analysis are truly encouraging.

Keywords: superparameterization, Indian summer monsoon
Hail is a fairly common meteorological phenomenon that causes important damages to crops and properties. To get a reliable forecast of the occurrence of hailstorms is remaining a challenge for meteorological services. At Meteo-France, the operational mesoscale prediction model is AROME, running at 2.5km and using a mixed one-moment microphysical scheme, ICE3, developed in the research model Meso-NH. ICE3 considers a single category for graupel and hailstones, including dry and wet growth. Therefore, a diagnostic based on the integrated vertical graupel content has been operationally implemented in order to estimate a hail risk. However, there is a recognized need to provide forecasts of appropriate hail parameters such as maximum and mean hailstone sizes. An extension of ICE3, called ICE4, including a prognostic hail content, has been developed in Lascaux et al. (2006). The Meso-NH model with ICE4, running at 500m horizontal resolution, is here evaluated on 7 hail events in 2013 over Southwestern France. Parameters such as the number of hailstones, their mass and their kinetic energy are compared to measurements through a network of polysterene hailpads managed by ANELFA. In parallel, a statistical analysis of hailpad measurements over a 1-year period allowed to determine different values concerning the hydromeeteor size distribution and power law relationships than those used in the microphysical scheme. Sensitivity tests on the microphysics are therefore leded. ICE3 and ICE4 simulations are also compared to address the impact of prognostic hail on the dynamics of the simulated hailstorms, as the depth and intensity of cold pools.

**Keywords:** hail, microphysics, simulation, mesoscale
Parallel Session

SCI-PS245.03 - Water vapor isotopic diagnostics to evaluate the representation of moist processes during Madden-Julian oscillations

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The simulation of the Madden-Julian Oscillation (MJO) by atmospheric general circulation models (GCMs) has been a long-standing challenge. It depends strongly on the representation of moist processes in models. Here, we explore the possibility of using water vapor isotopic measurements to better evaluate the representation of these moist processes. In particular, isotopic observations may help differentiate between different moistening processes (rain reevaporation, convective detrainment, large-scale ascent) and between different dehydrating processes (compensating subsidence, large-scale condensation). We analyze various isotopic datasets (e.g. TES and IASI satellite datasets, surface observations) and model simulations using the LMDZ isotope-enabled GCM. We investigate the sensitivity of the simulated water vapor isotopic composition to parameters in the deep convection, shallow convection and large-scale condensation schemes. We show that the water vapor isotopic composition in the free troposphere strongly depends on the relative roles of the deep convection and large-scale condensation schemes to produce the precipitation. These relative roles have been shown to be a critical aspect in the simulation of the MJO. We also show that during the course of an MJO event, specific humidity and water vapor isotopic composition exhibit cycles whose relative amplitudes and phasing vary with altitude and longitude. The properties of these cycles reflect the relative role and the timing of different moistening and dehydrating processes. We attempt to use these properties as process-oriented diagnostics to evaluate moist processes during the different phases of the MJO.

Keywords: MJO, water isotopes, convection, parameterizations
Many cloud microphysical processes occur on a much smaller scale than a typical numerical grid box can resolve. In such cases, the assumed PDF method can be used to account for sub-grid variability in these microphysical processes by placing a distribution on the microphysics parameters and sampling the microphysics to obtain statistical moments. In the assumed PDF method, the calculation of such microphysical quantities has been done with classic Monte Carlo methods and Latin hypercube sampling. Although these techniques are fairly easy to implement and ubiquitous in the literature, they suffer from statistical noise due to finite sample sizes. Moreover, the decay of statistical noise scales poorly with the number of samples when the function of interest is smooth. In this paper, we propose using quadrature based methods instead of traditional random sampling approaches to compute the microphysics statistical moments for the assumed PDF method. The quadrature based methods can very often achieve much greater accuracy with much fewer sample sizes by choosing tailored quadrature points and weights instead of traditional random sampling. Furthermore, the resulting approximation has no statistical noise since the quadrature points are chosen deterministically. As a prototypical microphysical formula, we use Khairoutdinov and Kogan’s autoconversion and accretion formulas to illustrate the benefit of using quadrature instead of Monte Carlo or Latin hypercube sampling. For these examples, we show at least an order of magnitude improvement in accuracy with far fewer sample points.

Keywords: quadrature, monte carlo, cloud microphysics, latin hypercube
Parallel Session

SCI-PS246.01 - GCMs with implicit and explicit representation of cloud microphysics for simulation of extreme precipitation frequency

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The present study aims to develop a general circulation model (GCM) with improved simulation of heavy precipitation frequency by improving the representations of cloud and rain processes. GCMs with conventional convective parameterizations produce common bias in precipitation frequency: they overestimate light precipitation and underestimate heavy precipitation with respect to observed values. This frequency shift toward light precipitation is attributed here to a lack of consideration of cloud microphysical processes related to heavy precipitation. The budget study of cloud microphysical processes using a cloud-resolving model shows that the melting of graupel and accretion of cloud water by graupel and rainwater are important processes in the generation of heavy precipitation. However, those processes are not expressed explicitly in conventional GCMs with convective parameterizations. In the present study, the cloud microphysics is modified to allow its implementation into a GCM with a horizontal resolution of 50 km. The newly developed GCM, which includes explicit cloud microphysics, produces more heavy precipitation and less light precipitation than conventional GCMs, thus simulating a precipitation frequency that is closer to the observed. This study demonstrates that the GCM requires a full representation of cloud microphysics to simulate the extreme precipitation frequency realistically. It is also shown that a coarse-resolution GCM with cloud microphysics requires an additional mixing process in the lower troposphere.

Keywords: GCM, cloud microphysics, simulation of extreme precipitation, convective parameterization
Parallel Session

SCI-PS246.02 - Realistic initiation and dynamics of the Madden-Julian Oscillation in a coarse resolution aquaplanet GCM

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The main mechanisms for the initiation and propagation of the Madden-Julian Oscillation (MJO) are still widely debated. The capacity of operational global climate models (GCMs) to correctly simulate the MJO is hindered by the inadequacy of the underlying cumulus parameterizations. Here, we show that a coarse resolution GCM, coupled to a simple multicloud model parameterization mimicking the observed dynamics and physical structure of organized tropical convection, simulates the MJO in an idealized setting of an aquaplanet without ocean dynamics. We impose a fixed non-homogeneous sea surface temperature replicating the Indian Ocean/Western Pacific warm pool. This results in a succession of MJOs with realistic phase speed, amplitude, and physical structure. Each MJO event is initiated at a somewhat random location over the warm pool and dies sometimes near the eastern boundary of the warm pool, and sometimes at a random location way beyond the warm pool. Also occasionally the MJO events stall at the center of maximum heating. This is reminiscent of the fact that in nature some MJOs stall over the maritime continent while others reach the central Pacific Ocean and beyond. The initiation mechanism in the model is believed to be a combination of persistent intermittent convective events interacting with observed large scale flow patterns and internal tropical dynamics.

Keywords: MJO, GCM
Parallel Session

SCI-PS246.03 - Structure and dynamics of the MJO-related temperature, vertical velocity and divergence fields

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The three dimensional structure of the temperature, divergence and vertical velocity fields in the MJO in the ERA-Interim dataset is examined. The analysis reveals the MJOs far reaching influence upon the occurrence and organization of precipitation. Over the equatorial belt (10°N/S), the eastward passage of the region of ascent over a fixed point the evolution of the vertical velocity profile implies that convection begins shallow and becomes progressively deeper and more elevated. This systematic evolution is explained in terms of the difference between divergence within the boundary layer (1000-850 hPa) and the lower free troposphere (850-500 hPa) induced by the passage of equatorial Kelvin and Rossby waves. Over the outer tropics (10°−20°N/S) ascent is dominated by friction-induced boundary layer convergence in association with equatorial diffluent flow west of the maximum convection. The influence of these waves results in a structure in deep convection that resembles a swallowtail: vertical motion extends eastward from the center of maximum ascent only along the equator and splitting into two symmetric, off-equatorial centers west of it. At higher latitudes, 25°−40°N/S ascent is observed in the regions of warm advection to the west of the upper-level flanking Rossby waves. The temperature anomalies closely correspond to the upper-level wave structure and serves as an indicator of the MJO-related wave structure, which drive the wind patterns that lead to the observed vertical velocity.

Keywords: Madden-Julian Oscillation, wave dynamics, vertical velocity, divergence
Parallel Session

SCI-PS246.04 - Vertical structure and diabatic processes of the MJO: 2-day hindcasts

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A Joint Research Activity by the WCRP-WWP/THORPEX MJO Task Force & Year of Tropical Convection (YOTC) and the GEWEX Atmosphere System Study (GASS) is in progress to characterize, compare and evaluate the heating, moistening and momentum mixing processes associated with the MJO that are produced by global weather and climate models, with a particular focus on their vertical structure. Three sets of experiments are conducted i) twenty-year climate simulations ii) a series of daily initialized 2-day hindcasts for two successive MJO events during boreal winter 2009-10 and iii) 20-day hindcasts to assess the performance of the models MJO as a function of forecast lead time. Analysis of the 2-day hindcast component focuses on processes that control transition from suppressed to active convective phase over the Indian Ocean. Model errors develop fairly quickly and are well established by the end of 48 hours forecasts. There are general agreement among models on the shape of diabatic heating and moistening profiles in the suppressed, transition and convective phases, despite some systematic differences. Two important findings from the initial analysis are that 1) most models lack the cumulus congestus heating and moistening at the mid levels in the transition from suppressed to convective phase of MJO. 2) the radiation tendencies in the convective phase are the least consistent among models and points to the large uncertainties in the longwave cooling and cloud properties. Detailed diagnostics of these processes will be presented.

Keywords: Madden-Julian Oscillation, Diabatic Processes, vertical structure
Parallel Session

SCI-PS247.01 - Translating weather forecasts into impact-relevant information: Practice of impact-based forecast in weather forecast operation

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Traditionally, the primary responsibility of NMHSs mainly involves in timely and accurate forecasts and warnings of hydrometeorological hazards and events, however, the routine products do not respond to the requirements of the users (e.g., emergency managers) well, and can be hardly put direct use in decision-making and actions. Decision-makers and the public need to know impact of weather-related hazard on lives, livelihood, property and economy, etc., in other words, there is a growing demand for weather-impact-based forecast. Recently, an integrated forecast operation platform has been established in Shanghai to meet needs of not only traditional weather forecasts, but also related impacts and risks forecasts. The platform includes production of weather analysis and forecast data, translation of weather information (extraction of relevant information), impact estimation and risk assessment within situational context, and response scenarios and mitigation strategies (multi-hazards early warning mechanism and system). In terms of impact forecast technology, we will present an example of translating ensemble weather forecast into probabilistic impact forecast of flu/cold epidemics based on the Bayes' theorem (manipulation of conditional probabilities), and flooding risk forecast by making use of quasi-quantitative analysis of vulnerability and exposure of a particular area.

Keywords: weather impact forecast, impact estimation and risk assessment, ensemble forecast
Parallel Session

SCI-PS247.02 - Localized urban heat island development and associations with air pollution and synoptic weather

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The urban heat island (UHI) is amplified by two of the most critical environmental factors of today’s time: population growth and climate change. The synergistic biophysical systems within urban areas can produce substantive societal and health consequences due to the mutli-hazards of heat and air pollution. In order for cities to manage the growing risks and vulnerability of such exposures, progress in understanding the spatial and temporal variations in the development of UHIs is critical. The current study aims to address the multidimensional issues of these hazards on health, science, and society. The formation of the UHI is studied under various synoptic-based air mass types to determine differential spatial and temporal development and intensities of the surface UHI. Neighborhood-scale 'UrbaNet' weather station data collected by NOAA and Earth Networks is analyzed in conjunction with daily synoptic weather type and air pollution levels in both urban and rural areas in Philadelphia, New York, Boston, and Baltimore. The data from >300 stations consist of over 25 meteorological variables collected at 5-min intervals from 2006–2013. We explore the use of diurnal biophysical measurements to better understand the heterogeneous nature of the UHI with respect to local urban form and fabric. The study further addresses urban risks and hazards of the UHI, and development of vulnerability indices for application towards more sophisticated and spatially resolved heat/health warning systems. With improved observations and understanding, we can support operational meteorologists, leading to more targeted adaptation and intervention strategies now and for projected city-specific growth.

Keywords: Urban Heat Island, Air Pollution, UrbaNet, Applied Synoptic Climatology
SCI-PS247.03 - The WMO Severe Weather Forecasting Demonstration Project – bringing benefits of NWP to developing countries

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Modern NWP systems, including ensembles, provide unprecedented capabilities for National Met Services (NMSs) to issue warnings and prepare their nations for high-impact weather events, but in many developing countries forecasters have little or no access to such data. The WMO Severe Weather Forecasting Demonstration Project (SWFDP) was established to provide information, along with training on its use, to NMSs through a Cascading Forecasting Process. Forecast information is provided from global centres via a regional centre which provides interpretation and guidance, enabling forecasters to issue severe weather warnings and communicate them effectively to decision makers in their countries. The use of ensemble prediction systems (EPS) has always been central to the SWFDP and its training, enabling NMSs to develop risk-based warning systems. The SWFDP has also developed close links with the research community to provide a testbed for new forecasting capabilities. Examples include multi-model ensemble products developed using the TIGGE database, and the use of convection-permitting models in the Lake Victoria region of East Africa. Following several successful regional demonstration projects, the future aim is to extend the SWFDP into a global programme to support severe weather forecasting and capacity building of NMSs.

Keywords: Severe Weather, Forecasting, Demonstration, SWFDP
Parallel Session

SCI-PS247.04 - Integrating nowcasting with crisis management and risk prevention in a transnational framework

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In frame of WWRP/WMO and funded by European Union (3.6m Euro), 15 national weather services and other 10 govermental angencies worldwide have conducted a Forecast Demonstration Project INCA-CE (INtegrating nowCAsting with Crisis management and risk prEvention in a transnational framework)in the year 2010-2013. It aims at reducing risks and impact of weather-related natural disasters (e.g. windstorms, flooding, mudflows, icing, and drought) by integrating nowcasting with crisis management and risk prevention. Main purpose is the improvement of risk management standards and methodology in order to enable management institutions and public authorities to issue more detailed risk assessments and warnings. Within INCA-CE, a state-of-the-art, very high-resolution in time and space, application-oriented, real-time analysis and nowcasting system INCA (Integrated Nowcasting through Comprehensive Analysis) has been developed and implemented at the partner weather services, providing analyses and nowcasting to end-users in crisis management and risk prevention. The INCA-CE project idea has been applied in three application areas: operational hydrology, civil protection and road safety and carried out in a trans-national framework. In the talk the results of the project will be presented in the following three aspects:

• Integration of nowcasting with crisis management and risk prevention.
• Multidisciplinary collaborative research on severe weather prediction and its application.
• Development of transnational strategy and cooperation on severe weather warning.

**Keywords:** Severe weather forecast, nowcasting, weather warning, meteorological application
SCi-PS248.01 - Hail and the climate system: Large scale environment relationships for the Continental United States 1979-2012

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Each year over the United States, large hail produces in excess of one billion dollars of insured losses. Despite this impact and the risk of locally incredible damage, hail is often thought of as the poor child of severe storms research. While environmental conditions that produce hail are reasonably well understood, these relationships have seen little application to the climatic system. A relationship between environmental characteristics and large hail occurrence has been developed to estimate the monthly frequency of hail occurrence. While thermodynamic sources of energy are essential to promote the strong updrafts that support hail, other factors such as vertical wind shear, interactions on the microphysical scale, moisture loading and structure of the vertical temperature profile can influence the potential for relatively large hail formation. These relationships imply that indices for other severe phenomena (e.g. tornadoes) may not be representative of the appropriate set of ingredients. Using observations from the National Climatic Data Center’s Storm Data, a hail ‘index’ that describes the probability of occurrence of severe hail given objective fitting of a Poisson distribution to pre-defined convective variables is derived. This index describes the monthly climatological likelihood is based on environmental data from the North American Regional Reanalysis (NARR) over the continental United States for the period 1979-2012. Here, the applications of this index to understanding how the climate system interacts with the seasonality, spatial distribution and occurrence of large hail will be discussed.

Keywords: Hail, Severe Thunderstorms, Climate Variability
Parallel Session

SCI-PS248.02 - Using regional climate models to simulate extreme rainfall events over South Africa

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This study evaluates the capability of nine regional climate models (RCMs) in simulating extreme rainfall events over South Africa, and in reproducing the synoptic features that produce the events. Using 95th percentile of daily rainfall as a threshold for extreme rainfall events, we applied Self Organizing Maps (SOMs) to group the spatial distribution of the simulated and observed extreme rainfall events. In addition, we used a RCM, forced with different global climate models (GCMs), to study the role of lateral boundary forcing in simulating the extreme rainfall events. The study shows five major patterns of extreme rainfall events over South Africa. The first pattern (ISE) features isolated extreme rainfall events; the second pattern (TTE) links extreme rainfall events with a truncated tropical temperate trough that terminates at the coasts; the third pattern (ETE) links them with an elongated tropical temperate trough that extends from the tropics to the mid-latitude; the fourth pattern (MLE) links them with a mid-latitude cyclone; and the fifth pattern (ACE) links them with rainfall activities over the Agulhas current. Most RCMs give realistic simulations of the patterns. However, some RCMs underestimate the frequency of ISE over the eastern coasts, and while some overestimate the frequency of TTE over the western and eastern coast. Most RCMs overestimate MLE over the region. Detailed results will be presented in the conference. The results will provide valuable insights into the capability of RCMs in downscaling impacts of global warming on extreme rainfall events over South Africa.

Keywords: extreme rainfall events, regional climate models, South Africa, Tropical Temperate troughs
Parallel Session

SCI-PS248.03 - A sounding climatology and forecasting methodology using self-organizing maps over Gauteng, South Africa.

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Thirty years of South African Weather Service sounding data from Gauteng, South Africa were used to create a climatology of the thermodynamical profile of the atmosphere during heavy rainfall by using self-organizing maps (SOMs). SOMs provide a mechanism for visualizing a collection of atmospheric states after dominant modes within a dataset are identified. The SOM technique identifies representative nodes spanning the data space so that individual data elements may be associated with a node. SOMs have wide application but in meteorology SOMs are often used to create synoptic climatologies of sea level pressure or geopotential heights at different pressure levels. SOMs are also applied to explain events such as the occurrence of fog, or extreme temperatures, rainfall and wind. In this research SOMS are used to create a climatology of sounding derived parameters and it is shown how this technique provides climatological information about heavy rainfall not available from conventional methods. The ability of the SOM to associated individual data elements to a specific node is exploited and a technique is proposed to predict rainfall frequencies over Gauteng. This is done by identifying to which node a specific day’s sounding belongs and using previously identified rainfall characteristics of that node to predict rainfall. This method offers a technique to provide a probabilistic daily rainfall forecast for the Gauteng Province, South Africa using observed sounding data.


Keywords: self-organizing maps, sounding, heavy rainfall, South Africa
Many thunderstorms in mid-latitude South America stand out in satellite observations as being among the strongest anywhere on earth in terms of satellite-based convective proxies, such as lightning flash rate per storm, prevalence for extremely tall, wide convective cores and broad stratiform regions. Knowing when and where strong convection is initiated presenting a great interest because the close relationship between convective storms and severe weather phenomena. The great uncertainty on numerical weather forecasts during the warm season are generally the result of the inability of these anticipate the onset of deep moist convection. Determining when and where convective storms are initiated is a complex function that involves vertical movements from micro to intraseasonal scale. This paper seeks to identify the most salient features associated with mesoscale and synoptic scale pre-condition the environment in which deep convection develops in mid-latitude South America region close to principal mountain barriers (Sierras de Córdoba and Northwestern Argentinean Andes), distinguishing between those that initiate in the afternoon and early evening hours. They delve into the mesoscale processes that may be helping the onset of convective activity, focusing on the role of topography as a destabilizing element in the lower troposphere and its relation to the presence of local circulation, cold fronts and South American low-level jet.

**Keywords:** deep convection, OROGRAPHIC, mesoscale
UAS-PA409 - Panel Discussion

The impact of weather on human health and the influence of weather information on health-related behaviour

Panelists representing a variety of agencies will discuss the impact of weather on aspects of human health and safety, and the influence of weather information on health-related behaviours, decisions, and policies. The feedback will be used to guide the direction of future scientific research, applications and services.

UAS-PA409.01 – Panel Participant

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Managing heat health hazards: Risks for extreme weather in preparation for the PanAm Games

Weather, climate variability, and other environmental factors are important determinants of health. Across Ontario extreme weather events are becoming more frequent and more intense. Extreme temperatures and high humidity poses a significant health risk to Canadians. There is a demonstrated link between heat and excess mortality. Mortality is largely preventable, given appropriate notification and interventions. There is no consistent national approach for issuing heat advisories and/or the responses required to reduce heat related mortality and morbidity. In Ontario, a decentralized system exists where public health authorities have chosen different approaches to triggering their heat alerts and response plans. Greater coordination is required amongst federal, provincial and municipal decision-makers in the identification of risks and vulnerabilities and the innovative responses to those challenges. The Meteorological Service of Canada, Health Canada, Ministry of Health Long-Term Care and Toronto Public Health have been working closely to continuously improve evidence-based capacity building and decision-making at the provincial and local levels in order to reduce morbidity and mortality related to heat in Ontario. This initiative is focused on developing an efficient, coordinated, evidence-based system comprised of robust, standardized criteria for calling heat alerts, and language easily understood by the public as well as the flexibility to address local vulnerabilities and needs. This innovative system will be piloted at the Pan Am Games in 2015 and it will provide a suite of inter-jurisdictional heat health management tools to anticipate and adapt to the ongoing challenges of climate change and extreme weather events.

Keywords: PAN AM Games, Heat Health Hazards, Extreme Weather
UAS-PA409 - Panel Discussion

The impact of weather on human health and the influence of weather information on health-related behaviour /cont

UAS-PA409.02 - Panel Participant

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UAS-PA409.03 - Panel Participant

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UAS-PA409.04 – Panel Participant

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Please refer to mywwosc14 conference website and on line APP for updates to abstracts for panel sessions.
Parallel Session

SCI-PS249.01 - Snow cover physical properties and impacts on surface atmospheric fluxes

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Snow cover is a key component of the climate system. Its presence on the ground drastically changes the physical properties of the continental surfaces and thus strongly impacts the energy exchanges between the surface and the atmospheric boundary layer. The most important features of snow cover with respect to weather predictions will be presented in details. Its radiative and thermal properties, including its capacity, its conductivity and its melting latent heat, lead to an efficient cooling of the snow surface and to a stabilization of the atmospheric boundary layer. A major difficulty in the simulation of the processes occurring at the snow/atmosphere interface stems from the rapid temporal evolution of snow physical properties, often over more than one order of magnitude. Observations and outputs from current snow/atmosphere models in Antarctica and Northern Eurasia will illustrate the main characteristics of the energy budget at the snow surface. Strengths and weaknesses in the simulation of snow surface temperature and of air temperature and humidity will be presented. Main challenges for improving the representation of snow/atmosphere feedbacks in weather prediction or climate models will be discussed.

Keywords: snow cover, snow modelling, snow atmosphere exchanges
Parallel Session

SCI-PS249.02 - Foehn jets and their implications for the Larsen C Ice Shelf, Antarctica

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Previously unknown foehn jets have been identified to the east of the Antarctic Peninsula above the Larsen C Ice Shelf (LCIS). These jets have major implications for the east coast of the AP, a region of rapid climatic warming and where two large sections of ice shelf have collapsed in recent years. During three foehn events across the Antarctic Peninsula, leeside warming and drying is seen in new aircraft observations and simulated by the Met Office Unified Model (MetUM) at \textasciitilde1.5 km grid spacing. The foehn jets – apparent in aircraft observations and MetUM simulations of all three cases – are mesoscale features (up to 60 km in width) originating from the mouths of leeside inlets. Through back trajectory analysis they are identified as a type of gap flow. In Cases A and B the jets are distinct, being strongly accelerated relative to the background flow, and confined to low levels above the LCIS. They resemble the ‘shallow foehn’ of the Alps. Case C resembles a case of ‘deep foehn’, with the jets less distinct. The foehn jets are considerably cooler and moister relative to adjacent regions of calmer foehn air. Despite this, according to Synthetic Aperture Radar data, the inlets within which the jets are observed are associated with higher annual melt durations than adjacent regions of typically calmer foehn flow. This is probably due to greater surface turbulent heat fluxes associated with the stronger winds within the jets, and more frequent occurrences of foehn winds in the inlets.


\textbf{Keywords:} Foehn, Larsen Ice Shelf, Gap flows, Orographic jets
Parallel Session

SCI-PS249.03 - Parameterizing the effects of leads upon the atmosphere and surface fluxes of the Arctic Ocean

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The ocean and atmosphere exert stresses on sea ice that create elongated cracks or openings ("leads") where the ocean is exposed directly to the atmosphere. Leads cover a small fraction of the surface but tend to dominate the vertical exchange of energy, particularly in winter when heat fluxes over leads can be orders of magnitude larger than over thick ice. The width and orientation of leads markedly influence their vertical fluxes, but these effects are not currently included in earth system models (ESMs). Wide leads in particular can generate convective plumes that penetrate the surface inversion and produce condensate that spreads up to 250 km downwind of the lead, significantly affecting the longwave radiative fluxes at the surface and thereby the sea ice thickness. The effects of leads must be accurately represented in climate models to allow possible feedbacks between them and the sea ice thickness and extent. During the next three years, we plan to quantify how the width and orientation of leads affect surface-atmosphere fluxes over sea ice, develop parameterizations to account for these effects in ESM frameworks, and quantify the response of regional and global scale climate to the new parameterizations. To realize these objectives, we will: (1) Use remote sensing imagery to determine the distributions of lead widths and orientations. (2) Develop new formulations for lead-flux parameterizations. (3) Evaluate the skill of the lead-flux parameterizations against large-eddy and cloud-resolving simulations. (4) Incorporate the lead-flux parameterizations into ESM frameworks.

Keywords: atmosphere-ocean-sea ice, leads, surface fluxes, parameterization
This presentation introduces an operational tropical cyclone (TC) numerical model, namely GRAPES-TCM (Global/Regional Assimilation and PrEdiction System – Tropical Cyclone Model), which was developed by China Meteorological Administration (CMA) under the support of China Typhoon "973" Project during 2009-2013. The model, designed with emphasis on TC vortex initialization and physical parameterization, was initially developed by Shanghai Typhoon Institute (STI) of CMA in the year 2005. Based on a four-years quasi-operational (2005-2006) and operational (2007-2008) run and tests on vortex initialization schemes, in the year 2009, the original vortex relocation scheme in GRAPES-TCM was replaced by a Cycled Data Assimilation (CDA) scheme based on Model Controlled – Three Dimensional Data Variation Assimilation method. Preliminary verification shows that the CDA scheme improves the 0-48h TC track prediction by about 20% relative to the GFDL relocation scheme. Since the year 2010, model physical schemes were also updated. Specifically, a new Kain-Fritsch convection trigger scheme is used to reduce rainfall overestimation under the circumstance of weak environmental forcing. The original surface/PBL parameterization scheme was also updated in 2011 to accommodate the "wind-drag coefficients/roughness length" relationship in the situation of strong winds. The implementation of the above techniques in operation greatly reduces GRAPES-TCM's track prediction error of TCs in north Pacific, which is 196km/24h and 95km/24h, in the year 2008 and 2013, respectively. During 2012-2013, the coupling with ocean model is also implemented for GRAPES-TCM. The verification shows that TC intensity simulation was improved obviously.

**Keywords:** GRAPES-TCM, Tropical Cyclone, Vortex Initialization, Convective Parameterization
Météo-France provides the French Overseas territories with forecast products from both global and regional numerical weather prediction systems. The regional systems are currently based on the ALADIN model, which is run with an 8-km horizontal resolution, over 4 domains (Antilles-French Guiana, La Réunion, New Caledonia, French Polynesia). Each system is operated with a 3D-Var data assimilation, using additional pseudo-observations and specific tunings for tropical cyclone initialization. A major upgrade in 2015 will consist in switching from ALADIN to AROME, a non-hydrostatic model with enhanced physical parameterizations. The present plans are to implement five domains, smaller than the current ALADIN ones, with a 2.5km horizontal resolution. The increased resolution will improve the representation of orography for small and steep islands, and lead to a more realistic modeling of local effects. A further downscaling with AROME will be tested in regions where a 500m resolution may be beneficial. According to the domain, the initial conditions of the Overseas AROME models will either come from the ECMWF deterministic model, or from a limited area 3D-Var data assimilation cycle. The latter would enable the assimilation of local radar data whenever available. Efforts are also undertaken to verify the Overseas model performances with respect to satellite precipitation retrievals. The first results indicate that AROME rainfall forecasts score better than ALADIN ones. A more prospective work focuses on the coupling of AROME with an ocean model, in order to improve the representation of the life cycle of tropical cyclones.

**Keywords:** Numerical weather prediction, AROME, Tropical precipitation, Tropical cyclones
Parallel Session

SCI-PS250.03 - The DACCIWA Project: Dynamics-Aerosol-Chemistry-Cloud interactions in West Africa

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The purpose of this contribution is to introduce the interdisciplinary research consortium DACCIWA (Dynamics-Aerosol-Chemistry-Cloud interactions in West Africa), which comprises 16 partners in six European and West African countries. DACCIWA is funded by the European Commission as part of Framework Programme 7 from 2013 until 2018. A key research interest of DACCIWA are the impacts of the massive economic and population growth and urbanisation from southern West Africa (SWA) on human health, ecosystems, food security and the regional weather and climate. The DACCIWA project will conduct extensive fieldwork in SWA to collect high-quality observations, spanning the entire process chain from surface-based natural and anthropogenic emissions to impacts on health, ecosystems, weather and climate. This will include a major field campaign in summer 2015 with three research aircrafts and two ground-based supersites. Combining the resulting benchmark dataset with a wide range of modelling activities will allow us: (a) to assess all relevant physical and chemical processes, (b) to improve the monitoring of climate and compositional parameters from space, (c) to determine health impacts from air pollution, and (d) to develop the next generation of numerical models capable of representing coupled cloud-aerosol interactions, which will ultimately lead to reduced uncertainties in weather and climate predictions. SWA with its rich mix of emissions and diverse clouds is ideal for such a study and many findings and technical developments will be applicable to other monsoon regions. DACCIWA will deliver a comprehensive scientific assessment and actively guide policy-making for West Africa and beyond.

**Keywords:** cloud-aerosol interactions, anthropogenic emissions, monsoon, precipitation
Parallel Session

SCI-PS250.04 - Assimilation of satellite-based temperature and moisture soundings on mesoscale analyses and forecasts of tropical cyclone

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The Atmospheric InfraRed Sounder (AIRS) onboard NASA’s Aqua platform provides global atmospheric temperature and moisture profiles with 28 pressure levels and a spatial resolution of 50 km. However, higher resolution IR soundings are needed for mesoscale applications, especially for the development of tropical cyclone. A set of specially processed AIRS soundings is provided by CIMSS with 101 pressure levels and a horizontal resolution of 13.5 km. In addition, total precipitable water (TPW) derived from Advanced Microwave Scanning Radiometer – Earth Observing System (AMSR-E) provides the measurement of atmospheric moisture as water depth in a column of atmosphere with a horizontal resolution of 17 km. Influence of assimilating the satellite-based observations into the Weather Research and Forecasting (WRF) model using the Ensemble Kalman Filter (EnKF) is investigated for the cases of Typhoon Sinlaku and Hurricane Ike (2008). Four WRF-EnKF cycles, using 84 ensemble members with a horizontal resolution of 27 km on the analysis grid (and 9 km in the forward forecast model), are prepared. A ‘Control’ WRF-EnKF cycle is first produced with the assimilation of conventional observations. In addition to the conventional observations, the second, third, and fourth WRF-EnKF cycles, ‘AIRS-STL2-TQ’, ‘AIRS-CIMSS-TQ’, and ‘AMSR-E-TPW’ assimilate temperature and moisture soundings from the AIRS Level 2 products and from those specially processed by CIMSS, and TPW from AMSR-E, respectively. Preliminary results suggest that the initial positions and intensity of ‘AMSR-E-TPW’ analysis are closest to best track. Insights into the influence of the respective datasets on tropical cyclone forecasts will be provided.

Keywords: Ensemble Kalman Filter, tropical cyclone, total precipitable water
SCI-PS251.01 - Mitigating the impact of weather hazards on aviation

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“How can aviation become safer, greener, and more efficient?” This is a key question in aviation industry today. Meteorology plays a key role in answering that question since no other industry is more sensitive to weather than the aeronautical industry. Decision makers in air transportation will have to rely more and more on precise, on-demand and tailored information on weather and weather-related hazards in order to fulfil the requirements of the airspace users and passengers for a smooth, undisturbed, safe, and punctual flight. But which meteorological information is required by the aviation stakeholders? How can such information be extracted from observation and prediction data? The information must be unambiguous, on-time and easy to understand. How can it be tailored to the user’s needs? The hazardous phenomena vary from a few tens of metres and seconds for wake vortices to several thousand of kilometres and days for volcanic ash. How to prepare and harmonize that information for system integration? DLR is developing an integrated advisory system for adverse weather, climate protection and disruptive events for a future air traffic management. Candidate phenomena include hazards like in-flight icing, thunderstorms, turbulence, snow and ice, wake vortex, volcanic ash, and sensitive areas of noise abatement and high climatic impact. The aim is to characterize such phenomena by objects, coded in xml/gml format. The system is seen as an enabler for Common Information Sharing and Collaborative Decision making.

Keywords: detection, tracking and prediction of weather phenomena, unambiguous, tailored information, from wake vortices to volcanic ash clouds
Parallel Session

SCI-PS251.02 - Using TRMM precipitation estimates to understand landslide occurrence in Papua New Guinea

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Papua New Guinea (PNG) is a region affected by numerous landslides annually, many of which result in wide-spread socio-economic impacts. These events can range in scale from slips and slumps of a few cubic metres of material to failures with estimated volumes of 1.8 x 10⁹ m³. Landslides are typically triggered by rainfall and/or earthquakes, although underlying causal factors, such as geology and geomorphology are also critical contributors. This presentation focuses on the relationships between landslide occurrence and rainfall variability in PNG. Using a 12-year landslide inventory and daily precipitation estimates from the Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis products, the rainfall characteristics preceding historical landslides are examined over time scales ranging from 5 to 90 days. By comparing these characteristics against rainfall events which did not result in landslides, a framework for quantifying the probability of landslide occurrence has been developed. In addition to assessing the likelihood that different magnitude rainfall events will trigger landslides, the underlying causal factors associated with historical landslides are examined. This approach assesses the pseudo-static susceptibility of slope instability, based on morphometric assessments of landslide prone regions in PNG.

Keywords: TRMM precipitation estimates, landslides, tropics
Environment Canada’s FireWork system has been under development since 2010. This system calculates near-real-time emissions from wildfires and large prescribed burns and then inputs these emissions into Environment Canada’s real-time GEM-MACH air quality (AQ) forecast model. Because the GEM-MACH forecast domain covers Canada and most of the U.S., including Alaska, fire location information is needed for both of these large countries. Near-real-time satellite data are obtained and processed for both countries. Fire location and fuel consumption data for Canada are provided by the Canadian Forest Service’s Canadian Wild Fire Information System (CWFIS), whereas different approaches have been assessed for including American fire sources, through a collaborative effort with the Canadian Forest Service (CFS) and the U.S. Forest Service (USFS). During GEM-MACH model runs, emissions from individual fire sources are injected into elevated model layers based on plume-rise calculations, and subsequently, transport and chemistry calculations are performed. One-way coupled interactions between meteorology and chemistry are considered, with the former affecting the latter. An experimental FireWork version of GEM-MACH has been executed in real time for three consecutive summers (2012 to 2014). Noticeable improvements in the AQ forecasts for PM2.5 were seen in numerous regions where fire activity was high or that were affected by long-range transport. Model performance will be described through regional case studies as well as computed hourly and daily objective and categorical scores. Various benefits that this new system can provide to AQ forecasting, wildfire management, and AQ studies will also be discussed.

**Keywords:** GEM-MACH, Air Quality, Wildfire, Forecast
Parallel Session

SCI-PS251.04 - Reliability analysis for drought early warning in an ecological system

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Ecological system reliability is seriously influenced by fluctuation in weather parameters such as precipitation. However, the prediction of transitions taking place in the state of these systems is a complicated issue. The main reason behind this problem is the lack of an appropriate methodology to evaluate the combination impacts of predicted drought properties (severity and duration) and system reliability on the future state of the system. In the present study, we used the concept of Profust theory to evaluate the future state of an ecological system considering predicted drought events and the system reliability. The proposed methodology uses different tools including Semi-Markov and Bernoulli processes and fuzzy theory to include both randomness of predicted drought properties and the vagueness of drought impact in analysis. To demonstrate the methodology, a real case study (a rangeland system) is considered in southern part of Iran and the results of analysis are presented for this study area. The proposed approach provides a comprehensive framework that can be applied to evaluate the sensitivity of a variety of environmental systems to weather-related hazards.

Keywords: drought, reliability, impact analysis, prediction
Parallel Session

SCI-PS252.01 - A case for strongly coupled data assimilation: impact of scatterometer winds on ocean analyses

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Scarcity of observations of the ocean interior is a key barrier to further improvements in ocean state estimation and forecasting. Coupled data assimilation has the potential to ameliorate this problem by extracting information from atmospheric observations using coupled atmosphere-ocean covariances. Here, we investigate the impact of scatterometer wind measurements on ocean analyses in the Mediterranean Sea. Using a combination of twin and real-data experiments conducted with an ensemble coupled data assimilation system, we show that scatterometer measurements can be effective at reducing errors in ocean temperature, salinity, and currents. This positive impact extends below the surface and through the mixed layer. Our results encourage further development of coupled data assimilation techniques and incorporation of wind scatterometer measurements into the next generation of ocean analysis systems.

**Keywords:** Coupled data assimilation, Ocean-atmosphere processes, Scatterometer winds, Ensemble data assimilation
Parallel Session

SCI-PS252.02 - The NCAR Community Earth System Model coupled data assimilation system

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Recently the Community Earth System Model (CESM) has been interfaced to a community facility for
ensemble data assimilation (Data Assimilation Research Testbed – DART). In the CESM-DART
framework, data is assimilated into each of the respective atmosphere/ocean/land model components
during the assimilation step, and information is exchanged between the model components during the
forecast step. This development of a coupled multi-component data assimilation system highlights a
significant step towards better prediction of climate variability and climate trends across a variety of
temporal scales (for example, short-term climate extremes, long-term decadal predictions). In this
presentation, we will provide an overview of the system design and its skill for simulating a variety of
seasonal-to-interannual (S-I) events (for example, the space-time structure and propagation of the
Madden-Julian Oscillation, the formation of sea-ice around the Arctic, seasonal controls on the equatorial
Pacific ocean thermocline depth, etc.). Using a suite of coupled system configurations, we will discuss the
benefit of the coupled multi-component framework over simpler coupled single-component frameworks in
which observations are assimilated only into one of the model components. In such coupled single-
component systems, we find that the impact of observations across the air-sea interface are limited,
which result in inconsistent ocean-atmosphere dynamical feedbacks and an overall reduction in the
fidelity of the system. We expect that the results from our study will improve our understanding of the
applicability of coupled ocean-atmosphere systems, their climate prediction capabilities and provide
guidance on future implementation of coupled cross-component data assimilation systems.

Keywords: coupled data assimilation, CESM-DART, air-sea interaction, MJO prediction
parallel session

sci-ps252.03 - a high-resolution reanalysis for the european corDEX region

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The work presented here comprises the setup and evaluation of a 30-year high-resolution reanalysis for the European CORDEX domain currently in production. Results are shown for two 5-year streams. As reanalyses gain more and more importance as a source of meteorological information for many purposes, global reanalyses provide high quality four-dimensional atmospheric data sets. However, due to their spatial resolution (70-125km) and temporal output intervals (3- to 6-hourly), they are not suitable for small scale problems (e.g., regional climate assessment, meso-scale NWP verification, input for subsequent models such as river runoff simulations). Regional reanalyses are therefore based on a limited area model and complemented by a corresponding data assimilation scheme allowing for the generation of reanalysis data sets with high spatio-temporal resolution. Our regional reanalysis for Europe is based on the COSMO model and matches the CORDEX-EURO-11 domain specifications, albeit at a higher spatial resolution of 6km. The production of a 30-year period of reanalysis data in several streams is currently in progress. Results shown here are from the first stream covering the 6-year period from 2007 to 2012 and the second stream of 5 years from the early 1980s. The evaluation is performed using independent observations with a special emphasis on precipitation and high-impact weather. Further, results are compared to ERA-Interim and experiments with a pure downscaling approach as well as altered procedures regarding the assimilation of radar observations. In addition, we present first results of reanalysis runs at a convection-permitting scale of 2km for Central Europe.

Keywords: regional reanalysis, CORDEX, verification, precipitation
In the present study, land surface dataset is prepared using High Resolution Land Data Assimilation System (HRLDAS) over Indian region at 20 Km special resolution. For this purpose, an uncoupled HRLDAS simulation is carried out for the period of 01 January 2001 to 31 October 2013. Atmospheric forcing parameters viz. surface temperature, surface specific humidity, horizontal wind components, and surface pressure is provided from Modern-Era Retrospective Analysis for Research and Applications (MERRA). The downward solar radiation and precipitation is obtained from Global Land Data Assimilation Systems (GLDAS) and Tropical Rainfall Measuring Mission (TRMM) respectively. The landuse (20 categories) and time varying green vegetation fraction is derived from Moderate-resolution Imaging Spectroradiometer (MODIS). The simulated soil temperature, soil moisture and sensible heat flux is validated against the representative in-situ observations over India. Daily variation of soil temperature in different seasons is analyzed and compared with in-situ observations. The analysis is made for different regions of India with varying soil and vegetation cover. The result indicates that simulated soil temperature agrees reasonably well with observations. Soil moisture is significantly under predicted. This is due to precipitation provided from TRMM which under estimates precipitation. Sensible heat flux is validated against two sites of India, Kharagpur and Ranchi. Analysis of interannual variability of simulated soil temperature and soil moisture over central India shows that the interannual variability of the land surface parameter is well captured in the dataset.


Keywords: Soil moisture, Soil temperature, Sensible heat flux, Interannual variability
Parallel Session

SCI-PS253.01 - Variational assimilation in a coastal ocean model using another model's adjoint: the AVRORA-SHOC assimilation system

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A unique coastal ocean data assimilation system has been developed: satellite sea surface temperature (SST) observations are assimilated into a costal ocean model using variational codes developed for another ocean model. SST data near the Bonney Coast in South Australia are assimilated into the Sparse Hydrodynamic Ocean Code (SHOC), whose tangent linear (TL) and adjoin (ADJ) models have not been developed. Instead, the TL and ADJ codes come from the Advanced Variational Regional Ocean Representer Analyzer (AVRORA), whose TL is dynamically and algorithmically consistent with the Regional Ocean Modeling System (ROMS). The variational representer method is implemented in a series of 2-day time windows, with initial conditions corrected at the beginning of each window. A 4-day forecast is then run using SHOC with the corrected initial conditions. In the next assimilation window, the last two days of the 4-day forecasts are used as the background for AVRORA linearization and the same assimilation procedure is repeated. The assimilation and forecasts are cycled for the austral summer of 2012 for two months. The assimilation improves the accuracy of analyses and forecasts of upwelling events along the Bonney Coast. This study demonstrates that variational data assimilation is feasible in a nonlinear ocean model without its own TL and ADJ codes, using variational codes from another ocean model with similar physics. This opens the door for ocean models to borrow variational codes from other ocean models to perform variational data assimilation and to develop hybrid ensemble-variational data assimilation scheme.


Keywords: variational data assimilation, ROMS, SHOC, AVRORA, coastal upwelling, representer method
Parallel Session

SCI-PS253.02 - Assimilation of VIS/NIR reflectance data into the detailed snowpack model SURFEX/ISBA-Crocus

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Physically based multi-layer snowpack models are used for numerous scientific and operational applications such as avalanche hazard forecast. Although snow models perform reasonably well, differences with observed snowpack conditions exist and, weather forcing inputs are known to be a major source of uncertainty. Yet, no snow observations are assimilated into the snow model SURFEX/ISBA-Crocus driven in French mountainous regions by the SAFRAN meteorological analysis and downscaling tool. Thus, simulation errors accumulate over the winter season. The aim of our work is to assimilate data from visible and near-infrared imagers into the snowpack model to improve snowpack simulations. The new radiative transfer scheme of SURFEX/ISBA-Crocus allows to compute spectrally-resolved reflectance values as diagnostic variables of the model. These reflectances are sensitive to snow properties such as grain size and impurity content. They are also measured by several satellites and can thus be used in an assimilation framework to account for the high spatial and temporal variability of the snow cover in mountainous areas. Prior to assimilation, the relationships between albedo and model prognostic variables must be examined. Consequently, we performed numerous sensitivity tests to investigate the behavior of the snowpack model and identify the best assimilation scheme to be implemented. First tests of reflectance assimilation in the snowpack model have been done using punctual simulation and observation at Col de Porte site (French Alps). The benefit of the assimilation has been evaluated in terms of simulated snow properties.

Keywords: Assimilation, Reflectance, Snow, Remote-sensing
Here we describe a new system implemented recently at the Canadian Meteorological Centre (CMC) entitled the Global Ice Ocean Prediction System (GIOPS). GIOPS has been developed as part of the Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) tri-departmental initiative between Environment Canada, Fisheries and Oceans Canada and National Defence. The development of GIOPS was made through a partnership with Mercator-Océan, a French operational oceanography group. GIOPS provides ice and ocean analyses and 10 day forecasts daily at 00GMT on a global 1/4° resolution grid. GIOPS includes a full multivariate ocean data assimilation system that combines satellite observations of sea level anomaly and sea surface temperature (SST) together with in situ observations of temperature and salinity. In situ observations are obtained from a variety of sources including: the Argo network of autonomous profiling floats, moorings, ships of opportunity, marine mammals and research cruises. Ocean analyses are blended with sea ice analyses produced by the experimental Global Ice Analysis System. Atmospheric fluxes for 10 day forecasts are calculated using fields from CMC’s Global Deterministic Prediction System. GIOPS has undergone a rigorous evaluation of the analysis, trial and forecast fields demonstrating its capacity to provide high-quality products in a robust and reliable framework. In particular, SST and ice concentration forecasts demonstrate a clear benefit with respect to persistence. These results support the use of GIOPS products within other CMC operational systems, and more generally, as part of a Government of Canada marine core service.

Keywords: ocean modelling, data assimilation, operational oceanography
Parallel Session

SCI-PS253.04 - Ensemble-variational sea ice data assimilation

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The Regional Ice Prediction System is being developed at the Canadian Meteorological Centre in collaboration with the Canadian Ice Service. The forecast component of the system uses the CICEv4.0 model to produce 48hr sea ice forecasts with atmospheric and oceanic forcings from the operational global atmospheric and ice-ocean prediction systems. The analysis component is a 3DVar data assimilation system that estimates sea ice concentration from passive microwave, scatterometer, and ice chart observations. Currently, the system uses static and homogeneous background error covariances. However, for the sea ice state, real background uncertainties can be highly dependent on the state itself (e.g. larger errors close to the ice edge than in open water or pack ice). This research aims at introducing spatially and temporally varying background error covariances into the assimilation system. We do so by estimating these covariances from the ensemble spread of background states in an ensemble of 3DVar assimilations. This presentation will focus on validation of the ensemble spread through comparisons with actual background error estimates. Approaches to address the specific challenges of accounting for model error in a sea ice prediction system will be presented. These include state-dependent additive inflation, perturbing atmospheric and oceanic forcings, using perturbed model parameters. We will also present the first results of ensemble-variational sea ice data assimilation.

**Keywords:** EnVar, sea ice
Moisture transport to Antarctica is a significant factor in determining the mass balance of the continental ice sheet, and consequently global sea levels. Synoptic-scale cyclones are well known to transport moisture towards Antarctica, but the large-scale conditions under which cyclones can transport significant amounts of moisture and what factors control the transport remain unclear. To address this we use OpenIFS, a version of the Integrated Forecast System (IFS) used at ECMWF for operational weather forecasting that has been made available to academic and research institutions under license since early 2013. Multiple southern hemisphere winters are simulated, cyclones which result in a large meridional moisture flux are identified, and their structure and evolution analysed. Initial results from case studies show that the presence of a large-scale diffluent trough at upper levels leads to the development of cyclones which transport large amounts of moisture polewards and that large evaporation rates in the warm sector of cyclones also correlate well with high meridional moisture transport. Surface evaporation is strongly affected by sea surface temperatures and sea ice extent. Therefore, to identify how meridional moisture transport by cyclones is related to sea ice extent, additional sensitivity experiments are conducted in which the sea ice extent is altered.

**Keywords:** extratropical cyclones, moisture transport, Antarctica, sea ice
Parallel Session

SCI-PS254.02 - A multi-scale perspective of Arctic to tropical interactions for a high impact event over Europe

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In order to improve predictive capability of numerical weather prediction models beyond timescales of days to weeks, it is essential to strengthen the physical understandings of features and their interactions over a wide-range of horizontal scales. While global circulation models (GCMs) may not fully resolve important smaller-scale features, higher resolution limited area models (LAM) can be sensitive to the larger-scale choice of initial and boundary conditions downscaled from a relatively coarse global model. Here, we examine a high impact weather event (Dagmar) to evaluate the significance of particular features that we hypothesize are important in achieving longer-term forecast skill. One such feature are tropopause polar vortices (TPVs), which are coherent, and often long-lived disturbances that are important for the formation of surface cyclones and hence the predictability of weather. To perform our experiments, we use a new fully compressible, nonhydrostatic, global model called the Model for Prediction Across Scales (MPAS) and the Weather Research and Forecasting (WRF) LAM to isolate the impact of traditional downscaling and nesting approaches. MPAS allows for local refinement of the horizontal grid such that there is a smooth transition in resolution from the relatively coarse global mesh to finer mesh in regions of primary interest. Experiments will evaluate a particular case testing the significance of accurately simulating global interactions from meso- to large-scales and the subsequent impacts on the longer-term atmospheric flow. Results will be discussed in the context of the role that TPVs have in connecting Arctic to tropical interactions through jet stream dynamics.

\textbf{Keywords:} Arctic and tropical interactions, tropopause polar vortex, Dagmar, multi-scale processes
Parallel Session

SCI-PS254.03 - An examination of the persistent Northern Hemisphere cold pool during the winter of 2013-2014

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Observations since the 1940’s have shown that the preferential formation zones for the coldest air masses in the Northern Hemisphere are generally located near the Northwest Territories and Yukon of Canada as well as the Siberian regions of Russia. However, considerable inter-annual and decadal variability exists with recent decades (the past 30 years) indicating that the coldest air masses have been more commonly found over northwestern Canada and/or Greenland. The winter of 2013-2014 however has deviated significantly from climatology in that the coldest air masses have consistently formed over Canadian provinces that are east of the usual formation zones, in association with a polar vortex that has generally resided in the vicinity of Hudson Bay. This study will endeavour to 1) place the winter of 2013-2014 in historical context through a comparison of the persistence, areal extent, and intensity of the cold pool relative to the last 60 years, and 2) understand the mechanisms responsible for the persistence and intensity of the cold pool. Early indications suggest persistent warmth over the eastern portion of the North Pacific has helped anchor a warm upper-level ridge over the western portions of Canada and the United States resulting in persistent troughing downstream. Furthermore, abnormal warmth over the polar oceans also favors colder temperatures and lower pressures in the upper-troposphere at lower latitudes in association with the Arctic Oscillation teleconnection pattern.

Keywords: polar, vortex, winter, persistent
Parallel Session

SCI-PS254.04 - Dynamical coupling between high and low latitude regions during 2009 sudden stratospheric warming event

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Dynamical coupling between high and low latitude regions is very important for forecast point of view. For instance the effect of sudden stratospheric warming (SSW) is found to be directly linked between high and low latitude regions. Significant temperature changes are observed in stratosphere and tropopause area from polar to tropical region during a major SSW event that occurred in Jan 2009. SSW event strongly modified the polar and tropical stratospheric circulation pattern and the newly emerged pattern, after termination of SSW, dominated for ~ 2-3 months. Stratospheric and tropospheric region have shown certain unique changes after the event such as a clear downward propagating cold phase at polar region seen which is located at similar heights as that of warming phase. The magnitude of this cold phase was ~ -80°C whereas the temperature prevailed of ~ 40°C in upper stratosphere (>30 km altitude) during warm phase. On the other hand, during cold phase at polar region that followed after the SSW event, a new warm motion emerged over tropical region. Strong implications of these unusually warm and cold phases are shown. Specifically it altered the cold point tropopause temperature and its height significantly for a period of ~2-3 months from polar to tropical region. SSW event also affected the tropical atmospheric stability, which is reduced during the event. Cross equatorial response from northern to southern hemisphere of cold and warm anomalies are also observed.

Keywords: Sudden Stratospheric Warming, Dynamical coupling between high and low latitude regions, Stratospheric dynamics, Radio Occultations/ COSMIC FORMOSAT
Parallel Session

SCI-PS255.01 - Earth's flattening: which impact for meteorology and climatology?

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Centrifugal effects of the Earth's diurnal rotation are neglected in current meteorological and climatological models. This approximation, known as 'spherical geopotential approximation' (SGA) results in two types of simulation errors: geometric errors (e.g. the distances are erroneous on the model's horizontal surfaces) and gravity errors (e.g. the intensity of gravity is erroneous since its meridional variations may not be represented). These errors are thought to be systematic and cumulative in time, and it is argued that as the quality of simulations and forecasts progressively increases, they might adversely affect the quality of long-range predictions. Recent studies, mostly conducted at U.K. Met Office, have brought to light how dynamically-consistent governing equations systems can be practically formulated in axially-symmetric non-spherical geometries, and in particular in ellipsoidal geometries, where horizontal surfaces around the Earth are represented by concentric oblate spheroids. This latter 'ellipsoidal geopotential approximation' (EGA) allows a reduction of geometric and gravity errors by two orders of magnitude. Dynamically-consistent models in EGA may now be built with optional application of various other approximations, such as shallow-water, shallow-atmosphere, or hydrostatic ones, as well as in the fully-accurate deep-atmosphere non-hydrostatic framework. A short review of the recent progresses on this topic will be made, and early results of comparisons between SGA and EGA simulations with shallow-water and with shallow-atmosphere hydrostatic models will be presented. This suggests that centrifugal effects should be taken into account without further ado, at least for long-range predictions.

Keywords: governing equations, spheroid ellipsoid geoid, geopotential, geometry
Parallel Session

SCI-PS255.02 - Sensitivity of short-range forecasting with the AROME model to a modified semi-Lagrangian scheme and high-resolution.

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AROME (Seity et al. 2010), the operational model at Météo-France for short-range and fine-scale weather prediction (with a 2.5-km horizontal grid spacing), uses a semi-implicit temporal scheme and a semi-Lagrangian (SL) advection scheme with a physical package including microphysical, shallow convection, surface, radiation and 1D turbulence schemes. The lack of conservation in the SL scheme is suspected to generate too intense outflows under convective cells with unrealistic structures when using a strong diffusion. We have tested a SL scheme using the COMA D (COntinuous MAping at Departure) correction (Malardel and Ricard, 2014), applied to the original interpolation weights, that takes into account the deformation of air parcels along each direction of interpolation. This corrected SL scheme is tested for different periods and in particular for cases of deep convection for which divergent modes are important with a strong interaction between the dynamical core and the physical parameterizations. The evaluation is based on subjective analysis but also on objective diagnostics (classic and fuzzy scores, precipitation distribution, spectra). The density currents are less intense and the positive bias in precipitation is reduced with a significant diminution in the occurrence of moderate to heavy precipitation. In the near future, the resolution of AROME-France will be increased to 1.3-km horizontal grid spacing and 90 vertical levels. Tests are currently carried out to assess the benefit of this finer resolution for forecasting thunderstorms. Results show an improvement in precipitation forecasts with more small convective cells and less large ones which is more consistent with radar data.


Keywords: semi-Lagrangian scheme, high-resolution, convection
Parallel Session

SCI-PS255.03 - Inherently mass-conservative semi-Lagrangian transport scheme and global hydrostatic atmospheric model

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Cell-integrated semi-Lagrangian (CISL) approach ensures local mass-conservation and shape-preservation during numerical solution of advection equation while allowing for longer time-steps as compared to the Eulerian schemes. The important part of CISL schemes is the integration of the tracer density over the Lagrangian control volume. Here we present the 3D CISL scheme that uses cascade approach (CCS-RG). The cascade approach allows splitting the three-dimensional integration in three subsequent one-dimensional integrations. CCS-RG uses reduced lat–lon grid, i.e. the grid where the number of points in longitude at each latitude circle is gradually diminished while approaching the pole. Three-dimensional tracer transport cases from the Dynamical Core Model Intercomparison Project (Kent et al., 2013) were carried out to test the performance of the CCS-RG. The accuracy was found to be comparable with other mass-conservative semi-Lagrangian and Eulerian schemes. The impact of the reduced grid with 20% less points than in the regular grid of the same resolution at the equator is found to be negligible. The presented mass-conservative scheme was applied to discretize continuity equation in the global hydrostatic semi-implicit semi-Lagrangian model SL-AV (Tolstykh, 2010). This results in the inherently mass-conservative version of SL-AV. The baroclinic instability (Jablonowski and Williamson, 2006) and Held-Suarez test cases results showed good agreement between mass-conservative SL-AV, SL-AV and results from other models available in literature. The mass conservative SL-AV also showed good performance in the medium-range weather forecast test.

Keywords: semi-Lagrangian, advection, mass-conservation, hydrostatic atmosphere
Parallel Session

SCI-PS255.04 - Achieving seventh-order amplitude accuracy in leapfrog integrations

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The leapfrog time-stepping scheme makes no amplitude errors when integrating linear oscillations. Unfortunately, the Robert–Asselin filter, which is used to damp the computational mode, introduces first-order amplitude errors. The Robert–Asselin–Williams (RAW) filter, which was recently proposed as an improvement, eliminates the first-order amplitude errors and yields third-order amplitude accuracy. However, it has not previously been shown how to further improve the accuracy by eliminating the third- and higher-order amplitude errors. Here, it is shown that leapfrogging over a suitably weighted blend of the filtered and unfiltered tendencies eliminates the third-order amplitude errors and yields fifth-order amplitude accuracy. It is further shown that the use of a more discriminating \( (1, -4, 6, -4, 1) \) filter instead of a \( (1, -2, 1) \) filter eliminates the fifth-order amplitude errors and yields seventh-order amplitude accuracy. Other related schemes are obtained by varying the values of the filter parameters, and it is found that several combinations offer an appealing compromise of stability and accuracy. The proposed new schemes are tested in numerical integrations of a simple nonlinear system. They appear to be attractive alternatives to the filtered leapfrog schemes currently used in many atmosphere and ocean models.


Keywords: leapfrog, time-stepping, RAW filter, numerical modelling
Parallel Session

SCI-PS256.01 - Tigge Ensemble Forecasts with useful skill-spread relationships for African Meningitis and Asia Streamflow Forecasting

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One potential benefit of an ensemble prediction system (EPS) is its capacity to forecast its own forecast error through the ensemble spread-error relationship. In practice, an EPS is often quite limited in its ability to represent the variable expectation of forecast error through the variable dispersion of the ensemble, and perhaps more fundamentally, in its ability to provide enough variability in the ensembles dispersion to make the skill-spread relationship even potentially useful (irrespective of whether the EPS is well-calibrated or not). In this paper we examine the ensemble skill-spread relationship of an ensemble constructed from the TIGGE (THORPEX Interactive Grand Global Ensemble) dataset of global forecasts and a combination of multi-model and post-processing approaches. Both of the multi-model and post-processing techniques are based on quantile regression (QR) under a step-wise forward selection framework leading to ensemble forecasts with both good reliability and sharpness. The methodology utilizes the ensemble’s ability to self-diagnose forecast instability to produce calibrated forecasts with informative skill-spread relationships. A context for these concepts is provided by assessing the constructed ensemble in forecasting district-level humidity impacting the incidence of meningitis in the meningitis belt of Africa, and in forecasting flooding events in the Brahmaputra and Ganges basins of South Asia.


Keywords: Tigge, skill, spread, post-processing
A weather regime is a persistent and/or recurrent large-scale atmospheric circulation pattern which is associated with specific weather conditions on a regional scale. Accurate simulations of weather regimes are important in weather and climate. The predictability of Euro-Atlantic weather regimes at medium-range timescales (up to 384hr) are investigated for winter (December-February) in the periods 2006/07-2012/13 and 1984/85-2012/13 using the THORPEX Interactive Grand Global Ensemble (TIGGE) and NOAA’s Global Ensemble Forecasting System (GEFS) reforecast datasets, respectively. In the TIGGE data, we focus on five of the leading operational NWP centres: CMC, ECMWF, JMA, NCEP, and UKMO. The NOAA’s reforecast data has been produced with a fixed numerical model, whereas the TIGGE data has been produced with a various versions of operational numerical model. The positive and negative phases of the North Atlantic Oscillation (NAO+ and NAO-), Atlantic ridge (ATLR), and Euro-Atlantic blocking (EABL) are detected as weather regimes over the Euro-Atlantic region from the ERA-Interim data. The NWP models have common biases in the frequency of regime transitions, and therefore the models prefer NAO- and ATLR to NAO+ and EABL with lead time, compared with the ERA-Interim. The models show small skill differences regarding probabilistic regime forecasts, suggesting that the skills of regime forecasts strongly depend on atmospheric flows. The models show higher forecast skills when predicting NAO+ and NAO-. The persistence of NAO- is the most predictable. In contrast, EABL forecasts from ATLR have the lowest skill, followed by ATLR forecasts from NAO+, ATLR, and EABL.

**Keywords:** predictability, weather regime, medium-range ensemble forecast, TIGGE
Parallel Session

SCI-PS256.03 - How predictable was the 2014 North American cold wave in medium-range forecasts?

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We have developed the website at http://goo.gl/WDfTpc to show the ensemble-based products for extreme weather events up to 15 days, using the four global NWP centers: ECMWF, JMA, UK Met Office and NCEP in the TIGGE database. Using the products we examined how predictable the 2014 North American cold wave in medium-range ensemble forecasts. There are four products available; heavy precipitation, strong wind, high temperature and low temperature. In each case, the extreme weather is identified by comparing the actual model forecast values with the model forecast climatology. As each model has the different climatological forecast PDF and it is different from the observational PDF, we decided to use the percentiles (not real number, such as 50 mm/day for heavy precipitation) of 90th, 95th and 99th in the climatological forecast PDF in each model. Occurrence probability of an extreme event at each grid point is calculated by the fraction of ensemble members that predict a higher/lower values than the specified “climatological” percentile to the total ensemble members. A website includes a verification data, which is the analysis in each model, except for precipitation (GSMaP has been used in this study), to see how the products is good or not. The occurrence probability maps of 10-day forecasted extreme cold surface temperature, which is valid at 12UTC 1 January 2014 in North America shows the high potential of cold wave over North America, and also mild weather over Europe during the same period.


Keywords: TIGGE, midium-range global ensemble forecasts
SCI-PS256.04 - Evaluation of TIGGE ensemble predictions of Northern Hemisphere summer precipitation during 2008-2012

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The ensemble mean quantitative precipitation forecasts (QPFs) and probabilistic QPFs (PQPFs) from six operational global ensemble prediction systems (EPSs) in The Observing System Research and Predictability Experiment (THORPEX) Interactive Grand Global Ensemble (TIGGE) dataset are evaluated against the Tropical Rainfall Measuring Mission (TRMM) observations using a series of area-weighted verification metrics during June to August 2008-2012 in the Northern Hemisphere (NH) midlatitudes and tropics. Results indicate that generally the European Centre for Medium-Range Weather Forecasts (ECMWF) performs best while the Canadian Meteorological Centre (CMC) is relatively good for short-range QPFs and PQPFs at light precipitation thresholds. The overall forecast skill is better in the NH midlatitudes than that in the NH tropics. QPFs and PQPFs from China Meteorological Administration (CMA) have very little discrimination ability of different observed rain events in the NH tropics. The day +1 QPFs from Japan Meteorological Administration (JMA) have remarkably large moist biases in the NH tropics, which leads to the discontinuity of forecast performance with the lead time. Performance changes due to the major model upgrades during the five summers are also examined using the forecasts from CMA as the reference to eliminate the interannual variation. After the model upgrade, the excessively enlarged ensemble spread of CMC increases the forecast errors, while the QPFs and PQPFs from the US National Centers for Environmental Prediction (NCEP) are significantly improved in various verification metrics.

Keywords: TIGGE, probabilistic quantitative precipitation forecast (PQPF), Ensemble Prediction System (EPS), verification
The parameterization of turbulent and convective mixing in weather, seasonal and climate prediction models has been a major challenge in meteorological research for a long time. In particular, different parameterizations are used, and patched together often artificially, for different types of convection: dry or moist, in the boundary layer or in the full troposphere. The Eddy-Diffusivity (ED) approach has been successful in representing some characteristics of neutral boundary layers and surface layers in general. The Mass-Flux (MF) approach, on the other hand, has been used for the parameterization of shallow and deep moist convection. In this presentation, a new approach that relies on an optimal combination of the ED and MF parameterizations (EDMF) is discussed in detail as a possible solution for the unification of the parameterizations of convective mixing in global atmospheric models. In particular we will present results from a new stochastic EDMF approach coupled to cloud microphysics that unifies the representation of convection in weather and climate prediction models: One parameterization that represents the effects of dry, shallow and deep moist convection in the atmosphere.

**Keywords:** Parameterizations, Convection, Boundary Layer, NWP
In a context of increasing complexity of climate models through the addition of various interactive schemes, the treatment of cloud subgrid-scale structure is a significant source of uncertainty when the radiative transfer scheme is applied, even if a complex microphysics scheme is used and could provide such information. Instead, models often use tuning parameters in order to correct homogeneous cloud radiative biases even if it leads to compensating biases and simulated clouds or precipitation that disagree with observations. The Monte Carlo Independent Column Approximation (McICA, Pincus et al., 2003) and its stochastic cloud generator (Räisänen et al., 2004) were created to address this issue by replacing fixed and biased hypotheses with flexible and unbiased cloud fraction overlap and cloud water horizontal variability assumptions, independently of the radiative transfer scheme. This method is currently used in several climate and numerical weather prediction models. For the Global Environmental Multi-scale (GEM) model (used as a climate and NWP model), the McICA methodology has been implemented and compared to other cloud scaling parameterizations. Results will show how surface (SFC) and top of atmosphere (TOA) radiative budgets are affected differently and how the different cloud phases contribute to these modifications. A comparison with satellites observations will be presented to validate modeled relationship between TOA fluxes and cloud water content.


Keywords: cloud inhomogeneity, subgrid-scale parameterization, Monte Carlo Independent Column Approximation
Parallel Session

SCI-PS257.03 - A data-driven stochastic parameterization of deep convection

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We use a data-driven stochastic method based on conditional Markov chains to construct a parameterization for deep convection. The Markov chains consist of 5 states, each corresponding to a cloud type, and form area fractions for each cloud type. The transition probabilities are estimated from an extensive data set of radar observations of clouds. The Markov chains are conditioned on the mean vertical velocity, which is the large-scale forcing displaying the highest correlation with deep convection. After the training process, we implement the parameterization in a simplified general circulation model. The deep convective area fractions produced by the Markov chains are used as a closure for the mass flux at cloud base. We compare the stochastic scheme with a deterministic relaxation scheme by looking at precipitation patterns, Hovmoller diagrams and wavenumber-frequency diagrams and show that the impact of the new scheme is large. The stochastic scheme shows promising MJO-like patterns.


Keywords: Deep convection, Stochastic parameterization, data-driven, Conditional Markov chains
Parallel Session

SCI-PS257.04 - Convection-permitting, multiscale modeling with the HARMONIE forecast system

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The HARMONIE forecast system (Hirlam Aladin Research for Mesoscale Operational NWP In Europe) that is jointly developed by the ALADIN and the HIRLAM consortia, is a multi-physics system targeted at the convection permitting scales. Two model configurations are currently used from this system; the Arome model and the Alaro model, reflecting two historical strategies in the treatment of deep convection. In Arome there is no parameterization of deep convection, while Alaro is developed around the concept of a scheme called 3MT that aims at scale-independent model behavior in the so-called gray zone (resolution of 10 km to 1 km). The two models are used within both consortia for different applications; Arome has been a vehicle for rapidly increasing the resolution of the applications, while Alaro strives at a seamless transition for the mesoscale to the convection permitting scale. In this talk we will discuss the definition of the system via a thermodynamical flux-conservative coupling of the physics to the dynamics. Secondly, the scientific basis of the 3MT scheme (Modular, Multiscale Microphysics Transport) will be explained. Seamlessness of the behavior in the gray zone of deep convection will be illustrated by a few cases and the scaling of the statistical properties of precipitation extremes. Finally, the multi-physics nature will be illustrated by a few examples of running different configurations of the HARMONIE system.


Keywords: weather forecast, convection-permitting, multiscale, seamless
SCI-POS1009 - Seasonal trends, variability and relationship of soil moisture with precipitation in the Philippines

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Despite being an essential climate variable and its role in land-atmosphere interactions, studies on soil moisture has barely spurred interest due to limited data resources and challenges in obtaining soil moisture measurements. Because of its direct association with rainfall, monitoring soil moisture is crucial to the climate change vulnerable Philippines, which has been scathe by severe typhoons, torrential rains brought by monsoon, rainfall-triggered floods and landslides over the past year. In this study, time series analysis, correlation and regression studies were employed to investigate on the seasonal trends and variability of soil moisture across the country, as well as to determine the influence of precipitation on soil moisture. Also, seasonal soil moisture maps were produced to detect areas vulnerable to extreme moisture conditions. This is the first study in the country that looks into the soil moisture of the Philippines using satellite data. It provides a more comprehensive and continuous seasonal record of soil moisture of the country that will be useful for crop and agricultural land monitoring. In addition, the same dataset can be used as basis for providing early-warning system for extreme weather and climate related events such as drought, flood and landslide.

Keywords: soil moisture, Philippines, AMSR-E, land-atmosphere interaction
SCI-POS1011 - CentNet—A deployable 100-station network for surface exchange research

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Improvement of model surface parameterization schemes continues to require near-surface observational data covering a wide variety of surface and stability conditions. NCAR/EOL currently provides a facility to the research community to make direct eddy-covariance flux observations to quantify surface-atmosphere interactions. However, just as model resolution has continued to increase, there is a need to increase the spatial density of flux measurements to capture the wide variety of scales that contribute to exchange processes close to the surface. NCAR/EOL now has developed the CentNet facility, that would have on the order of 100 surface flux stations deployable for periods of months to years. Each station would measure standard meteorological variables, all components of the surface energy balance (including turbulence fluxes and radiation), atmospheric composition, and other quantities to characterize the surface. Thus, CentNet also can support observational research in the biogeoosciences, hydrology, urban meteorology, basic meteorology, and turbulence. CentNet has been designed to be adaptable to a wide variety of research problems while keeping operations manageable. Tower infrastructure has been designed to be lightweight, easily deployed, and with a minimal set-up footprint. CentNet uses sensor networks to increase spatial sampling at each station. The data system saves every sample on site to retain flexibility in data analysis. We welcome guidance on development and funding priorities as we build CentNet.

Keywords: eddy-covariance, sensor network, observations
Poster Session

SCI-POS1016 - Data management methods in the service of supporting background for regional climate prediction

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Being fully aware of past and present climate conditions is essential for carrying out successful forecasts on any time scale. Several observational datasets and reanalysis fields are available to provide background for various types of forecasts, among others by supporting the process of calibration or verification; however, it can often be confusing to decide what source to rely on. Given the differences in measurement and data management of individual countries, an optimal system is constructed using quality controlled data and applying unified methodology. In this work we present the production of such a regional gridded database of various meteorological parameters by introducing the CARPATCLIM (Climate of the Carpathian Region) project and its comparative examination with a number of reanalyses. We review an example of the process of regional seasonal forecast through our experiences in participating in the South East European Climate Outlook Forums. At the sessions of this international cooperation seasonal forecasts are being assembled for the following season in the form of a consensus statement by the attending experts. The differences of climatological background, base periods and verification methods used by the 18 participating countries raise several questions. In this work we attempt to summarize the obstacles we are facing in the frame of such a cooperation as well as to give an overview on how the methods used in creating the mentioned dataset might help overcoming them, especially regarding data policies and verification of the forecast products.

Keywords: data management, seasonal forecast, verification
SCI-POS1018 - Using webcam imaging to validate the SAFNWC Cloud Top Height product over Switzerland

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Fog or low stratus clouds (FLS) are common weather conditions over the Swiss Plateau between October and February. Elevation and thickness of FLS are of chief interest to the aviation sector as their presence may represent a safety threat to air travel. Direct observation of the upper limit of FLS is however difficult if not impossible. The satellite-derived product SAFNWC “Cloud Top Temperature and Height” (SAFNWC CTTH), which integrates MSG SEVIRI and NWP data (e.g. COSMO-7 or COSMO-2 at MeteoSwiss), is therefore a very valuable tool to abridge the issue. It provides cloud top height (CTH) estimates at a fine spatio-temporal resolution using IR brightness temperature measurements. Throughout the 2013/14 winter, a validation of the SAFNWC CTH product, processed over the central part of the Alps, was performed using 41 available webcams as independent reference. As a preliminary result following an analysis of 64 manually-processed observations from 27 days between October and December with ideal FLS conditions (i.e. at least one webcam above the cloud top), SAFNWC CTH was found to give correct height estimates in around 75% of the cases. Discrepancies found between the estimated SAFNWC CTH and observations from webcams may be attributed to low optical thickness of the clouds, the presence of multiple cloud layers (e.g. thin cirrus) or sub-grid-sized cloudiness which is filtered out in the SAFNWC algorithm. The poster will present final results of the analysis.

**Keywords:** cloud top height, Swiss plateau, fog, satellite product
Poster Session

SCI-POS1038 - Sensitivity experiments to design a regional assimilation system combining the LETKF and the WRF model

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This work is motivated by the necessity of developing a regional forecast and data assimilation system adequate to be run operationally by the Argentine Weather Service. To accomplish this goal our strategy is based on the combination of the Local Ensemble Transform Kalman Filter (LETKF) implemented in the Weather Research and Forecasting model (WRF). A series of sensitivity experiments using OSSE approach have been designed to analyze the error growth and evaluate the optimum combination of model and boundary settings. The main purpose is to produce an adequate ensemble spread taking into account the different error sources. This set of experiments has been done with 40 ensemble members, adapting covariance inflation and relatively low resolution (aprox. 100 km horizontal grid spacing) given limited computational resources available. Experiments include: perfect and imperfect model with perfect and imperfect boundary conditions (i.e. 5 different cases). Perfect model / Perfect boundary refer to the same model configuration and boundary conditions used to generate the “true state”. The imperfect model is obtained changing model parameterizations with respect to the “true state” run, while the imperfect boundary conditions are provided by introducing errors in the lateral boundary conditions. Results show that, in general, adaptive inflation makes a good job in adjusting the ensemble spread, still, there is a need to implement additional approaches like using diverse parameterizations and boundaries perturbations to better represent the different sources of error.

Keywords: Local Ensemble Transform Kalman Filter, Weather Research and Forecasting model, error sources
Quantitative evaluation of the impacts of observations in NWP models is an increasingly important requirement for meteorological services. The adjoint-based Forecast Sensitivity to Observations (FSO) is a powerful tool for assessing observation impacts. FSO impacts represent individual observations’ contributions to forecast error reduction, and can be combined to assess the relative impact of whole observing systems. The ‘impact per observation’ can be a useful variable to consider, but its properties mean that it may not be the most appropriate for evaluation of observing networks. A useful variable is the ‘cost:impact ratio’ – the average impact of an observation type divided by the overall cost of the network (for a chosen time period). This variable avoids some of the issues inherent to ‘impact per observation’, and comparisons have clear potential to provide evidence to inform network business cases. Such an analysis could even influence the overall design of the global observing system. In this work, we suggest appropriate methods of representing the ‘cost:impact ratio’ of Met Office (UK) observing networks, starting with analysis of their impact upon 24-hour global forecasts. We also discuss the possible pitfalls in the interpretation of results, and provide insight into their proper interpretation and potential applications.

**Keywords:** FSO, Impact, Cost, Observation
Poster Session

SCI-POS1046 - Observation Impacts Using the Gridpoint Statistical Interpolation Data Assimilation System for Regional Applications

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The Grid Point Statistical Interpolation (GSI) Data Assimilation (DA) System is a three-dimensional (3D-Var) and hybrid DA system currently used by various United States (US) agencies as part of operational systems for both regional and global applications. In 2013, the Air Force Weather Agency (AFWA) updated their operational system to GSI. The GSI is also a community research model with public access supported and released by the Developmental Testbed Center (DTC). The DTC annually releases an updated GSI code and performs various testing and evaluation activities to test the capability and robustness of the GSI system for regional applications. GSI has users in both research and operations within the US and internationally on domains outside the contiguous US (CONUS). The DTC is working to identify and understand issues when running GSI over data-sparse regions and domains with complex terrain. This work will investigate observation impacts over regional theaters around the globe by running a functionally similar system to AFWA operations. The functionally similar system includes assimilation of conventional (including surface) observations, satellite radiances, and Global Positioning System Radio Occultation (GPSRO) soundings. Understanding the impacts of these observations on forecast performance gives vital information for AFWA operations, especially in data-sparse regions. Thus, the forecast sensitivity from select observations of interest is investigated. Additionally, research to understand and diagnose a discrepancy in the GSI procedure to update the surface pressure field, evident in the derived sea level pressure field is addressed.

Keywords: Data Assimilation, Observation Impacts, Gridpoint Statistical Interpolation
SCI-PS158.02 - An adaptive data assimilation approach and tests

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In this paper, a four-dimensional ensemble-variational (4DEnVar) hybrid assimilation approach called dimension-reduced projection four-dimensional variational (DRP-4DVar) assimilation is proposed, which is originally based on the samples of historical forecasts (Wang et al, 2010; Liu et al, 2011). First, it is a four-dimensional variational (4DVar) approach because its optimal analysis is a solution to a 4DVar cost function. Second, it is an adjoint-free and ensemble-based method, because the tangent linear model and adjoint model necessary for the standard 4DVar are replaced by a linear statistical relationship matrix between the initial perturbation and the simulated innovation using historical forecast information near the initial time and its transpose. A time-saving localization technique is also proposed for DRP-4DVar to further reduce the cost of analysis. Finally, the hybrid use of historical forecast samples and some flow-dependent samples keeps updating in assimilation cycle makes the DRP-4DVar adaptive and in particular naturally overcomes the filtering divergence existing in all ensemble-based assimilation approaches (Lu et al, 2013). Ideal tests and case studies show that the DRP-4DVar can achieve reasonable performance to improve the initial conditions and the corresponding forecasts. Some results even indicate that the DRP-4DVar has comparable or even better performance than standard 4DVar.


Keywords: DRP-4DVar, Localization, Adaptive, Timesaving
SCI-POS1067 - Verifying NWP model analyses and forecasts using simulated satellite imagery

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Simulated satellite imagery is a way of interpreting numerical weather prediction (NWP) model output and presenting it as if it were a satellite image. The imagery is created using a fast radiative transfer model, RTTOV-11, to calculate a top of atmosphere brightness temperature from NWP model surface parameters and profiles of pressure, temperature, humidity and cloud properties from every NWP model grid-point. When the brightness temperatures are plotted as an image this can be compared with observed satellite imagery. Currently simulated imagery is produced for Meteosat and GOES-E in water vapour and IR channels from Global and, for Meteosat, high resolution model configurations. Simulated satellite images are used by forecasters at the Met Office. They can be compared to real satellite images to quickly verify the model analyses and forecasts or where real imagery is not yet available to provide a forecast satellite image. Simulated imagery can also be used by research scientist to determine how an experimental model change alters the cloud and moisture in the model compared to a control and observations. Work on computing quantitatively how well the simulated imagery from the models fit the measured data is ongoing and various techniques are being tested including analysis using Fourier transforms of the simulated and observed images. This will provide a quick metric of how well the model fields fit the measured data and hence the likely accuracy of the forecasts from the model.

Keywords: verification, radiative transfer, simulated brightness temperatures
Atmospheric Motion Vectors (AMVs) have long stood as an important contributor of tropospheric wind information to analyses and NWP on the global scale. The latest in the series of U.S. operational geostationary satellites, GOES-R, will allow superior cloud-tracking and AMV generation on time scales that will be useful for mesoscale applications as well. Upon the expected launch in 2016, GOES-R will provide a significant improvement in the temporal sampling of images, with a routine refresh of 5 minutes over the CONUS region, and 1 minute over smaller regions targeting interesting weather events (e.g. severe weather, tropical cyclones). GOES-R AMVs will be an important contributor to mesoscale analyses based upon recent studies using proxy rapid-scan datasets occasionally made available from the current GOES. In this presentation, we will highlight some examples regarding the potential for rapid-scan AMVs to make a positive impact on mesoscale data assimilation and NWP. One example is in applications to improve the initial analyses of tropical cyclones and their near environment. Accurately specifying the initial conditions in terms of vortex structure and environmental wind flows affecting it is paramount to achieving superior predictions of track and intensity. The cases of Hurricane Ike (2008) and Sandy (2012) will be presented, and illustrate the increased AMV coverage and improved definition of smaller-scale flow features. In collaboration with NOAA/ESRL and their rapid-refresh analysis/modeling systems, cases of severe weather outbreaks and forecast busts over CONUS are being studied to determine if the enhanced AMVs can be useful to these mesoscale applications.


Keywords: Atmospheric motion vectors, mesoscale analysis, tropical cyclones
Poster Session

SCI-POS1075 - A Numerical Study of Southern Ontario Squall Line Event in 2009 with Data Assimilation

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A high-resolution data assimilation and modeling system is being developed to improve the short-term numerical forecasts for the southern Ontario and Quebec region. In this system, we will deploy the ensemble-based data assimilation method to assimilate the O-QNet wind profiler data, conventional observations and radar data. The O-QNet is a network of ten wind profilers over southern Ontario and nearby area of Quebec, which provides hourly wind profiles in the whole troposphere. A benchmark test has been conducted using the 3-dimensional variational (3DVAR) data assimilation component in the Gridpoint Statistical Interpolation (GSI) system and the 3-km resolution Weather Research and Forecasting (WRF) model to simulate a squall line case, which spawned numerous tornadoes in Ontario on August 20th, 2009. The significant impact of data assimilation is noted on the short-time (3-9 h) forecasts for the convective initiation of the squall line. Compared with the radar observations, the control experiment without data assimilation produces an unrealistically strong convective system, while the data assimilation experiment assimilating the conventional observations and the O-QNet wind profiler data better captures the convective initiation (an initial narrow convective band). The subsequent forecasts of the squall line in the data assimilation experiment are improved by showing stronger intensity and better organization. The impact of assimilating various observations (conventional, O-QNet wind profiler, and radar) using the ensemble-based data assimilation methods on the short-term numerical forecasts of the squall line is under investigation. The ensemble analysis and forecast will be used to study the predictability of the squall line.

Keywords: squall line, data assimilation
The vertical height assignment of Atmospheric Motion Vectors (AMVs) constitutes the major error source for the total AMV wind error, which poses a severe issue for assimilation of AMVs in NWP models. In this study, we investigate how to correct AMV pressure heights firstly with independent satellite lidar observations from CALIPSO, and secondly by treating AMVs as layer-winds instead of winds at a discrete level (Folger and Weissmann, 2014; Weissmann et al. 2013). The wind verification is performed with operational radiosondes during an 8-month period in 2012/2013. The study shows that the wind error of AMVs above 700 hPa is reduced by 12-17% when AMV winds are assigned to 120 hPa deep layers below the lidar cloud tops. In addition, the lidar-AMV height correction is expected to reduce the correlation of AMV errors as lidars provide high resolution cloud top observations that are independent of the height assignment method used in the AMV processing.


Keywords: Atmospheric Motion Vectors, AMV height assignment
Poster Session

SCI-POS1083 - Quantification of the impact of T-PARC Typhoon Jangmi (2008) on the midlatitude flow

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Extratropical transition (ET) of a tropical cyclone (TC) can modify the midlatitude flow and impact the weather and predictability in downstream regions. This study uses a combination of model and observational data to investigate the interaction of T-PARC Typhoon Jangmi with the midlatitude circulation in September 2008. The contribution of ET to the midlatitude flow modification is quantified with a novel PV surgery technique. The joint interaction of the TC circulation with the midlatitude baroclinic zone and of the TC outflow with the upper-level jet results in substantial diabatically enhanced vertical transport of lower-tropospheric air that arrives tropopause level with low PV values and is further isentropically advected to the jet. This key physical process explains the ridgebuilding and the evolution of the jet streak to the Northeast of Jangmi, with upper-level PV being reduced by 6 PVU and the midlatitude jet enhanced by at least 25 m/s. Subsequently Jangmi decayed missing a region favourable for reintensification ahead of a midlatitude trough. Relocation experiments reveal a critical bifurcation point for the track of Jangmi in the midlatitude background flow. The relative position to this bifurcation point exhibits two contrasting scenarios. Firstly, decay of Jangmi accompanied by a broad ridge over the Pacific. Secondly, extratropical reintensification accompanied by a pronounced Rossby wave train and downstream cyclogenesis. The observed behaviour gives a simple explanation for the reduced predictability of the track and of the downstream midlatitude flow during ET and corroborates the crucial role of ET for the downstream midlatitude flow evolution.


Keywords: extratropical transition, T-PARC, potential vorticity inversion, tropical cyclone
SCI-POS1084 - T-NAWDEX-Falcon: Lagrangian observations of warm conveyor belt air masses

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The transport of water vapor in coherently ascending Warm Conveyor Belt (WCB) airstreams within extratropical cyclones governs large parts of diabatic processes in the mid-latitudes. These processes associated with latent heat release due to phase transitions of water, surface fluxes or radiative effects are highly relevant for the evolution and intensity of northern hemispheric mid-latitudes cyclones and the dynamics at the tropopause. Still, the representation of diabatic processes along WCBs is considered to be a limiting factor for the predictability of cyclones and downstream weather. In October 2012 the T-NAWDEX-Falcon (THORPEX-North Atlantic Waveguide and Downstream Impact Experiment) took place over Europe and nine research flights were conducted in WCBs. The aim was to quantify the transport of moisture and the net latent heating along the WCB. We present an overview on the efforts that were made to carry out Lagrangian matches of two consecutive flights. The Lagrangian connection between the performed flights and the observed data during different stages of the WCB is discussed. Besides in-situ observations of wind, temperature and humidity to characterize the thermodynamic structure of the WCBs, data of a set of dropsondes is shown to gain a complete view on the complex structure of the WCB.

Keywords: diabatic processes, water vapour
Poster Session

SCI-POS1085 - International cooperation and technological advances pave the way: from GARP (1967-1982) to THORPEX (2005-2014)

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Jacob BJERKNES declared 50 years ago: "But yet I would give highest recommendation to the less narrow and more basic field or meteorology which still is our first duty to society: WEATHER FORECASTING." He applauded the advent of satellite observations, but rejected the naive belief that reliable forecasts would be a by-product of Earth-observation from space. Conception and conduct of THORPEX profitted from a sequence of international field campaigns during the previous decades, e.g. the First GARP Global Experiment (FGGE, 1978/79) and ALPEX (1982) within the Global Atmospheric Research Programme (GARP), the Fronts and Atlantic Storm Track Experiment (FASTEX 1997) or the Mesoscale Alpine Programme (MAP, 1995-2005), all under the auspices of WMO and, since 1997, its World Weather Research Programme (WWRP). A mixed participation of meteorological services, university institutes and research laboratories was characteristic to all endeavours, while repeated participation of the same groups and key personalities provided continuity. Novel observational techniques (inter alia radar networks, dropsondes, lidar profiles) as well as specialized airborne and spaceborne platforms regularly provided extra motivation for the planning of campaigns. The growing integration of research suites at operational centres (e.g. ECMWF, NRL) much aided the digestion of the non-routine data, either post festum or increasingly near real-time. The presentation provides some highlights from previous campaigns and attempts to underscore generalities of large international fields experiments, sometime dubbed "particle accelerators" of the atmospheric sciences. So presentations on the various THORPEX campaigns are put into a tradition and their specific achievements obtain backcloth.


Keywords: Field experiments, WWRP, WMO
Poster Session

SCI-POS1086 - Structural Characteristics of T-PARC Typhoon Sinlaku during its extratropical transition

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The structure and the environment of Typhoon Sinlaku (2008) were investigated during its life cycle in the THORPEX-Pacific Asian Regional Campaign (T-PARC). On 20 September 2008, during the transformation stage of Sinlaku's extratropical transition (ET), research aircraft equipped with Dual Doppler radar and dropsondes documented the structure of the convection surrounding Sinlaku and low-level frontogenetical processes. The observational data were assimilated with the Spline Analysis at Mesoscale Utilizing Radar and Aircraft Instrumentation (SAMURAI) software tool. The resulting analysis provides detailed insight into the ET system and allows specific features of the system to be identified, including deep convection, a stratiform precipitation region, warm frontal structures, and a dry intrusion. The analysis offers valuable information about the interaction of the features identified within the transitioning tropical cyclone. The existence of dry midlatitude air above warm-moist tropical air led to strong potential instability. Quasigeostrophic diagnostics suggest that forced ascent during warm frontogenesis triggered the deep convective development in this potentially unstable environment. The deep convection itself produced a positive potential vorticity anomaly at mid-levels that modified the environmental flow. A comparison of the operational ECMWF analysis and the observation based SAMURAI analysis exhibits important differences. In particular, the ECMWF analysis does not capture the deep convection adequately. The nonexistence of the deep convection has considerable implications on the potential vorticity structure of the remnants of the typhoon at mid-levels.

Keywords: Typhoon, T-PARC, Extratropical transition
Poster Session

SCI-POS1087 - Observations - Eyewall structure of Typhoon Sinlaku (2008) during the transformation stage of extratropical transition

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This study analyzes observations of the transformation stage of the extratropical transition of Typhoon Sinlaku collected during the THORPEX-Pacific Asian Regional Campaign (T-PARC). Research flights with the Naval Research Laboratory P-3 and the United States Air Force WC-130 aircraft were conducted in the core region of Sinlaku. Data from the Electra Doppler Radar (ELDORA), dropsondes, aircraft flight level, and satellite atmospheric motion vectors were analyzed with the recently developed Spline Analysis at Mesoscale Utilizing Radar and Aircraft Instrumentation (SAMURAI) software with a 1 km horizontal and 0.5 km vertical node spacing. The SAMURAI analysis shows marked asymmetries in the structure of the core region in the radar reflectivity and three-dimensional wind field. The highest radar reflectivities were found in the left of shear semicircle, and maximum ascent was found in the downshear left quadrant. Initial radar echos were found slightly upstream of the downshear direction and downdrafts were primarily located in the upshear semicircle, suggesting that individual cells in Sinlaku’s eyewall formed in the downshear region, matured as they travelled downstream, and decayed in the upshear region. The observed structure is consistent with previous studies of tropical cyclones in vertical wind shear, suggesting that the eyewall convection is primarily shaped by increased vertical wind shear during step 2 of the transformation stage, as was hypothesized by Klein et al. (2000). A transition from active convection upwind to stratiform precipitation downwind is similar to that found in the principal rainband of more intense tropical cyclones.

Keywords: Eyewall Structure, Typhoon, Extratropical Transition
Poster Session

SCI-POS1088 - HiWeather: Growing resilience to High Impact Weather

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Despite substantial advances in forecasting & emergency preparedness, weather-related disasters continue to kill, to displace populations, and to damage property & infrastructure, while less severe weather events place an increasing strain on society, especially in countries with fragile economies and infrastructure. Building on recent advances in weather forecasting from THORPEX and other initiatives, the WWRP High Impact Weather project (HiWeather) will “Promote Co-Operative International Research to achieve a Dramatic Increase in Resilience to High Impact Weather, worldwide, through Improving Forecasts for timescales of minutes to two weeks and Enhancing their Communication & Utility in Social, Economic & Environmental Applications”. It will be delivered through research in Processes & Predictability; Multi-scale Forecasting; Vulnerability & Risk; Evaluation; and Communication and will focus on five hazards: urban flooding, wildfires, extreme local winds, disruptive winter weather, and heat & air pollution in megacities. A comprehensive set of integrating and knowledge transfer activities will link the different research communities to each other, to weather services, and to end users.

Keywords: High Impact Weather, HiWeather
The TROWARA (TROpospheric WAter RAdiometer) microwave radiometer measures water vapour and cloud liquid water at Bern, Switzerland, since 1994. Using up to three channels between 21.3 and 31.5 GHz, TROWARA continuously measures the total column density of water vapour and cloud liquid water, also known as Integrated Water Vapour (IWV) and Integrated Liquid Water (ILW), with an average time resolution of 7 s. These measurements are invaluable for validation of satellite and model data. In case of TROWARA's ILW measurements, a quality assessment is rather difficult since coincident ILW data from other measurement techniques are rare. The TROWARA data generally permit the analysis of temporal variations in IWV and ILW on time scales from one minute to nearly 20 years. The measurements can be used to study dynamic and radiative transfer processes in the atmosphere and can be assimilated by numerical models to improve weather forecasting. Here, we compare ILW and IWV from TROWARA with simulations of the summer 2012 in Switzerland performed with the Weather Research and Forecasting (WRF) model. We find a very good agreement between instrument and model data for IWV and similar occurrence frequencies for ILW values between 0.01 and 0.3 mm. These results indicate that the WRF model is able to predict exceptionally well the diurnal cycle and day-to-day IWV variations and to represent fairly well the probability density function of ILW.


Keywords: water vapour, cloud liquid water, microwave radiometer, WRF model
**Poster Session**

**SCI-POS1091 - Danger at Sea: Diagnosing and Communicating the Threat for Strong Maritime Thunderstorms**

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The National Weather Service’s Ocean Prediction Center (OPC) and the Tropical Analysis and Forecast Branch (TAFB) at the National Hurricane Center (NHC) forecast maritime thunderstorms in “offshore zones” year round. These thunderstorms pose daily threats to mariners that traverse the Atlantic waters off the U.S. East Coast, the Gulf of Mexico, and the Caribbean. More accurate navigation tools (e.g., GPS) and weather prediction of general wind and wave conditions have allowed recreational boaters to travel farther offshore to fish or sail. These mariners often must navigate around or through approaching storms as they seek safe haven on shore. The offshore oil industry operates platforms and support vessels of all sizes in the very active convective areas of the Gulf of Mexico. A broad variety of marine activities are vulnerable to strong winds, building seas, and reduced visibility associated with strong convective storms. The OPC and TAFB have selected offshore convective storms as a focus area for the Satellite Proving Ground to help improve their short term prediction of thunderstorms. A variety of convection targeted GOES-R proxy products are being evaluated in operations to prepare for the increased temporal sampling, imager, derived products, and the Geostationary Lightning Mapper (GLM). This research and assessment of the GOES-R proxy products (Overshooting Top Detection and GLD-360 Lightning Density) will help OPC and TAFB forecasters understand the future GOES-R capabilities, and will provide information to plan and prepare appropriate products to help mariners anticipate and avoid severe weather at sea.

**Keywords:** Maritime Convection, Thunderstorms, Severe Weather, GOES-R
Poster Session

SCI-POS1093 - A deployable atmospheric profiling network, and the NCAR 449-MHz Modular Wind Profiler

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Prestigious reports over the past decade have indicated the strong need for increased core measurements in the boundary layer and free atmosphere above. A mesoscale network of boundary layer profiling stations would support needs of research, and of forecasting for many public sectors. Radiosonde networks provide excellent data quality and vertical resolution, but they are only released typically twice each day (more frequently during field projects), and with a station density appropriate for synoptic, rather than mesoscale applications. Remote sensing technology is rapidly advancing. NCAR has considered the potential of a facility, developed to be deployable for research field experiments, which would form a temporary network of measurement stations. The NCAR Integrated Sounding System (ISS) has been used in this way for many years, with a wind profiler as the central instrument. The envisioned facility would have more stations than the current suite of 3 ISS, would take advantage of lidars and other remote sensors, and would have enhanced in-situ measurements of the surface-atmosphere interface (lower boundary condition). At NCAR we have made considerable progress toward development of a modular radar wind profiler, and more suitable in-situ surface flux station. Other groups and industry have made advances in lidar technology to profile wind, temperature, and water vapor. We will describe the development status of NCAR’s Modular 449-MHz wind profiler, and the technologies that would complement it for a multi-use deployable profiling network.

Keywords: atmospheric profiling, deployable observing network, wind profiler
Poster Session

SCI-POS1095 - Feature extraction for remote sensing data using massive parallel processors

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Spectral imaging continues to register an increase in spectral and spatial resolution, as well as in the use of satellite, airborne and land-based platforms, producing tremendous continuous amounts of high-dimensional data that are creating new processing challenges. Most remote sensing techniques suffer from high execution times. They are usually iterative algorithms that have each step’s computational complexity dependent on the size of the data. Given the continuous increase in data size, in order for such techniques to remain feasible, one must investigate approaches to speed them up without compromising accuracy. Supported by technological advances, high-performance computing has continuously increased its usability for remote sensing applications. This poster introduces a new group of parallel algorithms for linear unmixing to be developed for massively parallel processors such as graphical processing units (GPU). The focus of the work is on the parallelization of recently introduced techniques such as Nonnegative Matrix Factorization (NMF). First, a theoretical classification of hyperspectral data processing algorithms based on the impact their parallel counterparts have, is provided. To support the goal for execution speedup, the aim is the design novel parallel algorithms that minimize the data distribution and communication overhead. Finally, the poster will show how the distributed algorithms provide a significant computational compared to their sequential counterparts.

Keywords: Feature Extraction, Remote Sensing, Parallel Processing, GPU
Atmospheric Nanoparticles are suspended particulate matter (PM) in the atmosphere, with size distribution of spherical equivalent diameter Dp< 50µm. Studies on atmospheric Nano-particles are of growing interest to climate scientists because of their role in shaping conditions of the atmosphere, both at the surface and in the lower troposphere. Nano-particles are important precursor for the formation of larger particles, which strongly influence global climate. However, their variation, mass concentration with location and time strongly depend on the proximity to source, effectiveness of dispersal and removal mechanisms. The main goal of this seminar is to highlight key aspects of current knowledge about the global distribution of atmospheric Nano-particles, properties and characterization of different categories. These act as a background to understanding their behavior, as they relate to climate change and atmospheric modeling. Examples of leading measurement techniques and modeling approaches are briefly summarized; estimated source strengths, lifetimes and major sinks that act to remove these particles from the atmosphere are also emphasized.


Keywords: Atmospheric Nano particles, Troposphere, Atmospheric deposition, Climate change
SCI-POS1101 - Evaluation of data assimilation for comprehensive aerosol model in East Asia

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The comprehensive aerosol model, which can deal with Asian dust and haze phenomena in East Asia simultaneously, has been developed by the Korea Meteorological Administration (KMA). The model has 53 variables related to particular matters by coupling the US EPA’s CMAQ (Community Multi-scale Air Quality) model with the ADAM (Asian Dust Aerosol Model) which is the operational Asian dust forecasting model at KMA. In the model, anthropogenic emissions for Asian region are retrieved from the INTEX-B data with NH3 emission data of ACE-Asia and, for Korea, the latest CAPSS (Clean Air Policy Support System) emission data made by the Ministry of Environment of Korea is utilized. Meteorological inputs are constructed from global Unified Model (UM GDAPS), which is being operated by the KMA. The model has been applied for a severe haze event in Korea (Jan. 10~16, 2013). In this study, three dimensional optimal interpolation (3DOI) has been applied to this model with ground PM10 observation data in Korea and China. This study reveals that the 3DOI with ground PM10 concentration does not make a notable improvement with one time assimilation. However, the consecutive optimal interpretation with 6 hour interval for 3 days yields a significant improvement in the prediction of PM10 concentration, especially for the downwind region of observation sites. It is also found that the influence of data assimilation can be maintained up to 36 hours in the consecutive assimilation cycle.

Keywords: Data assimilation, Aerosol model, Dust, Haze
SCI-POS1103 - VAQUM: Environment Canada’s Air Quality Verification System

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Environment Canada’s VAQUM (Verification of Air QUality Models) was built for the performance evaluation of air quality model forecasts. This system has been under development since 2008 and uses PostgreSQL, an open-source, enterprise-grade relational database management system that supports geospatial data thanks to the PostGIS module. VAQUM first pairs air quality forecasts at the surface level with AQ observations at locations where AQ observations are available. The system is then able to produce a number of different statistical analyses, including objective scores, categorical scores, spatial analyses, and time series. Over the last few years, Environment Canada’s air quality verification system has been greatly improved. In this poster we will present essential VAQUM products used for the evaluation of the Canadian Regional Air Quality Deterministic Prediction System (RAQDPS), Environment Canada’s operational air quality forecast system. Current development projects and future plans will also be described.

Keywords: Air, Quality, Verification, Geospatial
Between April and June 2014 three mineral dust events have been observed over Germany. Due to the meteorological situation the dust was transported from the source region Sahara to central Europe. At Deutscher Wetterdienst (German weather service), additionally to the standard model chain, the model system COSMO-ART (Vogel et al., 2009; Bangert et al., 2012) was used in an operational mode to forecast the dust load and to investigate the impact of the dust particles on radiation and cloud coverage. Both parameters are important variables concerning the yield of solar energy. In contrast of the operational setup COSMO-ART describes online the temporal development of mineral dust particles and their feedback on radiation and cloud formation. Additionally the two-moment scheme of Seifert and Beheng (2006) was activated instead of the standard bulk scheme that is usually used in COSMO for operational weather forecast by DWD. Every 24 hours a simulation was started where for the initialization of the dust the concentrations from the previous run were used. Sensitivity runs were carried out to study the impact of the dust particles on the state of the atmosphere and to analyse if the consideration of the actual dust load instead of climatological values leads to an improvement of the weather forecast during such situations. It can be shown, that the dust load caused a decrease of the global radiation in southern Germany above 100 W m$^{-2}$. This shows the great importance of including dynamic mineral dust for the forecast of photovoltaic energy yield.


Keywords: mineral dust, radiation, cloud coverage, modeling
SCI-POS1107 - Detailed impacts of aerosols on clouds and precipitation in a winter cyclone

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To address a very complex and uncertain research problem that affects storms from convective to synoptic scales, the Thompson et al (2008)bulk microphysics scheme was recently updated to incorporate aerosols explicitly (Thompson and Eidhammer, 2014). The scheme explicitly nucleates water and ice from their dominant respective nuclei and fully tracks and predicts the number of available aerosols. Using the Weather Research and Forecasting (WRF) model, the scheme was tested in a very high resolution (4-km spacing) simulation of a three-day winter storm event over the entire contiguous U.S. A control simulation was run with climatological aerosol conditions and then two sensitivity experiments with very clean and very polluted conditions were used to evaluate the magnitude of aerosol-cloud-precipitation interactions. Analysis of these sensitivity experiments clearly shows the expected change to water droplet populations, including both large and small droplets. Less well documented changes to liquid water content and mean size as a function of temperature occur as well, which has interesting implications to frequency and severity of aircraft icing that go beyond the usual findings associated with surface precipitation impacts.


Keywords: aerosols, microphysics, radiation
Poster Session

SCI-POS1109 - Why can't current large-scale models predict mixed-phase altocumulus correctly?

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Stratiform mid-level mixed-phase clouds have a significant radiative impact but are often missing from numerical model simulations for a number of reasons. This is particularly true more recently as models move towards treating cloud ice as a prognostic variable. This presentation will demonstrate three important findings that will help lead to better simulations of mixed-phase clouds by future models. 1) Predicted mixed-phase altocumulus is compared with ground based remote sensors, finding an under-prediction of the supercooled liquid water content in models of a factor of 2 or more. This is accompanied by a low bias in liquid cloud fraction whilst the ice properties are better simulated. Models with more sophisticated microphysics schemes that include prognostic cloud ice are the worst performing models. 2) A new single column model is used to investigate which processes are important for the maintenance of supercooled liquid layers. By running the model over multiple days it was determined that the most sensitive areas of the model are ice microphysical processes and vertical resolution. 3) Vertical resolutions finer than 200 metres are required to capture the thin liquid layers in these clouds. Leading models are still far coarser than this, limiting hope of simulating these clouds properly. A new parameterization of the vertical structure of these clouds is developed and allows their properties to be correctly simulated in a resolution independent way by numerical models with coarse vertical resolution. This parameterization could enable significant improvement in model simulations of stratiform mixed-phase clouds.

Keywords: altocumulus, Microphysics, Resolution
With an ever-growing need to improve the understanding of how mesoscale and smaller weather features initiate and evolve, there is a strong motivation for higher resolution thermodynamic profiling of temperature and humidity on smaller spatial and temporal scales than can be provided by standard radiosonde measurements. While radiosondes do provide accurate thermodynamic profile information at synoptic-scale (generally twice per day) timing, the infrequency of these observations make it possible to potentially miss the onset and evolution of meteorological events that occur on much smaller time scales. One potential way to complement the radiosonde observations by filling the gaps between launches is to utilize thermodynamic profiling from a microwave radiometer (MWR). The MWR measures downwelling radiance from the atmosphere in the microwave portion of the spectrum (~20 to 60 GHz), which can be used in an iterative thermodynamic retrieval algorithm to retrieve vertical temperature and humidity profiles within the lowest 2-4 km of the atmosphere (within and just above the boundary layer) at temporal resolutions on the order of 5 min. This research focuses on using a dataset from a Radiometrics MP-3000A MWR, which was operated on the rooftop of the National Weather Center in Norman, OK, from approximately October-2011 through June-2013. An algorithm was developed, the error characteristics evaluated, and several case studies were examined. This project’s overall aim is to eventually use this algorithm to help supplement existing profiling systems and radiosonde observations to improve current boundary layer studies and improve the evaluation of pre-convective environments and weather forecasting.

**Keywords:** Retrieval, Radiometer, Thermodynamics
As spatial resolution in numerical models continue to increase, explicit microphysics schemes activated upon grid-scale saturation become more important in representing cloud and precipitation processes. Milbrandt and Yau's explicit microphysics parameterization is a bulk, multimoment scheme that allows for changes in three parameters in the gamma distribution function, which is used to represent size distributions of six hydrometeor categories. One of these parameters is the shape parameter $\alpha$, which is obtained by inverting a function $G(\alpha)$. This inversion, however, can result in solutions of $\alpha$ that are negative and multi-valued. To avoid the problem, an assumption of $\alpha$ being positive definite is applied in the scheme. Another issue in relation to the shape parameter is that $G(\alpha)$ is asymptotic to one for increasing $\alpha$, such that unreasonably large variations in $\alpha$ may result due to small changes in $G(\alpha)$. This problem is avoided by restricting the maximum value of the shape parameter to 40. To relax some of these assumptions, a reformulation of the scheme is performed in this study by using the log-normal distribution function instead of the gamma distribution function for the hydrometeor categories. The two versions of the scheme are then compared in the context of a one dimensional kinematic model. The similarities and differences in the evolution and distribution of the total number concentration, mass mixing ratio, radar reflectivity, and precipitation rate will be presented.


Keywords: microphysics parameterization, bulk method, log-normal distribution, gamma distribution
Poster Session

SCI-POS1143 - Projection of extreme rainfall related to the tropical cyclone landfall over East Asia

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We have developed the statistical prediction model for the extreme rainfall related to the tropical cyclones (TCs) affecting the East Asian countries during 1961-2005. The method applied to the statistical prediction model was based on the non-stationary general extreme value (GEV) distribution which was suitable to represent the characteristics of extreme. The indices of NINO4 and PDO, zonal winds at 200 hPa, and the accumulated specific humidity at troposphere were selected as predictors up. Using the changes in the predictors and the observed relationship between the predictors and the predictand, the changes in TC-induced extreme rainfall in 2070-2099 were projected. The changes in predictors were obtained from the 21st century simulation with A1B emission scenario in eleven global circulation models (GCMs) from Intergovernmental Panel on Climate Change (IPCC). As the results, the current 20-yr return value of TC-induced rainfall will generally be more frequent across East Asia, with large increase in the surrounding region of Hong Kong and the eastern coast of Japan. In contrast, it will be less frequent in the eastern and western edge of the coastal region in China and the western of Japan.

Keywords: extreme rainfall, tropical cyclone, GEV distribution, statistical downscaling
Poster Session

SCI-POS1145 - On the northward moisture transport by ageostrophic wind associated with a tropical cyclone

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It is well-known that heavy rainfalls in Japan often occur when a typhoon or tropical depression exists on the sea far south of Japan. These phenomena, so-called pre-typhoon precipitation, are in many cases explained by the moisture transport over Japan from the tropical cyclone, however, the reason why the moisture is transported northward from the sea south of Japan has not been clarified. Ageostrophic winds are also sometimes observed over Japan in such the cases. Possible causes of the ageostrophic winds may be 1) The pressure gradient force by precipitation associated with the mesoscale convective system, 2) The vertical transport of horizontal momentum by deep convection or influence of orography, 3) Ageostrophic wind toward the left direction of the local acceleration vector. In this study, first we show an example of significant ageostrophic winds observed over Japan on 6 October 2010, when typhoon Melor (200918) existed off the far south coast of Western Japan. This ageostrophic wind event was successfully reproduced by a numerical experiment using the JMA nonhydrostatic model with a horizontal resolution of 10 km. We review the relationship between ageostrophic wind and local acceleration vector, and show that the observed ageostrophic wind was mainly caused by the acceleration vectors in the northeast quadrant of the typhoon and in the south of the jet stream over Japan.

Keywords: Ageostrophic wind, tropical cyclone, moisture transport, pre-typhoon precipitation
Linear sensitivity analysis has proven to be a powerful tool both for forecasting and understanding tropical cyclones (TCs). Singular vectors (SVs) are being used as initial perturbation for ensemble forecasts, and the closely related adjoint based sensitivity can be used to control automatic mesh refinement for TC forecasts. Both sensitivity measures have been used to identify sensitive regions for targeted observations and to investigate perturbations growth mechanisms in TCs that limit their predictability. However, the complex structure of SVs in three-dimensional full-physics models impedes their interpretation. Idealised studies with reduced complexity allow for a clearer view on selected growth processes. In this study we investigate SVs and adjoint based sensitivity for TC-related problems in a non-divergent barotropic framework. The structure of SVs for TCs in horizontal shear is interpreted by analysing the mechanisms contributing to the growth of the initial SVs. We demonstrate that horizontal shear enhances perturbation growth rates for stable vortices and tends to reduce growth rates for unstable vortices. For sufficiently strong anticyclonic shear, the initial SVs are aligned with streamlines connected to stagnation points. The results for vortices in horizontal shear are used to interpret the structure of SVs and adjoint based sensitivity for a more complex case, the binary interaction of tropical cyclones.


Keywords: tropical cyclone, singular vector, perturbation growth, predictability
SCI-POS1162 - Construction of Extreme Rainstorm Probability Prediction Index Based on Radar Echo

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For applying the approaching, high resolution data of Doppler radar echo on the extreme rainstorm prediction, the radar echoes at scanning surfaces are analyzed to recognize and extract 3-D dynamic characteristics of rainfall systems. Then to build the warning and prediction probability index of different grades of the extreme rainstorm in next one hour by the improved probability prediction methods based on the extreme rainstorm and Radar echo. It is for proving technique support and professional reference to governments making emergency scheme and strategy and tactics. Based on the Doppler radar echo digital data at scanning surfaces and the precipitation data of Jianhu weather station during June, July, August in year 2006-2009, the dynamic upstream of the local heavy rainfall system is sought and determined by Radar echo through the Lucas-Kanade local optical flow method. Further the probability correlation is calculated between echo classification and precipitation series by Peirson III and Generalized Pareto methods, and the probability characteristics of returning time of graded extreme rainfall under the echo types of the local extreme rainfall is also calculated, then the statistic index is constructed between the Radar echo dynamic features and the probability of local extreme rainfall in next hour. The index can predict the probabilities of different grade extreme rainfall at local place, the test result of the suitable prediction gets to 70%. It is an optimization method of Radar dynamic statistics for nowcasting and warning of the extreme rainstorm in next hour. Funding: NFSC (41276033); NROL (BJG201105); NSTSP (2012BAH05B01); MPPP (201206068); PAPD


Keywords: Radar echo probability index, System echo dynamic upstream, The Return time of extreme rainfall, P-III probability and Generalized Pareto methods
A statistic analysis of rainstorm vortices during Meiyu seasons from year 2007 to 2011 at Yangtze-Huaihe River basin shows that the vortex rainstorm is up to 41% in all rainstorm day during the period, and most of them are shallow vortices (under 700hPa), they are easy to be impacted by the Dabieshan Mountain (about 1500m height). Two shallow vortices are analyzed when they circumambulate and climb the Dabieshan Mountain from south and north respectively under influences of mountain and the high level trough. The vortices round the mountain cause their rain zones along Huaihe River basin at north and along Yangtze River basin at south of the mountain. The wind shear structure of high level jet combined the low level jet increases the cyclone vorticities of the vortices and indicates vortices paths and positions. The low level jet at 850 hPa also responses to the mountain hindering with its intensity weaken and shows a circumambulated state to the south part of the Mountain. The numerical simulation shows that the topography effect causes the center position of vortex center, moisture convergence and rainfall close or overlap at two key areas (face-wind side of the mountain south part and the lee-ward arc area of mountain north part), where the air is vertical stretched, moisture convergence is strengthen and the vortex rainfall is special heavy. Due to the south part of the mountain is larger and higher than the north part, the topography impacts on the south vortex is more remarkable.

Funding: NSTSP(2012BAH05B01); MPPP(201206068); NFSC(41276033); NROL(BJG201105); PAPD


Keywords: Yangtze-Huaihe River basin, the storm low vortex, the dabieshan mountain obstruction, the topographic effect
Extreme precipitation events occurring in populated areas surrounded by steep terrain, lakes and rivers like northern Switzerland have great potential to cause damages. Breaking synoptic Rossby waves located over western Europe, play a central role in triggering such extreme events in southern Switzerland (e.g. Massacand et al. 1998). In contrast, synoptic scale structures triggering extreme precipitation events on the north side of the Swiss Alps have so far not been studied comprehensively.

An observation based high resolution precipitation data set for Switzerland (MeteoSwiss 2011) is used to identify extreme precipitation events affecting the north side of the Swiss Alps for the time period 1961-2010. For these events a detailed dynamical analysis of the upper level flow is conducted using ECMWFs ERA-40 and ERA-Interim re-analysis data sets. For the analysis northern Switzerland is divided in two investigation areas north-eastern and western Switzerland. Using k-means clustering, a distinct classification of upper level structures associated with extreme precipitation events in the areas of interest is presented. For each class we present the tropopause level flow, low level winds and precipitation composites. The integrated moisture and the moisture flux towards Switzerland prior to and during the events is also studied. The significance of the PV anomalies indicated by the classification and the potential for an upper-level Rossby wave upstream precursors is examined using a Monte Carlo significance test.


Keywords: extreme precipitation, Rossby waves, precursor
SCI-POS1178 - Can we trust climate models to realistically represent severe European windstorms?

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Despite the enormous advances made in climate change research, robust projections of the position and the strength of the North Atlantic stormtrack are not yet possible, bearing considerable risks to societies and (re)insurance industry. Previous studies have addressed the problem of model reliability through statistical comparisons of simulations of the current climate with (re-)analysis data. A weakness of this approach lies in the difficulty to separate influences of the climate model's basic state from that of fast processes on the development of the most intense storms, possibly leading to the compensation of errors. To separate fast and slow processes, the AXA-SEAMSEW project uses a cost-effective "seamless" case-study approach, hindcasting historical, severe storms with climate models started from predefined initial conditions and run in a numerical weather prediction mode. Key results from this work focusing on 20 historical storms and using different lead times and horizontal and vertical resolutions include: (a) Tracks are represented reasonably well by most hindcasts. (b) Sensitivity to vertical resolution is low. (c) There is a systematic underprediction of cyclone depth for a coarse resolution of T63, but surprisingly no systematic bias is found for higher-resolution runs using T127, showing that climate models are in fact able to represent the storm dynamics well, if given the correct initial conditions. Combined with a too low number of deep cyclones in many climate models, this points too an insufficient number of storm-prone initial conditions in free-running climate runs. This question will be addressed in future work.

Keywords: cyclone, windstorm, seamless approach, resolution
Abstract: In order to understand the role of East Asian subtropical westerly jet (EASWJ) in forecasting summer precipitation in East China, interseasonal pentad characteristics of the EASWJ and their relation to summer precipitation in East China are analyzed with the daily reanalysis data provided by National Centers for Environmental Prediction (NCEP, USA) and daily precipitation data from 714 Chinese meteorological stations during the period 1960–2009. In addition, the daily evolution of the EASWJ and objective quantification of the EASWJ are investigated for the Meiyu season over the middle and lower reaches of the Yangtze River valley. It is found that the EASWJ and summer precipitation bands in East China move simultaneously. Especially, the stationary state and northward shift of the EASWJ are closely associated with the beginning, ending and stabilization of the annually first raining season in South China and Meiyu over these reaches. Analysis on the characteristics of the EASWJ in typical (atypical) Meiyu years over these reaches shows that the EASWJ swings steadily around its climatological position in meridional orientation (with large amplitude). Numerical experiments on an example in 2005 shows that indexes proposed in this study can depict the EASWJ well and should be valuable for application in the operation.

Keywords: medium-range characteristics, statistical analysis, East Asian subtropical westerly jet
Poster Session

SCI-POS1190 - The role of radiative forcing in teleconnections and predictability of southern African seasonal climate

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Seasonal forecast skill over southern Africa is largely confined to the summer season during El Niño and La Niña events. El Niño events are usually associated with below (above) normal summer rainfall over southern Africa (East Africa). However, the El Niño teleconnection to southern African rainfall is known to be non-linear, and has failed during the 1997/1998 and 2009/10 events. Here we investigate the radiative forcing of southern African climate and in particular its impacts on the El Niño teleconnection, through a series of Atmospheric Model Intercomparison Project (AMIP) simulations. In these simulations the Conformal-Cubic Atmospheric Model (CCAM) was integrated with a variety of radiative forcing settings (varying CO2, lower stratospheric ozone and aerosol concentrations) for the period 1979 to 2010 (12 ensemble members were generated for each radiative forcing setting). The simulations were designed to investigate the relative and combined effects of various forms of radiative forcing on the model simulations of inter-annual variability, compared to a control experiment where all forcings were kept constant at their climatological values. The simulations specifying varying ozone concentrations are of particular interest given the effects that anomalous spring Antarctic stratospheric ozone concentrations have on the tropospheric Southern Hemisphere summer circulation. We quantify improvements in skill in simulating inter-annual climate variability over Africa that can be obtained through the realistic specification of radiative forcing, and illuminate that radiative forcing of Antarctic stratospheric temperatures may play a role in the non-linearity of the El Niño teleconnection to southern African climate.

Keywords: Antarctic stratospheric ozone, El Niño, teleconnection, southern Africa
SCI-POS1192 - Study of low predictability cases of Northern Atlantic weather regimes abrupt transitions

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Northern Atlantic weather regimes are defined as recurrent patterns of the low frequency part of the atmospheric flow. They last between 6 and 8 days in average during which local weather variability is supposed to be reduced. Then, transitions between weather regimes may lead to drastic changes at large scale within short periods. Some diagnoses from the ECMWF Ensemble Prediction System show that while periods of well-established regimes are predictable, transitions often show too large dispersion in ensemble forecast, even at the short range (say 3 to 5 days). In these cases, the ensemble system somehow misses the regime following the transition. Some transitions periods of low predictability are collected from recent archive data and used to explore the factors leading to the large forecast spread. For example, in the case of the transition from the zonal regime to the blocking regime, successive surface cyclones are associated with the blocking onset in association with anticyclonic wave breaking (Michel et al (2012)). PV anomaly techniques are performed on the selected transitions to investigate the impact of surface cyclone life cycle upstream of the transition time.


Keywords: weather regimes, predictability, ensemble, midlatitude dynamics
SCI-POS1194 - A comparison of ERA interim reanalysis data with meteorological observations from the central Arctic

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Both, the analysis of polar climate change on the basis of observations and the validation of weather and climate prediction in polar regions are challenging since only few observations are available. In the inner arctic regions in-situ observations are available only from buoys, ship cruises and aircraft campaigns with large temporal differences and spatial separations. In the present contribution we compare near-surface meteorological observations and rawinsonde soundings from Arctic cruises with the German icebreaker RV Polarstern during August 1996, 2001, and 2007 with each other and with ERA-Interim reanalyses. Although the used observations are usually applied in the reanalysis, they differ considerably from ERA data. - ERA overestimates the relative humidity and temperature in the atmospheric boundary layer and the base height of the capping inversion. Warm biases of ERA near-surface temperatures amount up to 2 K. The melting point of snow is the most frequent near-surface temperature in ERA, while the observed value is the sea water freezing temperature. While this points to general drawbacks in the models, it shows also that the quantification of trends based on reanalyses is problematic especially when only one reanalysis is considered.


Keywords: Arctic atmospheric boundary layer, Soundings, air-ice interaction
Poster Session

SCI-POS1196 - Could mid-latitude weather forecasts be improved if we had perfect knowledge of the polar atmosphere?

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To determine the impacts of a perfectly simulated Arctic/Antarctic atmosphere on mid-latitude weather forecasts, we carried out relaxation experiments with the Integrated Forecast System (IFS) of the European Centre for Medium-Range Weather Forecasts (ECMWF). We conducted pairs of experiments initialized from different start dates between 1979 and 2012 of the INTERIM reanalysis data from ECMWF. Each pair contains a control hindcast (CTL) and a hindcast strongly relaxed to the reanalysis data (REL) in the Arctic north of 75 N and in the Antarctic south of 75 S. We determined the root mean square errors (RMSE's) for each grid point of the CTL and REL hindcasts with reference to the reanalysis data averaged over all CTL and REL hindcasts, respectively. Over the Northern mid-latitudes between 40 and 60 N hindcasts are improved especially over Eastern Europe and Asia (ca. 10% RMSE reduction), a region with little maritime influence. Over the Southern mid-latitudes improvements are generally smaller (ca. 4% RMSE reduction) and regionally roughly equally distributed between 40 and 60 S, but in winter and spring improvements of similar magnitude extend to the lower latitudes of Southern Australia. Over both hemispheres improvements are weaker in summer compared to the other three seasons. Generally, in weather situations with anomalous meridional wind components from the polar regions into the mid-latitudes improvements are pronounced. This has implications for the predictability of mid-latitude weather in a future climate with a changed large-scale circulation.

Keywords: relaxation experiments, predictability, future climate, meridional wind
Poster Session

SCI-POS1198 - Polar sea ice cover based on results of the CMIP5 models

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Sea ice is an important component of the global climate system acting both as an indicator of climate change as an amplifier. Several authors indicate that sea ice cover is more general indicator for climate change than are temperatures trends alone because changes in the sea ice depends on integrated changes on many different climate variables such as oceanic heat transport, temperature and winds. Polar sea ice has undergone marked changes during the last decades, Arctic experience a tragic decrease in sea ice extent, whereas Antarctica shows an increase (at a rate not as pronounced as the decrease in Arctic sea ice). We examine the recent (1979–2012) and future (2011–2100) characteristics of the summer Arctic and winter Antarctic sea ice cover based on satellite dataset and as simulated by 10 Earth system and general circulation models from the Coupled Model Intercomparison Project, phase 5 (CMIP5). Our results show that most of the models were able to represent the seasonal cycle in the Arctic and Antarctica and also were able to predict the record decline on Arctic sea ice thickness and extent in 2007 and 2012. The long-term trends (1960-2100) suggest that thickness and extent sea ice in the Arctic ocean will continue retreating, this is primarily because the Temperature in the Arctic has increased at twice the rate as the rest of the globe. To Antarctic sea ice, many of the models have show markedly differs when compared with satellite data, especially regarding the trend increase observed in last decade.

Keywords: Sea ice, CMIP5
SCI-POS1200 - Multi-decadal mobility of the North Atlantic Oscillation

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The North Atlantic Oscillation (NAO) is one of the most important modes of variability in the global climate system and is characterized by a meridional dipole in the sea-level pressure field over the North Atlantic, with centers-of-action near Iceland and the Azores. It has a profound influence on the weather, climate, ecosystems and economies in the region. It has been proposed that around 1980, there was an eastward secular shift in the NAO’s northern center-of-action that impacted sea-ice export through Fram Strait. Here we use both the one-point correlation map technique as well as EOF analysis to show that the meridional dipole that is often seen in the sea-level pressure field over the North Atlantic is not purely the result of the NAO (as traditionally defined) but rather arises through an interplay between the NAO and two other leading modes of variability in the North Atlantic region: the East Atlantic and Scandinavian patterns. We furthermore show that this interplay has resulted in multi-decadal mobility in the two centers-of-action of the meridional sea-level pressure dipole. In particular, an eastward movement of the dipole occurred during the 1930s-1950s as well as more recently. This mobility is not seen in the leading EOF of the sea-level pressure field in the region, i.e. the traditional definition of the NAO. This interplay will be used to diagnose the relative roles of the three modes of variability on the extreme winter weather experienced by the UK in 2014.


Keywords: North Atlantic Oscillation, Multi-decadal Climate Variability
Poster Session

SCI-POS1202 - Climatology and dynamical aspects of polar lows over the Nordic Seas

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Polar lows are low-level and convective meso-scale cyclones that occur at higher latitudes. They often cause significant damage offshore and along the coast, in particular in Norway. Thus, there is a need to understand the dynamics of their life cycle and their climatic variability. They usually form in marine cold air outbreaks and in reverse or forward thermal shear conditions. However, their development is not still well understood because of the vast variety of formation and intensification processes, mainly associated with baroclinic instability and convective processes. In order to gain further understanding of these phenomena, we compile trajectories of polar lows obtained with a cyclone detection/tracking algorithm applied to the mean sea level pressure from ERA-Interim and NORA10, a MET Norway hindcast with 10-km resolution. We present a polar low climatology over the Nordic Seas highlighting features of the detected polar lows and pinpoint characteristics of their dynamical evolution. Moreover, a comparison of the results with the observational STARS database hosted by MET Norway will evaluate the capability of the reanalysis products and tracking routines to simulate and identify polar lows.

Keywords: Polar lows, Cyclone tracks
NOAA has long been engaged in Arctic research and services, with statutory mandates that extend into the US Arctic and internationally. Within the context of a rapidly changing Arctic, NOAA’s environmental prediction and stewardship missions will continue to see strongly growing demands for services within this region, as well as for improved information on the linkages between the Arctic and lower latitude weather and climate. Toward planning NOAA actions required to address its present and anticipated future mission requirements, NOAA recently convened a Workshop on “Predicting Arctic Weather and Climate and Related Impacts: Status and Requirements for Progress.” This poster summarizes key findings from that Workshop, which included scientists from across NOAA and from the national and international science community. The workshop placed particular emphasis on addressing forecast challenges in the following areas: 1) Predictions of Arctic weather and climate, including sea ice, 2) Predictions of mid-latitude weather and climate, focusing on the role of higher latitude processes such as variations in Arctic sea ice and the Arctic Oscillation/ North Atlantic Oscillation. This Workshop has helped identify opportunities for NOAA to work together with other agencies and the external community, and in new international efforts including the WWRP Polar Prediction Project. This collaborative approach will be essential for accelerating progress in understanding and predicting Arctic weather and climate and related impacts, which will be required to better serve the needs of the public and decision-makers.

Keywords: NOAA Workshop, Arctic weather prediction, Arctic-lower latitude linkages, sea ice predictions
Poster Session

SCI-POS1222 - Anomalous weather patterns in relation to precipitation events during summer in Japan

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Anomalous weather patterns (WP) in relation to precipitation events during boreal summer season have been investigated by using a neural network algorithm, so-called "Self-Organizing Maps" (SOM). The SOM analysis is a nonlinear classification technique which extracts patterns in high-dimensional data onto a two-dimensional map, which visualizes those nonlinear relationships. We simultaneously analyzed four elemental variables composed of four atmospheric variables (i.e., 850-hPa equivalent-potential temperature, zonal, meridional wind and 200-hPa geopotential heights) around Japan by the SOM. As observational data, we use JRA55 reanalysis for past 54 years (1958-2011). The analysis well captured the feature of the WP in relation to the extreme high-precipitation events in Japan and enable us to easily understand the dependence of the each WP on the extreme precipitation events in the hydrologically separated regions. Comparison of the SOM frequency between the first and second half of past 54 years exhibits the significant change in the frequency of the precipitation-related WP. Furthermore, using the SOM, we also propose a new method to visually show the spread of ensembles for 51-member ensemble of JMA weekly forecast that can directly estimate the probability of local precipitation.

Keywords: Self-Organizing Maps, Baiu, JRA55, Weather patterns
SC1-POS1224 - Nowcasting of Lake-effect snow rates using both satellite and model sounding data

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Heavy lake-effect snow bands often affect communities downstream, causing airport shutdown and dangerous driving conditions. It is difficult to nowcast snow rates from these snow bands due to limited observations and model resolution. In order to address this challenge, an algorithm using both satellite and model sounding data is developed to improve nowcasting of lake-effect snow rates. A snow band viewed from satellite imagery is a snapshot of the time evolution of the cumulus growth from the initial to the mature stage. Using the GOES 11 µm and boundary winds data, the mean cloud-top cooling rate along individual snow band at its developing stage over the lake is calculated. Then, with the model sounding data, the vertical moisture fluxes and snow rates at different points along the snow band over the lake are calculated. As the snow band moves inland, the cumulus is cut off from the heat and moisture supply. The air mass becomes progressively less unstable and the vertical moisture fluxes diminish with increasing distance inland. This also leads to progressively warmer cloud top temperatures (CTTs) inland. Finally, the inland snow rates are parameterized by comparing the CTTs at different points above the snow band inland with the CTT at a point above the snow band near the shoreline. In this poster, the physical concept of the algorithm is presented. Results from several lake-effect snow events downwind of Lake Huron, Canada demonstrate that the algorithm can be applied to improve the nowcasting of snow rates from lake-effect snow.

Keywords: Lake-effect snow, Nowcasting, Cloud top cooling rate, Snow rates
SCI-POS1226 - An Automatic high wind forecast and warning system for construction projects and municipalities

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Environment Canada, the National Centers for Environmental Prediction (NCEP), and private weather companies provide numerical weather forecast products that cover Canada and the United States. While the spatial and temporal resolution of these numerical weather forecast products are often sufficient for public consumption there are limitations to the application of these products for predicting winds at multiple working heights for construction projects and high buildings. This paper summarizes an advanced gust wind warning system that was developed for the City of Calgary. This system combines high-resolution weather forecast technology, based on the Weather Research and Forecasting Model (WRF) at 4 km and 1 km resolution, with wind engineering best practices to predict winds at multiple working heights and provide alerts to reduce incidents of falling debris and the impacts of catastrophic wind related events. Technical, scientific and operational characteristics of the system as well as the results of preliminary model verification studies will be presented. The relevance of such forecast systems and their applicability to other parts of the world will also be discussed.

Keywords: WRF, Forecast, Gust, Winds
SCI-POS1228 - Evaluation of wind plant power loss with a coupled atmospheric-ice load model

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Atmospheric icing is one of the typical weather phenomena in cold climate that has strong impact on human activities. Icing occurs on transmission lines and the blades of wind turbines, which are usually installed on the top of hills where in-cloud icing and high winds are expected. Atmospheric icing on transmission lines and wind turbines is an important consideration for both design (to withstand the load) and operations (decreased efficiency of wind turbines). The objective of this research project is twofold: 1) to develop a coupled atmospheric-ice load model for simulating the icing start-up, duration and amount of icing episodes, and 2) to quantitatively evaluate icing impact on power loss in wind plants. In our research, eight of the 27 icing episodes identified in a wind plant of Gaspé region in the period of 2008-2010 were simulated with a mesoscale numerical weather prediction model, GEM-LAM (Global Environmental Multiscale - Limited-Area Model). It was found that the simulated near surface temperature, relative humidity and wind speed compare well with in-situ observations. These variables, as well as precipitation and cloud related fields, are important factors to estimate the total ice load on a simple structure (cylinder). The coupled model captures the start-up and duration of accretion ice well, and a good correlation was found between icing episode and reduction of wind power production in the wind plant. This study provides an exemplary framework for the quantitative evaluation and forecasting of icing impact on wind turbine operations.

Keywords: simulation, GEM-LAM, ice accretion, power loss
SCI-POS1234 - Current Development and Preliminary Operational Evaluation of the Regional Ice Prediction System (RIPS)

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The Regional Ice Prediction System (RIPS) is an automated numerical sea ice analysis and forecast system developed at Environment Canada. The goal is to provide numerical guidance to operational ice forecasters at the Canadian Ice Service (CIS). The system consists of a data assimilation component for automated analysis and model initialization, and a forecasting component using the Los Alamos CICEv4.0 model. The RIPS analysis component uses the 3DVAR technique to assimilate observations from variety of sources. The current system assimilates observations from CIS daily sea ice and image analysis charts and weekly lake ice charts as well as from satellites including SSM/I, SSM/IS, and ASCAT. CICE is forced by the 10 km resolution atmospheric forecasts from Environment Canada Regional deterministic Prediction System and by a monthly climatology of surface currents. Monthly climatologies of mixed-layer depth and sea ice thickness are also used for the initialization. Outputs from the forecast model includes sea ice concentration, ice drift velocity, ice pressure and ice thickness. The system is initialized four times daily (00z, 06z, 12z, 18z) with subsequent 48-hour forecast outputs. The system has been running operationally in its current configuration since July 2013. In this presentation, we will describe the RIPS system together with a dynamic model visualization system, provide a preliminary operational evaluation of the model products, and outline upcoming updates.

Keywords: Arctic Ice Prediction, Numerical forecast, sea ice forecast, data assimilation
Poster Session

SCI-POS1236 - Interannual variations of precipitation at two mountain observatories and their teleconnections with spring persistent precipitation

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Interannual variations of precipitation at the Nanyue (27.30N, 112.69E, 1266 m) and Lushan (29.58N, 115.98E, 1165 m) mountain meteorological observatories are analyzed and their correlations with the spring persistent precipitation (SPP) in the South of Yangtze River are explored. Daily precipitation observed at these two mountain stations and the CPC merged analysis of precipitation from 1979 to 2010 are used in this study. It is shown that the average annual precipitation amount is higher at Nanyue station than at Lushan station, and the annual amount at Nanyue (Lushan) experienced a decreasing (increasing) trend. The interannual variations and long-term trends are very similar between the Nanyue precipitation and the regional average of SPP. In the South of Yangtze River, high correlations between the Nanyue precipitation and the SPP are found slightly to the west of the SPP center, with the maximum correlation coefficient reaching 0.60. High correlations between the Lushan precipitation and the SPP are found to the north of the SPP center, with the maximum correlation coefficient lower than 0.60, but is still significant at the level of p < 0.10. The usefulness of these relations in improving operational forecast of SPP will be further discussed.


Keywords: Mountain observatory, Precipitation, Interannual variation
Poster Session

UAS-POS3000 – WITHDRAWN - Improving meteorological services to Canadian Armed Forces through research and development, science transfer and training

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As part of the Canadian Forces Weather and Oceanographic Service (CFWOS), the Defence Weather Services (DWS) of Meteorological Service of Canada (MSC) provides meteorological services, essential to successful military operations, to the Canadian Armed Forces (CAF). In addition to traditional weather products, services are also provided through other means. The first one is by research and development. DWS constantly looks for new ways to improve services within its Applied Development Cell (ADC) embedded in the Joint Meteorological Centre (JMC) in New Brunswick. ADC works closely with the clients, other research units in MSC and in the Department of National Defence (DND), NATO and other allies to develop experimental products and new services to meet clients’ current and emerging needs. The second way is to transfer latest meteorological development back to operations to improve service qualities. The third means is to augment the competencies of meteorologists in both scientific/technical domain and personal suitability. This empowers the staff to better serve the clients. This presentation will give an overview of the activities undertaken by DWS in the above-mentioned areas.

Keywords: Meteorological Services, Canadian Armed Forces, Research and Development, Science Transfer and Training
Poster Session

UAS-POS3001 – WITHDRAWN - Spatial effects of climate change on agricultural production and food security in Eastern Africa

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Climate change has large influences on agriculture which remains heavily dependent on rainfall over Eastern Africa (EA) and thus Food Security. This paper reviews the state of current scientific knowledge on links between climate change, agriculture and food security over EA, in terms of anticipating impacts, managing climate variability and risks and role for scientists in tackling food insecurity and climate change. Agricultural production is highly vulnerable with major implications for rural poverty and for both rural and urban food security, it also presents untapped opportunities for mitigation over EA. Notably, trends and impacts are highly uncertain at a range of spatial and temporal scales. The magnitude and rate of projected changes will require adaptation through better management of agricultural risks associated with increasing climate variability and extremes and accelerated adaptation to progressive climate change utilizing initiatives such as Global Framework for Climate Services (GFCS). Therefore, challenges posed by climate change to agriculture and food security require holistic and strategic approach to linking knowledge with action. Further, scientific community has an essential role to play in informing concurrent, strategic investments to establish climate-resilient agricultural production systems, minimize greenhouse gas emissions, make efficient use of resources, develop low-waste supply chains, ensure adequate nutrition, encourage healthy eating choices and develop a global knowledge system for sustainability. Maximization of agriculture’s mitigation potential requires investments in technological innovation and agricultural intensification linked to increased efficiency of inputs, and creation of incentives and monitoring systems that are inclusive of smallholder farmers in EA.

Keywords: climate change, agriculture, food security, climate services
UAS-POS3002 - A prototype WRF-based wind power forecasting tool for Argentina

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Wind power forecasting has become an important service for the appropriate management of wind power generation, particularly in those countries where there is a significant penetration of wind energy into their electricity markets. Although Argentina is at an early stage in the exploitation of wind energy (there is only 218 MW of installed capacity as of 2013), there are near-term plans to further deploy renewable energy capacities, with more than 1000 MW in wind power projects to be executed. This research is part of a series of studies whose objectives are the creation and validation of dynamic-statistical methodologies for wind power forecasting in Rawson Wind Park, located in northeastern Patagonia region and consisting of 43 wind turbines. To accomplish this, our first task was to convert WRF high-resolution wind speed forecasts to wind power predictions through the implementation of adaptive nonlinear regression models. This relies on a nonparametric methodology applied to find the relationship between wind speed forecasts at different heights and wind power observations from Rawson Wind Park. The techniques employed are inspired by those already developed and applied in Denmark. Then, wind power predictions are combined with an autoregressive linear model in order to better capture short-term local wind power dynamics. A simple reference model based on linear combination of WRF wind speed forecasts, theoretical power, and an autoregressive term, has been used to quantify the improvement of our proposed methodology for time horizons up to 72 hours ahead. Results show errors slightly larger than those found for Denmark.

Keywords: wind park, wind energy forecast, Argentina
UAS-POS3004 - The Application of Satellite Sensed Winds and Waves for Marine Weather Warnings and Forecasts

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Satellite derived ocean winds and waves have increasingly become key observations used by operational marine weather forecasters issuing warnings and forecasts at the NOAA Ocean Prediction Center. The oceans have long been data sparse for conventional surface observations. Wide swath scatterometer winds help fill the gaps in conventional ocean surface data by providing high resolution full vector wind fields at the scale of ocean cyclones. Altimeter wave heights also help fill the gaps for wave height observations. Forecasters use scatterometer winds and altimeter waves to enhance situational awareness, compare numerical model wind and wave fields with satellite inferred or measured fields, to update warnings, and verify forecasts and warnings. The NOAA Ocean Prediction Center uses integrated workstations called National Centers - Advanced Weather Information Processing System (N-AWIPS) to view weather information and for graphical product generation. N-AWIPS will be replaced by AWIPS II in late 2015. Ocean winds and waves from three scatterometers and three altimeters are available in N-AWIPS in near-real time with complimentary imagery, numerical model fields, and observations. This integrated display capability has greatly enhanced forecaster awareness and is reflected in the text and graphical products generated by the Ocean Prediction Center. This paper will discuss the operational application of satellite derived ocean winds and waves. Specific examples discussing the impact to forecaster based decisions, to warning and forecast products, and to marine weather services will be given.

**Keywords:** satellite, marine weather, ocean winds, ocean waves
Poster Session

UAS-POS3005 - Estimating road accident occurrence functions in response to bad weather and weather warnings

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The poster summarizes the estimation of a set of accident occurrence functions for road traffic accidents and road accident casualty numbers in Finland during the winter months (in this case defined as mid October - mid April). The data set comprises of the reported number of accidents and casualties per day by region in combination with daily weather observation and warning data per region as well as road infrastructure classification information. The total number of observations is about 80000. The models are estimated for regional road accident incidence in relation to weather conditions, while correcting for other influences, such as type of day, road type, etc. The output of the model indicates the expected rise in the number of accidents in a region as compared to a normal winter day. The model accounts for the effect that traffic flows diminish in response to bad weather. As the Finnish road transport system is well adapted to winter weather, conditions have to be really quite bad (winter storms; blizzards) before accident incidence rates start to rise clearly. The paper also shows the difference between well pre-warned and less well pre-warned adverse weather conditions. Last but not least it provides some cost estimates of changes in accident rates and provides some preliminary explorations regarding effects of climate change on incidence rates.

Keywords: road accidents, bad weather, responsiveness, weather warnings
This study was aimed to identify wave characteristics in Indonesian waters and identify times and areas with high vulnerability of high waves in Indonesian waters. Significant wave height of Windwaves-5 model output was used for obtaining such information, with surface level wind data for a period of 11 years (2000-2010) from NCEP-NOAA was used as model input data. The model output data was validated with multimission satellite altimeter data obtained from Aviso. The data then used to identify areas of high waves based on the classification of high waves by WMO. From all of the processing result, characteristic of wave on Indonesia Archipelagic Sea Lanes (ALKI) was identified, which lanes have high potential for dangerous waves and when it will occur. The study concluded that throughout the years, Windwaves-5 model has a magnificent performance in providing significant wave height data on South China Sea, northern waters of Papua, Arafuru and Timor Sea. It is the same area that have high vulnerability of high wave throughout the year. The best season for crossing ALKI I is in February to June and October to November, ALKI II is January to June and September to December, ALKI IIIA is from April to November, ALKI IIIB and ALKI IIIC is from April to Mei and August to November when the waves and vulnerability is likely less high. Throughout the years, ALKI II is the safest lanes among others since it have lower vulnerability of high waves than the others.


Keywords: Wave, Indonesian waters, trasport safety, sea transport
Seasonal ice roads are an important part of the Canadian arctic transportation network. Constructed over frozen lakes and rivers, the roads service communities and resource extraction projects which are otherwise fly-in only for the rest of the year. The Tibbitt-to-Contwoyto Winter Road connects three of Canada’s largest diamond mines, and has been constructed annually since 1982. The road requires a minimum ice thickness of 0.7 metres to open, and has an average operating season of 67 days. Recent projections suggest an arctic amplification of the global climate change signal, with potential impacts for the long-term viability of using ice roads to move supplies north via land. This study uses a one-dimensional thermodynamic lake ice model (Canadian Lake Ice Model - CLIMo) to make historical and near-future projections of ice phenologies and thickness. We first simulate historical conditions using atmospheric reanalysis data (ERA-Interim) for the known operations period 1982-2011 to discuss recent trends; we then use regional climate model data (Canadian Regional Climate Model – CRCM 4.2.0) to model historical conditions for a 1961-1990 baseline period, and the period 2041-2070 for a future climate scenario based on IPCC SRES scenario A2. Output for lakes at key depths suggest later ice-on events and earlier ice-off events, combining for a 15-25 day reduction in ice season, and a 20-40 centimeter change in maximum ice thickness over the same period, with statistically significant trends towards thinner ice cover, between 1982-2011. Implications for future road operations are discussed.

Keywords: Climate change, Ice road, Winter road, Cryosphere
Winter weather creates mobility challenges for most Canadian jurisdictions, leading to significant expenditures on winter road maintenance (WRM) activities. The science and practice of snow and ice control is evolving but climate variability and change are particularly challenging for strategic planning of WRM. This research explores how changes in winter weather may translate into changes in WRM activities by 2041-2070 in Prince George, British Columbia relative to current conditions. The linkage between weather and WRM are analyzed, using winter maintenance data made available by the City of Prince George and meteorological observations from Environment Canada. The approach taken to document the association between winter weather and WRM expenditures is a winter severity index applied to simulated climate data based on 65 global climate models from the Canadian Climate Change Scenarios Network. Findings show that, notwithstanding changes in maintenance strategies, much of the variability in WRM can be attributed to weather. Climate models indicate that the Prince George Region is expected to be at least two degrees warmer and with more precipitation overall but fewer snowfall days. The net effects for winter maintenance are expected to be beneficial as winter road maintenance activities are expected to be reduced by between 5 and 38%.

**Keywords**: winter road maintenance, Climate Change, winter severity index, transportation
Poster Session

SCI-POM1003 – WITHDRAWN - The impact of polar mesoscale storms on northeast Atlantic Ocean circulation

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Atmospheric processes regulate the formation of deep water in the subpolar North Atlantic Ocean and hence influence the large-scale ocean circulation. Every year thousands of mesoscale storms, termed polar lows, cross this climatically sensitive region of the ocean. These storms are often either too small or too short-lived to be captured in meteorological reanalyses or numerical models. Here we present simulations with a global, eddy-permitting ocean/sea-ice circulation model, run with and without a parameterization of polar lows. The parameterization reproduces the high wind speeds and heat fluxes observed in polar lows as well as their integrated effects, and leads to increases in the simulated depth, frequency and area of deep convection in the Nordic seas, which in turn leads to a larger northward transport of heat into the region, and southward transport of deep water through Denmark Strait. We conclude that polar lows are important for the large-scale ocean circulation and should be accounted for in short-term climate predictions. Recent studies predict a decrease in the number of polar lows over the northeast Atlantic in the twenty-first century that would imply a reduction in deep convection and a potential weakening of the Atlantic meridional overturning circulation.


Keywords: polar lows, ocean circulation
Poster Session

SCI-POM1005 – WITHDRAWN - Discretization-aware interpolation in coupled models

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The components of coupled models of the land-atmosphere, ocean-atmosphere or sea-ice atmosphere system are increasingly being solved on unstructured and even “meshless” (e.g. watershed-based) grids. However the coupling methods used to interpolate states and calculate fluxes between these grids still typically ignores the actual structure of the grids and assumes or forces all data to be placed on an “A” grid before being passed to the coupler. This transfer should instead be done directly in order to preserve accuracy inherent in the discretization method used for each grid type. To support these advanced interpolation we are replacing the mesh type in the widely used Model Coupling Toolkit (Larson, 2005) with the more powerful representation provided by the Mesh Oriented Database (MOAB; Tautges, 2004) A more complete description of the mesh in the coupler will allow the implementation of more accurate and powerful interpolation methods.


Keywords: Interpolation, coupler, "Model Coupling Toolkit", MOAB
SCI-PS249.04 - Connection between weakening of stratospheric polar vortex and Pacific Decadal Oscillation

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We investigate here the connection between the extreme weakening of stratospheric polar vortex (WSV) and Pacific decadal oscillation (PDO). Tropospheric preconditions of WSV during positive and negative PDO phases show a remarkable difference in terms of the spatial scale of tropospheric circulation pattern. Based on the linear wave interference, this difference of spatial scale was closely associated with the difference in spatial scale of upward propagating wave pattern, which trigger the WSV occurrence. It is demonstrated here that upward propagation of wavenumber 1 pattern mainly contributes to WSV occurrence during positive PDO phase, while contribution of wavenumber 2 is dominant during negative PDO phase. These features were well-represented in the zonal mean heat flux anomaly at 100 hPa, which is proportional with the strength of upward propagating stationary wave into the stratosphere. Furthermore, this difference of wave pattern seems to be closely related with the mean circulation and variability related with PDO phase. The mean circulation contributed positively (negatively) as background to anomalous upward propagation of wavenumber 1 in WSV events of positive (negative) PDO phase. In particular, the large contribution of wavenumber 2 which incur the WSV occurrence in negative PDO phase seems to be closely related with the intensification of intra-seasonal variability of tropospheric circulation over the North Pacific, which is driven by the northward shift of zonal wind in negative PDO phase.


Keywords: Weakening of stratospheric polar vortex, PDO, Wave linear interference
Poster Session

SCI-POM1007 – WITHDRAWN - Numerical Simulation of effects of Cloud Seeding on Precipitation over Equatorial East Africa

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Many regions around the world are subject to severe water shortage. Over Equatorial East Africa (EEA), many socioeconomic activities e.g. agriculture remain rainfall dependent. Based on numerical weather prediction COntsortium for Small-Scale MOdeling (COSMO) model version 5.0, the study investigated potential of enhancing rainfall through cloud seeding. Root Mean Square Error (RMSE) was used to evaluate model performance. COSMO model performed well over the EEA with RMSE values 0.96mm. Model simulations showed that Cloud Condensation Nuclei (CCN) conditions may have a significant impact on the development of clouds. During the March–April–May and October–November–December season, aerosols had considerable impact on the amount and spatial distribution of precipitation at the ground over the Region. Seeding with intermediate CCN concentration lead to significant increase in total accumulated precipitation while high CCN concentration lead to reduced precipitation. Observed precipitation was noted to be higher than simulated precipitation for intermediate CCN scenario. The study concluded that in order to get desired effects of significant increase in precipitation over the area of study, low to intermediate CCN concentrations. Therefore, understanding possible effects of intentional cloud seeding on clouds and precipitation would act as insight towards development of operational program for weather modification and thus achievement of Millennium Development Goals (MDGs)

Keywords: cloud seeding, aerosol, simulation, precipitation
SCI-POM1008 - Comparing and combining of observation-based QPE methods with high-resolution numerical weather prediction and data assimilation

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Quantitative estimation and prediction of precipitation (QPE and QPF) is among the most challenging tasks in atmospheric sciences. Correct estimates or forecasts of precipitation are fundamental for many end users, e.g., flood forecasting centers. The presented work is part of the Collaborative Research Unit “Catchments As Organized Systems” (CAOS) of the German Research Foundation (www.caos-project.de). The objective is the comparison and combination of observation-based QPE methods with high-resolution numerical weather prediction (NWP) and data assimilation of state-of-the-art observations. It is expected that the combination of both approaches provides better results than each of both methods alone. A Kriging algorithm is applied to spatially interpolate the data of a dense gauge network. This product is blended with available radar observations into an observed QPE product. Key components of the NWP QPE system are the WRF-NOAH-MP modeling system and a 3D variational assimilation system (3DVAR) applied on the convection-permitting scale over a huge domain in Europe. The system is operated with a 1-h rapid update cycle and processes a large set of standard observations complemented by data from French and German radar systems, a European GPS network and satellite sensors. Both QPE methods are compared and finally blended with each other to combine the advantages of both approaches. Detailed results for two horizontal resolutions are presented for an interesting case study containing large-scale as well as convective precipitation. A further refinement of the observation-based methodology, the applied numerical weather prediction and assimilation system and their combination is planned as future task.

\textbf{Keywords:} quantitative precipitation estimation, numerical weather prediction, data assimilation
Poster Session

SCI-POM1010 - Photon recollision probability based study on the fPAR of forest canopies

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The fraction of Absorbed Photosynthetically Active Radiation (fPAR) by green vegetation is one of the Essential Climate Variables (ECV). In boreal forests, the mixed green understory may have a non-negligible contribution to the total fPAR. However, while fPAR of the canopy increases with the growth of the trees, the fPAR of the understory remains relatively stable from year to year. Therefore, the variation in the amount of absorbed energy by the canopy is the more interesting part of the total fPAR of forested areas.

An existing simple canopy reflectance model based on the photon recollision probability (p) has been further improved to take into account that the probability of the first recollision of photons (p₁) may differ from the recollision probabilities of higher order. Although the difference between p₁ and the multiple order p is typically not large, it affects the bidirectional reflection and transmission characteristics of the canopy when compared to the case where the recollision probability is assumed to remain constant. Furthermore, this has an effect on the fPAR, which has a key role in the carbon cycle. The new model relates fPAR to the leaf area index (LAI) and the direction(s) of the incoming radiation. The model is used to simulate boreal forest canopy fPAR for typical LAI and sun zenith angle ranges. The modeled values of fPAR are compared to values retrieved using simple satellite based canopy fPAR estimation methods.


Keywords: boreal forest, canopy, fPAR, photon recollision probability
SCI-POM1017 - Probabilistic assessment of rainy season onset forecasts

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Prior knowledge about the likelihood of an early or late onset of the rainy season is an important societal demand. Several sectors including agriculture, energy production and public health are constantly looking for this information to help strategic decisions. The use of a pre-defined criterion applied to historical rainfall records allows the construction of climatological distributions of rainfall onset dates. With this historical information it is possible to diagnose for example the most likely rainfall onset dates, and the earliest and latest onset dates ever observed, which provide some indication about rainfall onset characteristics. However, for practical applications these climatological characteristics might not be sufficient for strategic decisions. Forecasts indicating whether the rainy season onset is more or less likely to occur earlier or later than the most likely onset dates estimated from historical records have the potential to provide important complementary information for decision making. This study will present a preliminary assessment of probabilistic rainy season onset forecasts produced with a simple empirical cox-regression model for selected locations in Brazil.

Keywords: rainy season, onset, probabilistic forecast, verification
Poster Session

SCI-POM1019 - Implications of 2000-2050 changes in climate, land use and land cover on global wildfires

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The occurrence and severity of wildfires are very sensitive to fire meteorology and vegetation coverage. We investigate the potential impacts of climate change and land use/land cover change on global wildfires over the period of 2000-2050. We account for the impacts on wildfires associated with fire meteorology (such as temperature, precipitation, and relative humidity), vegetation density, as well as lightning and anthropogenic ignitions. For the present-day conditions, our model results successfully reproduce the spatial variability of wildfires, with highest fire counts in Africa and South America, which are generally consistent with Moderate Resolution Imaging Spectrometer observations. Fire counts under the 2050 conditions are projected to increase by approximately 18% globally, relative to the 2000 level. Significant fire increases are observed in Africa and Australia, while most of regions in South America show a decreasing trend. Changes in fire meteorology driven by 2000-2050 climate change are found to increase the global annual fire counts by around 13%. Significant increases in fire counts at the mid-high latitudes, especially over the boreal forests are calculated in response to changes in lightning activities associated with climate change. Changes in land use and land cover by 2050 are expected to increase the global fire counts by 6% relative to the 2000 condition. Expansions of agriculture in Central Africa over the period of 2000-2050 lead to decrease of vegetation density and hence reductions in wildfires in that region.

Keywords: climate change, land use and land cover, wildfire
Poster Session

SCI-POM1020 - The coupled atmospheric-ocean-chemistry FIM global model

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NOAA/ESRL has developed a highly scalable earth system global model with a unique combination of an icosahedral horizontal coordinate and an adaptive isentropic-sigma hybrid vertical coordinate: FIM for Flow-following finite-volume Icosahedral Model. FIM has been tested extensively in retrospective and real-time experiments at resolution of 60km, 30km, 15km and 10km. In this poster, results will be presented showing commensurate skill with the GFS out to 5 days and improvement for 6+ days for height, and for improvement for wind, RH, and tropical cyclone track forecasts. FIM has been designed with a coupling to the HYCOM ocean model adapted to use the same icosahedral horizontal coordinate to minimize the introduction of errors from interpolation of air-water fluxes especially near coastlines. FIM also has an option for inline chemistry from WRF-Chem, with real-time versions running with a simpler GOCART option and also, if needed, for volcanic ash (e.g., Eyjafjallajokull). Comparisons for medium-range forecast accuracy will be shown between \(\theta-\sigma\) and \(\sigma\)-vertical coordinate options. Current efforts include development and testing of scale-aware convective parameterization and evaluation of FIM with GFS in a multi-model ensemble configuration for consideration at NCEP.

**Keywords:** icosahedral, isentropic, chemistry, coupled
Poster Session

SCI-POM1021 - Operational and research comparisons of a global variable resolution model to a limited area model

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The ability to skillfully predict weather patterns beyond days to weeks depends on accurate representations of the interactions among all components of the climate system, including the atmosphere, ocean, land, and cryosphere. A new fully compressible, nonhydrostatic, global model called the Model for Prediction Across Scales (MPAS) is currently being developed that allows for local refinement of the horizontal grid such that there is a smooth transition in resolution from the relatively coarse global mesh to finer mesh in regions of primary interest. This smooth transition in horizontal resolution is expected to reduce complications that typically arise from traditional downscaling and nesting approaches, and will eventually include full coupling capabilities currently available within the Community Earth System Modeling (CESM) framework. Here, we compare performance of the atmospheric component of MPAS with downscaled Weather Research and Forecasting (WRF) model for real-time forecasts greater than 8 days, as well as long-term climatologies, focusing on the Arctic region. We choose to focus on the Arctic because MPAS does not require the use of polar filtering and because high latitude regions exhibit relatively high sensitivity to weather climate that involve complex earth-system interactions. Although we expect MPAS real-time forecasts to be superior in performance to WRF, the benefits of any potential improvements have not been looked at in great detail. Our results shed insight into the impact that downscaled boundary conditions have on long term forecasts, which will be discussed through the examination of several experimental climatologies.

Keywords: MPAS, WRF, Arctic
SCI-POM1022 - Climate models' bias in surface temperature trends and variability due to treatment of boundary layer

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Global climate models (GCMs) use a variety of parameterization schemes to describe the Planetary Boundary Layer (PBL) and this results in large differences between models in their description of the PBL depth. These differences are greatest under stably-stratified conditions, related to shallow boundary layers. The planetary boundary layer depth modulates the magnitude of the surface air temperature (SAT) response to forcing: the strength of the temperature change on a given timescale is reciprocally proportional to the boundary-layer depth. Given that it is these shallow boundary layers that most strongly modulate the air temperature, we expect the greatest uncertainties in model temperature response to occur in stably-stratified conditions. Here we have investigated GCM performance with regard to some key metrics affected by the boundary-layer modulation of forcing: the SAT mean, trend and variability. We assessed the GCMs individually by determining each model’s departure from observations in the historical simulations, and as an ensemble, by assessing the inter-model spread in each metric. These assessments are performed both geographically, and as a function of the PBL climatology. We show that the greatest model error in these metrics occurs under conditions where the PBL depth is most uncertain i.e. in shallow/stably-stratified boundary layers, both for GCMs individually, and as an ensemble. Furthermore, we show that the bias in the models towards over-estimating the PBL depth in shallow layers corresponds with an under-estimation of the SAT variability. This highlights the importance of improving the treatment of the stably-stratified PBL in GCMs.

Keywords: Climate, Surface temperature, Global Climate Models, Thermodynamics
Poster Session

SCI-POM1023 - GPU Technology for computational acceleration of NWP Models

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Current trends in high performance computing (HPC) are moving towards the use of graphics processing units (GPUs) to achieve speedups through the extraction of fine-grain parallelism of application software. GPUs have been developed exclusively for computational tasks as massively-parallel co-processors to the CPU, and during 2013 an extensive set of new HPC architectural features were developed in a 4th generation of NVIDIA GPUs that provide further opportunities for GPU acceleration of atmospheric and ocean models used in climate science and numerical weather prediction. Today computational efficiency and simulation turnaround time continue to be important factors behind scientific decisions to develop models at higher resolutions and deploy an increased use of ensembles. This technical presentation will examine the current state of GPU parallel developments for stencil based numerical operations typical of dynamical cores, and introduce new GPU-based implicit iterative schemes with GPU parallel preconditioning and linear solvers based on ILU, Krylov methods, and multigrid. NWP models have demonstrated substantial gain in parallel efficiency from second-level fine-grain parallelism under first-level distributed memory parallel through a hybrid parallel implementation. Examples are provided relevant to science-scale HPC practice of CPU-GPU system configurations based on model resolution requirements of a particular simulation. Performance results compare use of the latest conventional CPUs with and without GPU acceleration. Finally a forward looking discussion is provided on the roadmap of GPU hardware, software, tools, and programmability for NWP model development.

**Keyword:** GPU, HPC, NWP, Atmospheric Models, Ocean Models
We describe new development and validation of a tangent linear and adjoint models for the High-Order Method Modelling Environment, the default dynamical core in the Community Atmosphere Model and the Community Earth System Model that solves a primitive hydrostatic equation using a spectral element method. A tangent linear model is primarily intended to approximate the evolution of perturbations generated by a nonlinear model, serving as an intermediate step to write and test adjoint models. Adjoint model based on the developed tangent linear model provides the gradient information in 4-dimensional variational data assimilation (4Dvar). This is a critical factor for the performance of 4DVar. In this study, each module in the tangent linear model is linearized by hands-on derivations and validated by the Taylor-Lagrange formula. The correctness of each module is confirmed by linearity checks and the field results of the tangent linear modules show that they converge to the difference field of two nonlinear modules as the magnitude of the initial perturbation is sequentially reduced. Various time step sizes are tested through numerical stability analysis of the tangent linear model and a reasonable time step size is determined without compromising spatial resolution, computational cost, or model performance. Although the scope of the current implementation leaves room for a set of natural extensions, the results and diagnostic tools presented here should provide guidance for further development of more advanced tangent linear model, adjoint model, and 4DVar in terms of resolution changes and improved linearization of dynamic systems.


Keywords: Tangent Linear Model, Adjoint Model, High-Order Method Modelling Environment, 4 Dimensional Variational Method
Poster Session

SCI-POM1043 - The Impacts of pressure level decisions on the KIAPS observation processing system

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The KIAPS Observation Processing System has been developed by the Korea Institute of Atmospheric Prediction Systems (KIAPS) to provide accurate and optimal observations to the data assimilation system. For the bias correction (BC) and quality control (QC) of the observations, the UM model outputs that are used by the Korea Meteorological Administration (KMA) for operational data assimilation are used as background data. The pressure values at half-levels should be calculated by the vertical interpolation from the pressure of the immediately lower and upper full-levels. In this study, we tested three vertical interpolation methods which were used or are currently in use by the UM, and examined the impacts of the different values of pressure and other variables calculated by the tested methods on the departure (O-B) of AMSU-A and IASI radiances and GPS-RO data. The vertical interpolation methods tested in this study are 1) simple average, 2) weighted average using difference of logarithmic scaled pressure, and 3) linear weighted average using difference of geopotential height. The results of the comparative study of the satellite based observation data will be presented with the current development status of the KIAPS Observation Processing System.

Keywords: KIAPS, Observation Processing System, vertical interpolation
SCI-POM1047 - Progress report on the development of GMAO’s 4DVar and preliminary comparison with 4D-EnsVar

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The Global Modeling and Assimilation Office (GMAO) has been experimenting with a 3D-Var-hybrid version of its data assimilation system (DAS) for over a year now. This system will soon become operational and it will rapidly progress toward a 4D-EnVar. However, the machinery to exercise traditional 4D-Var is in place and it is desirable to have a comparison of these two 4D approaches and examine how they perform in the Goddard Earth Observing System DAS. This work will also look into exploring possibilities for constructing a reduced order model (ROM) to make traditional 4D-Var computationally attractive for increased model resolution. Part of the research on ROM will be to search for a suitably acceptable space to carry on the corresponding reduction. The poster will illustrate how the various assimilation methodologies available at GMAO compare with each other.

Keywords: 4dvar, ensemble hybrid, model order reduction
Poster Session

SCI-POM1052 - The Improvement on IDW and its application on T variable in dense observation network

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The Dense Automatic Observation Network (DAON) is an important base of nowcasting due to its denser observational distribution, higher recording frequency and more newly information than the traditional observation network. The DAON has its own characteristics: observation scattering, height difference, background circulation variation, equipment mechanic response, etc., so the variable values coming directly from the DAON are easily with random error and with difficulty in operational application. A preprocessing and the quality control on the observation values are necessary. Considering the dynamic harmony between temperature and air pressure fields, and combing the temperature lapse rate, the inverse distance weighted interpolation method (IDW) applied on air temperature data of DAON is improved. During the processing, Gaussian filter is as distance weighting parameter, and the temperature spatial and temporal distribution features is classified including the latitude, longitude and altitude of observation position, seasonal features, present weather event etc. then the optimized algorithm parameters and minimum error of interpolation are calculated out, and they are applied on processing of T variable of the national DAON. By comparing with traditional spatial IDW method, it shows that the improved algorithm is more efficient in finding those wrong observation records, especially under situations of the neighboring values with large altitude differences, also the situations with near surface temperature inversion. The improved algorithm can recognize errors quickly and correct the values with better fitting to the real temperature field. The method is also efficient when it is used for missing data interpolation in DAON.

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Keywords: the Dense Automatic Observation Network (DAON), the inverse distance weighted interpolation method (IDW), the improved algorithm, the wrong and missing T variable
Poster Session

SCI-POM1055 - WRF dual polarized radar forward operator evaluation on a supercell event in Central Europe

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To equip the WRFDA with dual polarized radar data, the existing dual polarized radar forward operator in the ARPS model is adopted as part of the WRF microphysics package. The performance of the operator is studied by means of forecasting polarimetric signature of a supercell event in Central Germany. The comparison of single-moment and double-moment microphysics demonstrates that single-moment scheme does not capture all polarimetric signatures. However, the combination of two-moment microphysics and the dual-pol radar forward operator results a significantly more accurate demonstration of the supercell including low, and mid-level polarimetric signatures. Finally, methodologies and applications of pol. radar DA are discussed. Future applications will include the assimilation of polarized radar data on the convection permitting scale to obtain quantitative precipitation estimates (QPE). This will be done either by a 3DVAR/4DVAR RUC configuration or a multi-physics ensemble forecasting system and is subject for future research.


Keywords: Dual polarized Radar, Data assimilation
Poster Session

SCI-POM1058 - The Evaluation and Monitoring of Surface Air Quality Species at the Canadian Meteorological Center

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In February 2013, the Canadian Meteorological Centre (CMC) implemented with the collaboration of air quality research division a new surface analysis for air quality species. Initially surface analysis was generated for ozone (O\textsubscript{3}) and fine particulate matter (PM\textsubscript{2.5}). Research and development continue with respect to the surface analyses for other chemical species (NO\textsubscript{2}, NO, PM\textsubscript{10}, SO\textsubscript{2}). The Regional Deterministic Air Quality Analysis System (RDAQA) for new species is currently running in an experimental mode. The RDAQA evaluation statistics and monitoring results will be presented together with information about the end products that are available on an internal Environment Canada website. Monitoring procedures include the examination of the O-P (observation minus first-guess values) and O-A (observation minus analysis values) statistics for all new species on both an hourly and a day-to-day basis or in terms of monthly means. It is also possible to evaluate the quality of the data for all the stations as a group or the quality of the data for individual stations. This enables the detection of problems for particular station which can in-turn provide valuable feedback to the data provider. Moreover, systematic mismatches between model and observations (O-P) can indicate model bugs whereas systematic error (O-A) or analysis increment maps could point towards assimilation system problems.

Keywords: chemical species, RDAQA, monitoring statistics, surface analyses
SCI-POM1061 - Latest study results toward improving the UV index forecasts at Environment Canada

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The operational ultraviolet (UV) index forecasts being provided by Environment Canada (EC) rely on total column ozone maps empirically estimated from meteorological variables followed by scaling with ground-based total column ozone measurements from a few Brewer stations in Canada and a table-based attenuation factor to account for cloud and precipitation conditions. As well, stratospheric ozone assimilation has been conducted in research mode at Environment Canada for over ten years. A new project has been undertaken to produce UV index forecasts using ozone analyses, resulting model ozone forecasts, and also model-derived radiances in the UV spectral range. The ozone model consists of the LINOZ linearized ozone chemistry scheme. The assimilated ozone data include GOME2 and SBUV-2 observations. The latest results on total column ozone and UV index forecasts will be compared to ground-based and satellite measurements and to output of the EC and NOAA operational products.

Keywords: UV index, Ozone, Data assimilation, Forecasting
Poster Session

SCI-POM1064 - Assimilation of Near-Real-Time Albedo and Leaf-Area-Index for weather parameters and CO2

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The vegetation state can prominently influence the global energy, water, and carbon cycle and it is particularly evident during extreme droughts conditions in recent years (e.g Europe 2003, Russia 2010). Weather parameters are sensitive to the vegetation state and particularly to Albedo and Leaf Area Index that controls the surface energy fluxes partitioning (latent, sensible and net heat fluxes), the development of planetary boundary conditions and clouds. An optimal interpolation analysis of the GEOV1 surface albedo and LAI is performed through the combination of the satellite observations and derived climatologies, depending on their associated errors. The final analyses products have smoother temporal evolution, which makes them more appropriate for environmental and numerical weather prediction. The impact of assimilating these products in the ECMWF land surface scheme CHTESSEL is evaluated. Surface energy and carbon fluxes derived from offline runs are assessed for anomalous years. The near-surface air temperature and humidity derived from coupled runs using the ECMWF Integrated Forecasting system (IFS) are shown to respond to vegetation changes and the impact of considering both structural (LAI) and radiative (albedo) changes in the vegetation is analysed and discussed.


Keywords: NRT LAI/albedo assimilation, surface fluxes anomalies, screen level response
Poster Session

SCI-POM1068 - The Meteorological Service of Canada’s network planning and design process- progress, challenges and future opportunities

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The Meteorological Service of Canada’s (MSC) monitoring networks provide observations that support Canada’s most fundamental hydrometeorological information needs. To help ensure these networks remain pertinent as the evolving demand for information continually grows, the MSC has formalized a strategic network planning and design process. This process is an adaptation of the World Meteorological Organization’s internationally recognized Rolling Requirements Review. The purpose is to develop integrated hydrometeorological monitoring solutions to ensure the evolving requisite requirements are met in a manner which is scientifically rigorous, reliable and sustainable. The process places a strong emphasis on the collection and validation of user requirements, analyzing current monitoring capabilities, identifying discrepancies (e.g. gaps), assessing monitoring alternatives and developing network design options. The process is cyclical and adaptable in nature which allows for it to be reapplied as necessary in response to shifting priorities, evolving requirements and emerging monitoring capabilities. The Canadian Network of Networks (NoN) has been identified as one potential approach to help meet the departments’ evolving needs and to improve the overall quantity, quality and accessibility of hydrometeorological data in Canada. It is a voluntary, collaborative and multi-participant approach to monitoring that will encourage and facilitate timely and open exchange of data among many contributors. A general overview of the MSC network design process will be presented, including an exploration of recent progress, challenges and future opportunities.

**Keywords:** Network Design, Observational Requirements, Canadian Network of Networks
SCI-POM1072 - Assimilating snow depth measurement using Canadian Precipitation Analysis System (CaPA)

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In Canada over 20 percent of yearly precipitation reaches the ground as snow. Consequently snow is important variable in land surface models; comparison as well as validation of models with measurements is of primordial interest. Environment Canada is the lead coordinator for the pilot program responsible for providing volunteers with the equipment and training required to operate observation sites in Atlantic region during the winter 2013-2014. The project is held with collaboration from private sector, Scotia Weather Services which role in the project is: observer recruitment and training, equipment installation and maintenance, management of the data flow from Community Collaborative Rain, Hail and Snow (CoCoRaHS) Network and additional quality assurance checks on the data prior to delivery to Environment Canada (EC), assessment of the enhance precipitation analysis produced by EC and assessment of client usage of the analysis products that result from the project. The primary aim of this work is to present the project and give details on how these measurements will be assimilated by EC CaPA system. First of all, measurements from this network will be compared with operational daily CaPA product outputs. Then, simple method assuming snow depth 10:1 ratio obtained with precipitation from CaPA will be compared with daily snow accumulation predicted by Surface Prediction System and measurements. Finally, daily snow depth maps for Atlantic region, diagnostic with results from quality assurance procedure of measurements and leave-one-out analysis will be also presented.

References:
http://weather.gc.ca/analysis/index_e.html#APCP

Keywords: assimilation, snow depth, CaPA
SCI-POM1076 - Constraining a 3DVAR Radar Data Assimilation System with Large-scale Analysis to Improve Short-Range Precipitation Forecast

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It is known from previous studies that radar data assimilation can improve the short-range forecast of precipitation, mainly when radial wind and reflectivity are available. However, from our experience the radar data assimilation when using the 3DVAR system can increase the spurious precipitation and induce large errors on the position and the total amount of precipitation, mainly due to the lack of proper balance in the thermodynamical fields. The 4DVAR system has advantages in that aspect, however, its computational cost is still much higher than many operational centers have available. Therefore, this works tries to minimize this problem from the 3DVAR system using large scale analysis as a constraint in the cost function in order to guide the assimilation process and ensure that the final result still maintain the large scale pattern, while adding the convective characteristics from the radar data. The Fractional Skill Score (FSS) and the Local Root Mean Square Error (LRMSE) were applied over 6 convective cases to compare quantitatively the performance of the precipitation forecasts with and without the new constraint. The FSS takes into account only the spatial distribution of precipitation for a given threshold and radius of influence, while the LRMSE takes into account the deviation of the amount of the precipitation from the observation within the same radius of influence used for the FSS calculation. Both skill indexes have shown improvements when using the methodology presented here. The FSS has an improvement up to 60% and the LRMSE up to 70%.

Keywords: data assimilation, radar, constraint, precipitation
SCI-POM1080 - Bayesian Analysis of orographic precipitation sensitivity to upwind sounding and terrain

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Orographic precipitation is a key component of the hydrologic cycle. The amount and distribution are known to depend on mountain and atmospheric sounding characteristics: mountain height and width, wind speed, stability, temperature, and humidity. Numerical models, including the Weather Research and Forecasting (WRF) model and the CM1 cloud-resolving model (Bryan and Fritsch, 2002), are useful tools for exploring the response of precipitation to atmosphere and mountain characteristics, and have been used to model moist neutral flow over a mountain (Miglietta and Rotunno, 2005, 2006, 2009, 2010). However, exploring all possible combinations of mountain and sounding configurations with a numerical model is computationally exhausting. Bayesian techniques, namely Markov chain Monte Carlo (MCMC) algorithms, were recently used to explore parameter sensitivities in remote sensing retrievals and model parameterizations in a computationally efficient way (Posselt et al., 2008; Posselt and Vukicevic, 2010; Posselt and Mace, 2014). However, use of MCMC to explore interactions in the physical system is an original concept. Here we introduce a MCMC-based sensitivity analysis that, in conjunction with the CM1 model, provides insight into combinations of atmospheric and mountain parameters consistent with a given precipitation distribution.

Keywords: Bayesian, Orographic, Markov chain Monte Carlo
Poster Session

SCI-POM1100 - Spatial allocation of Canadian 2010 arctic marine emissions

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A GEM-MACH based Arctic air quality modelling capability is being developed at Environment Canada to assess the impact of current and future air contaminant emissions from shipping and other sources in the Arctic environment and human health. In the longer term, the modelling capability will also meet the needs of both scientific research and policy applications in understanding and addressing air quality and environmental issues in the Canadian North. In order to have adequate representation of the ambient concentrations of air pollutants, comprehensive emissions inventory for the Arctic must be processed and included in air quality model such as the Environment Canada’s GEM-MACH regional air quality model. This presentation aims to provide an overview of the work done to spatially allocate the Canadian 2010 marine emissions in most of Canadian navigable waters, namely within a 200 nautical mile region of the Canadian Pacific Coast, the Atlantic Coast and in the Arctic. The marine emissions inventory includes different classes of vessel including freighters, tankers, tugs, ferries, passenger boats, fishing boats and container ships.

Keywords: marine, arctic, emission, allocation
One major radioactive isotope released from the Fukushima nuclear accident is Cesium-137 (Cs-137). With a half-life of 30.1 y, Cs-137 is a big concern for human health after being deposited on the ground surface, subsequently contaminating agriculture lands, and being resuspended by winds or other disturbances. In this study, we model the wet and dry deposition of Cs-137 from the accident using the newly developed wet and dry deposition schemes for atmospheric dispersion models. The wet deposition scheme includes both in-cloud and below-cloud scavenging. The in-cloud scavenging scheme treats the process through parameterization of cloud nucleation of aerosol particles and explicitly deriving precipitation production rate from numerical weather prediction models. The new dry deposition scheme takes into account of effects on dry deposition velocity by friction velocity, surface roughness, and particle size. We compare the simulated the deposition with observations, and the simulations with other wet and dry deposition schemes.

**Keywords:** wet scavenging, dry deposition, atmospheric dispersion model, aerosol dynamics
Poster Session

SCI-POM1104 - Modeling ambient air VOC pollutants in Canada with AURAMS

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Air pollution has a significant impact on health, environment and economy. VOCs (Volatile Organic Compounds) are pollutants known to play an important role in the atmospheric chemistry, especially in the lower layers of the troposphere, where anthropogenic and biogenic emissions are abundant and meteorological factors can enhance their effects. Atmospheric modeling is a tool used to assist regulatory and decision making by assessing the impact of pollution sources, in the establishing of emission reduction goals. Thus, more attention needs to be paid to the accuracy of models and their capability to represent in more detail the chemical reactions involved in ground-level atmospheric chemistry. The SAPRC-07 chemical mechanism was implemented in Environment Canada's AURAMS (A Unified Regional Air quality Modeling System) model to explicitly represent six pollutants used to assess health risk: benzene, 1,3-butadiene, 1,2,4-trimethylbenzene, formaldehyde, acetaldehyde and acrolein. The current implementation contains 136 gas species and 601 chemical reactions. The model is driven with emission input speciated to explicitly include these compounds, and with meteorological fields from the Canadian GEM (Global Environmental Multiscale) forecast model. Three sets of simulations were performed: one on a North-American continental grid at 45 km resolution, and two nested ones on Canadian regional grids at 22.5 km. Simulation results are compared against routine measurements of the six compounds, from 54 NAPS (National Air Pollution Surveillance) stations across Canada. Model results will be presented and discussed.

Keywords: chemical transport model, atmospheric pollution, VOCs, chemical mechanism
SCI-POM1106 - Emissions inventory evaluation for air quality forecasting in Mexico

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This study describes the methodology used for preparing the latest emissions inventory for Mexico into model-ready emissions input data and an evaluation of the performance of the model. The region considered covers the central part of Mexico with an inner domain of 270 km x 270 km with Mexico City at its center. A high ozone episode from 8-11 of April, 2008 during the dry hot season is used for evaluating the performance of the model, air quality and observed meteorological data come from the Air Quality Monitoring Network; the results from the model are processed by the NCEP Unified Post Processor (UPP) and the statistical evaluation of the chemical species by a modified version of the NCAR Model Evaluation Tool (METv4.2). Preliminary model results showed an overestimation on wind intensity over the urban area of the city. In contrast model and measurements agree better with respect to temperatures. For the chemical species, some pollutants are overestimated (SO2, CO, NO2) while others are underestimated (O3). The results of the evaluation of the updated emissions inventory and the influence of land-use change, and the different chemical mechanisms on air quality forecasting for Mexico will be presented.

Keywords: emissions, air quality forecast, landuse change, meteorology
An appropriate representation of cloud macrophysical properties including cloud condensate amount and cloud fraction is important for the radiative and precipitation processes to be properly reproduced in the numerical weather prediction and climate models. Two statistical cloud macrophysics schemes that are diagnostic and prognostic schemes, respectively, have been implemented in the Korea Institute of Atmospheric Prediction Systems-Global Model (KIAPS-GM). To determine cloud macrophysical properties, the sub-grid scale variability of moisture and temperature is represented by a probability density function. Cloud water content and cloud fraction are diagnosed at every time step in the diagnostic scheme. In the prognostic scheme, cloud properties are more directly linked with other physical processes. In particular, the effects of convective heating/drying and detrainment are important. For moist convection, mass-flux convection schemes have been implemented. In this study, we evaluate cloud macrophysics schemes in KIAPS-GM and compare the performance of the diagnostic and prognostics schemes. For this, simulated temperature and humidity are evaluated against global reanalysis data and simulated cloud fraction, and radiative fluxes are assessed using satellite observational data. Precipitation rate is also compared with the observational dataset.

**Keywords:** cloud, parameterization, global model
SCI-POM1112 - Cloud classification using solar radiation data from NARIT Thai National Observatory at Doi Inthanon, Thailand

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Solar radiation data from the automated weather station of the National Astronomical Research Institute of Thailand (NARIT) Thai National Observatory (TNO) situated at Doi Inthanon national park in Northern Thailand was used to quantitatively classify clouds based on the observation-to-clear-sky-model solar irradiance ratio as well as on the standard deviation of the observed solar irradiance. The study was aimed at using observations at astronomical facilities for atmospheric science to complement existing weather stations as well as to optimize astronomical observatories in Thailand. It also aims to utilize its results to weather stations where there are no human observations possible for cloud types. Using the average of four solar irradiance models, the simulated clear-sky solar irradiance was obtained and compared to the observations (observation-to-clear-sky-model solar irradiance ratio). In order to have initial and baseline information in classifying clouds, the mean solar irradiance and its variability at specific times were matched to 6-minute all-sky images from TNO. Clear sky conditions would have a solar irradiance ratio close to 1, while thick and stratified clouds will have a solar irradiance ratio close to 0. However, both will have variability close to 0 due to minimal solar radiation fluctuations. Patchy clouds, on the other hand, will have a high variability, hence a high standard deviation, due to fast varying solar radiation intensities. Based on the observation-to-clear-sky-model solar irradiance ratio and the standard deviation of the observations, an empirically derived look-up table was produced for classifying clouds quantitatively.


Keywords: cloud classification, solar irradiance, all-sky-images
The Madden-Julian Oscillation (MJO) greatly modulates the onset and intensity of the South Asian summer monsoon. The MJO also modifies the large-scale environment that leads to tropical cyclone (TC) development in the Bay of Bengal (BoB). In this study, we analyze the extent to which the MJO modulates the Myanmar monsoon onset and BoB TC activity collectively. Using the ERA-Interim reanalysis and precipitation data from the Asia Precipitation-Highly Resolved Observational Data Integration Toward Evaluation of Water Resources (APHRODITE), spanning from 1979 to 2010, we find that stronger MJO events provide favorable conditions for springtime (pre-monsoon month of May) TCs in the BoB to occur concurrently with/or precede the monsoon onset in Myanmar. Together with warm BoB Ocean waters in May, springtime TCs form in connection with significant MJO fluctuations. The associated latent heating and ensuing circulation patterns lead to an intense deepening of the BoB monsoon trough. Emerging lower tropospheric westerlies and local convection thus intensify, subsequently leading to the monsoon onset over Myanmar. Myanmar employs 65 percent of its active labor force in agriculture, an industry that is heavily reliant on monsoon rainfall. Although tropical cyclones are important rain bearers, Myanmar is highly vulnerable to their destructiveness. An example is Cyclone Nargis that caused about 138,000 fatalities in May 2008. This work provides insight into predicting the Myanmar monsoon onset and to aid in disaster planning.

**Keywords:** Monsoon, Tropical cyclones, Coupling, Climate change
Poster Session

SCI-POM1154 - Predictability of the Typhoon Haiyan with the new weather forecasting model ICON

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The typhoon Haiyan made landfall on 8. November 2013 in the Phillipines with devastating effects. Storm warnings played a crucial role. The purpose of our work is to investigate how a new weather forecasting model (the German ICON model) is representing this typhoon in terms of initial condition and model physics. To investigate predictability the ICON model is initialized with 26 members of the ECMWF ensemble data assimilation (EDA) system at 32km resolution and 40 members of the ICON EDA system at 40km resolution. To investigate the dependence of model error on the physics we apply different physics packages (a TKE closure versus the DUALM-EDMF boundary layer cloud approach). Physical tendencies are analyzed to understand the interaction of transport at the extreme physics of a typhoon. Additionally, we run the ICON model at 40km, 20km and 10km globally and nested to 5km and 2.5km to investigate how simulations at low resolutions with convection parameterization can compete with convection resolving simulations. Generally, the ICON model is able to represent the track with reasonable accuracy and achieves a minimum pressure of 910hPa (2.5km nested run) compared to 895hPa as reported by JMA.

Keywords: tropical cyclones, convection, ensemble prediction
A tropical cyclone (TC) undergoing extratropical transition (ET) may interact with the extratropical flow such that a jet streak forms and an upper-level ridge amplifies. Moreover, the TC–extratropical flow interaction can amplify a Rossby wave train that disperses far downstream. Therefore, ET may cause high-impact weather in the vicinity of the ET-system and in downstream regions such as North America or Europe. In this study we unite the case study approach with composite analysis to elucidate the general characteristics of ET and to quantify the impact of ET on the midlatitude flow evolution. Recurring western North Pacific (WNP) TCs are composited based upon the strength of the TC–extratropical flow interaction. Then the TC is removed from the composite fields using a PV surgery technique. These modified composite fields serve as initial conditions for a simulation of the midlatitude flow evolution in the absence of ET. Comparing this “no TC” simulation against a “control” simulation allows for a quantification of the impact of ET. Lagrangian and Eulerian analyses of the simulations corroborate previous findings that a general characteristic of ET is downstream ridge amplification and jet streak intensification via diabatic PV reduction and isentropic transport of low-PV air by warm conveyor belt-like outflow of the ET-system. Furthermore, in the presence of ET, the initial amplification of the flow pattern disperses downstream, resulting in a second even stronger ridge over the eastern North Pacific and western North America. Thus, ET over the WNP significantly influences the flow pattern downstream over North America.


Keywords: tropical cyclone, extratropical transition, Rossby Wave Train, PV inversion
Poster Session

SCI-POM1167 - Analysis of three-dimensional motion on an intense anomaly ocean-effect snowstorm in Bohai Sea

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It is an intense anomaly example of Bohai Sea ocean-effect snowstorm which occurred in Shandong peninsula nearby the Bohai Sea, China on December 4-6th, 2008. Based on the simulation data of RAMS4.4 model, 3-D trajectory analysis of air parcel and diagnosis, three-dimensional structure and development mechanism is analyzed. There are some useful results. Strong extremely cold air leads large difference between the sea and air. In result, With 3-D trajectory analysis, air parcel in Bohai low level goes upward, but the mid and upper air parcel remain the original direction. Forceful upward motion of weather scale system and ocean-effect play the common action on the snowstorm. Upper trough deepening has two infections. One, compensatory upward motion caused by positive vorticity advection is favorable to more snowfall. Another, it can lead cold air to outbreak southwards. Then more instable layer will bring more ocean-effect snowstorm. In result, the strongest snowfall occurred during the upper trough influence. So the forecasters must attach importance to this phenomenon in the forecast operation. In the low troposphere, shear line between the north-west and north-east wind decide the position and snowfall of the snowstorm. What's more, weak vertical wind direction is helpful to form strong snowfall in local area.

**Keywords:** Ocean-effect snowstorm in Bohai Sea, Three-Dimensional motion, Cold air, Shear
Poster Session

SCI-POM1171 - ZDR columns and their practical diagnostic and prognostic value in Germany compared to the U.S.A.

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Polarimetric radar observations of deep convective storms frequently reveal columnar regions of enhanced differential reflectivity (ZDR). Such ZDR columns represent a key signature characterizing updraft location and strength, i.e. the primary feature hinting at a potentially explosive development in the cloud life cycle. ZDR columns can extend upwards more than 3 km above the environmental 0°C level, indicative of supercooled liquid drops being lifted by the updraft. Analyses in the U.S.A show that the vertical extent of the ZDR column above the 0°C level is positively correlated to precipitation and hail fall at the surface at 10 - 30 minute lag times. In Germany, warm rain processes occur frequently and ZDR columns do exist but they are mainly below the freezing level and are attributed to strong size sorting within relatively shallow updraft. In this case, the signatures are assigned to large drops and still have important nowcasting value, at least can be used to separate developing and dissipating systems and they definitely add information compared to the default advection-based nowcasting strategies. The predictive skill of vertical extensive ZDR-columns often observed in the U.S.A will be presented and compared with the prognostic value of moderate ZDR columns prevalent in Germany. The lifecycles of ZDR columns will be analyzed including the intensification of surface precipitation, hail occurrence, and lightning activity with lead times depending on the characteristics of the storm and the climate regime.

Keywords: Radar, Lifecycle of convective events, Nowcasting
Extratropical cyclones play a major role for daily weather in the mid-latitudes. They can be described in terms of different air streams: the warm conveyor belt (WCB), the cold conveyor belt and the dry intrusion. The WCB is a strongly ascending airstream and therefore responsible for the formation of clouds and precipitation. Within the ascending airstream, latent heat is released due to a variety of microphysical processes. Beneath the WCB the sedimenting hydrometeors lead to strong cooling. The resultant vertical gradient in diabatic heating and cooling leads to a remarkable modification of potential vorticity (PV) in the frontal region. In this study a baroclinic channel model is used to study the interaction between dry dynamical and moist physical processes in an idealized setup on the f-plane. The warm conveyor belt is defined as the set of trajectories that rise at least 600 hPa in 48 hours. We trace the vertical profile of heating rates along selected WCB trajectories for simulations with different atmospheric stability. This allows us (a) to study how the heating and cooling rates are partitioned between the large-scale and convective ascent and (b) how this influences the associated PV tendencies and thus the dynamics in the frontal region.

Keywords: Warm conveyor belt, Potential vorticity, PV, Microphysics
Poster Session

SCI-POM1179 - A new assessment model for ensemble-based predictability of persistent heavy rainfall events over East Asia

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The persistent heavy rainfall event (PHR) is one kind of high impact weather in East Asia, which has attracted intensive research in Asia. Using the operational global ensemble forecasts from Chinese Meteorological Administration (CMA), a new assessment model is developed to investigate the PHR predictability. Based on the new assessment model, the predictability in the 1-2 week forecasts of two episodes of PHR events in June 2010 and June 2011 is examined. Considering the ensemble members as different predictability of the evolution of PHR event in 1-2 week forecasts, a model named Composite predictability Index (CPI) is established to identify “good” and “poor” ensemble members. CPI model consists of equitable Threat Score (ETS) of 24h accumulated rainfall and root-mean-square error of 500hPa Height. The two chosen members represent the best and worst predictability among ensemble members. The differences of growth forecast errors are examined between “good” and “poor” ensemble members. The results were showed as below: (1) The “good” and “poor” member can be identified by CPI model. (2) The predictability of “good” and “poor” member is quite different. “Good” member shows the higher predictability both in synoptic-scale flow features and meso-scale flows in its location, duration and the movement speed. (3) Growth of forecast errors of “poor” member generally come from westerly and polar regions.

Keywords: persistent heavy rainfall, predictability, ensemble prediction, CPI model
SCI-POM1183 - Predictability of seasonal climate over South African Provinces and their relationships to climate indices

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This study analyses the spread of a large slightly-different-initial-condition ensembles of HadRM3P atmospheric model simulations spanning a 50-year period; it also investigate the relative role of some driving processes behind the variability of ensemble spread over South African provinces in a chaotic and warming climate. Measures of predictability are quantified by the use of contrasting and de-trended anomalies of standard deviation and the distance between the 90th and 10th percentiles of the simulations. Results show that there are significant long-term trends in the predictability of seasonal climates as measured by ensemble spreads and by extension there exist inter-annual variability in the seasonal climate. Further analysis revealed that the South African provincial measures of predictability significantly co-vary with the observed global SST far and near on seasonal time scales, suggesting that the climatic driving factors / forces may both be locally and remotely based. All significant climate predictors are of tropical origin. And that, El Nino-Southern Oscillation (ENSO) is the most influential in the predictability of seasonal precipitation and temperature over South Africa, particularly during the rainfall onset and peak periods, as well as during the coldest period of winter. Nevertheless, responses of predictability measures to predictors are weak, indicating that predictor-response relationships are more complex in nature than can be represented by the traditionally simple climate indices; therefore, there may be limits to the extent of which year-to-year variations in the predictability of seasonal climate over South Africa might be understood.

\textbf{Keywords:} Predictability, Ensemble spread, South Africa, Climate Indices
SCI-POM1185 - A new approach on approximations of Available Potential Energy and diagnosis of short-term increase events

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Available potential energy (APE), defined by Lorenz (1955) as the difference between the total potential energy of an atmospheric state and an adiabatically redistributed atmosphere that is horizontally stratified and statically stable, has been used to estimate the amount of potential energy available in the atmosphere for conversion to kinetic energy by cyclones. A series of exact and approximate equations for APE have been derived for use in previous studies (Lorenz, 1955; Dutton and Johnson, 1967; Boer, 1975, 1982) to solve for the available potential energy of the atmosphere, accounting for changing terrain amongst other variables. These equations, along with estimates of total hemispheric APE, APE generation, and conversion to kinetic energy, have been used to explain the annual APE cycle and short-term APE depletion events by mid-latitude cyclones. In this study, we build on the previously-derived set of approximate equations in isobaric coordinates and introduce a new variable to account for variations in the tropopause height. We compute a 1979-2012 APE climatology from the NCEP Global Reanalysis 2 data set using these new approximate equations, along with the zonal and eddy decomposition, to explore short-term (3-15 day) increase events that have previously been overlooked. A climatology of short-term APE increase events will be presented with a focus toward the synoptic-scale modulations of these events.

Keywords: Global Energetics, Available Potential Energy, Mid-Latitude Cyclones
We present a case study of the formation of a small-scale vortex, which has been observed by the aircraft campaign AIRMETH2 in the delta of the Mackenzie River, Canada. AIRMETH2 was carried out in July 2012 with the purpose to measure methane concentrations over arctic wetlands, thereby also providing a high-resolution data set of meteorological quantities in the lower troposphere. While the observed vortex of about 50 km horizontal scale is not resolved in the ERA-Interim data, high-resolution WRF simulations with a mesh size of about 2 km can indeed model its formation. The aircraft observations are then used to validate the model results in the lower troposphere. It turns out that the position of the vortex in the model is somewhat shifted in comparison to the observed vortex. Other meteorological quantities are also compared. For example, we find deviations in the structure of vertical temperature profiles.

**Keywords:** WRF modelling, aircraft observations, arctic wetlands
Increased economic, transportation and research activities in polar regions are leading to more demands for sustained and improved availability of predictive weather and climate information to support decision-making. However, partly as a result of a strong emphasis of previous international efforts on lower and middle latitudes, many gaps in weather, sub-seasonal and seasonal forecasting in polar regions hamper reliable decision making in the Arctic, Antarctic and beyond. In order to advance polar prediction capabilities, the WWRP Polar Prediction Project (PPP), has been established as one of three THORPEX legacy activities. The aim of PPP, a ten-year endeavour (2013—2022), is to “Promote cooperative international research enabling development of improved weather and environmental prediction services for the polar regions, on time scales from hours to seasonal.” In order to achieve its goals, PPP will enhance international and interdisciplinary collaboration through the development of strong linkages with related initiatives; strengthen linkages between academia, research institutions and operational forecasting centres; promote interactions and communication between research and stakeholders; and foster education and outreach. Flagship research activities of PPP include sea ice prediction, polar-lower latitude linkages and the Year of Polar Prediction (YOPP), an intensive observational and modelling period centred around the period mid-2017 to mid-2019.

**Keyword:** Polar Prediction
Poster Session

SCI-POM1197 - The role of albedo in medium-range and seasonal forecasts of 2m temperature over snow

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Modification of surface-atmosphere interaction in the presence of snow is attributed to the high reflectivity (albedo) of snow. The variations in snow albedo due to aerosol deposition (such as dust and black carbon) and water loading of snow can change the surface radiation fluxes significantly. We test some existing parameterizations of snow albedo related to the snow age and surface temperature in the framework of NWP model SL-AV used at Roshydromet both for medium-range and seasonal forecasts. We pay a special attention to the threshold value of fresh falling snow at which the albedo is reset to its maximum value due to effect of masking of ageing snow. This is because the northern part of Russia has certain specific features due to aerosol emission and deposition (caused by high pollution in some towns and burning of the oil gas). Two meter temperature fields produced by the SL-AV model are analyzed and compared to the synoptic station data to derive the sensitivity to snow albedo parameterization. Bias, absolute forecast errors and RMSE are used to validate model performance. It is shown that the threshold under investigation may vary from winter to spring. Also, the approach based on threshold value is not appropriate in the pristine environment of Antarctica.


Keywords: Snow albedo, seasonal forecasts, numerical weather prediction
The Arctic sea ice cover is experiencing the most striking decline over about the last 50 years, and is also possibly an exceptional period in the last two millennia. Such behaviour is an aspect of climate change with severe socio-economic impacts in the wider Arctic region and could potentially have global influence. We use the K-means cluster analysis of the Arctic sea ice concentration and thickness and various global climate fields to investigate mechanisms governing sea ice cover and its impacts on the climate of lower latitudes. We determine the key modes of Arctic sea ice cover variability in observations and reconstructions, and perform a compositing analysis of the associated climate variability and change in the Northern Hemisphere. The spatial patterns of the modes of variability are chosen to minimize the variance between the elements of a mode and to maximize the variance between the average spatial patterns of different modes. This clustering framework is free from underlying assumptions and limitations of the EOF analysis. The Arctic sea ice and climate variability and change is represented as a transition between a limited number of recurrent patterns. A prominent cluster of Arctic sea ice concentration that exhibits anomalous growth (decline) in the Beaufort Sea and the East Siberian Sea during the melt season, over the modern observational era since 1979, is associated with anomalous surface warming (cooling) over the western and northern Europe in the summer and fall.

**Keywords:** Arctic sea ice, K-mean cluster analysis, climate change and variability, Northern Hemisphere
Poster Session

SCI-POM1201 - The ICECAPS Experiment at Summit, Greenland

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Since spring of 2010, atmospheric and cloud properties have been continuously measured at Summit Station, Greenland, as part of the Integrated Characterization of Energy, Clouds, Atmospheric state, and Precipitation at Summit (ICECAPS) experiment. The observing capabilities include both active (radar, lidar, and sodar) and passive (microwave radiometer and infrared spectrometer) instruments. Twice-daily radiosondes are also being launched. Using these data, the ICECAPS team is advancing understanding of atmospheric processes over Greenland. The atmosphere is dry and cold relative to other Arctic locations with strong near-surface temperature and humidity inversions throughout the year. Because of this, horizontal advection of moisture is important for forming and maintaining local clouds. Liquid water clouds are observed throughout the year even in winter. Low-level stratiform clouds are common at Summit and are similar to clouds in other Arctic locations. Several research collaborations with other scientists are on-going as part of the ICECAPS project, and the data are available for others who are interested in Greenland weather and climate and model and satellite validation.


Keywords: Clouds, Radiation, Precipitation, Remote Sensing
Poster Session

SCI-POM1205 - Introduction to the new seasonal forecasting system at KMA: A joint system with Met Office

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According to the policy of seamless prediction from short-range weather forecast to climate projection, KMA has launched a new seasonal prediction system, called GloSea5, based on the HadGEM3 by collaboration with Met Office, which consists of Met Office Unified Model (UM) for atmosphere, JULES for land surface, NEMO for ocean, and CICE for sea-ice. Using the identical model configuration but for slightly different atmospheric initial condition as well as machine platform, both the hindcast and forecast ensemble members are shared for saving computing and human resources between two operational centres, e.g., Met Office and KMA, so that it is the first trial of Joint Forecasting System among twelve GPCs in the world. Each center performs 10 members’ run every day that consists of 6 hindcast members, 2 monthly-forecast members, and 2 seasonal-forecast members. Currently, due to the limitation of computing resources, hindcast period covers only 14 years from 1996 to 2009, but will be expanded up to 21 years at least since 1989. In 2014, KMA has a plan to adopt probabilistic representation in its monthly and seasonal forecast. Brief introduction to the new seasonal forecasting system at KMA including evaluation of its predictability, and recent changes in forecast service to the public will be covered in this talk.

Keywords: Operational monthly-to-seasonal forecast, Joint forecasting system, Predictability
Poster Session

SCI-POM1209 - Real time prediction of Indian Summer Monsoon, 2013

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An ensemble prediction system (EPS) is devised for the extended range prediction (ERP) of monsoon intraseasonal oscillations (MISO) of Indian summer monsoon (ISM) using NCEP Climate Forecast System model version 2 and the bias corrected CFS SST forced GFS\textsuperscript{2} (GFSbc) at T126 resolution. The EPS is formulated by producing 11 member ensembles through the perturbation of atmospheric initial conditions. Real-time extended range forecast for 2013 monsoon season has been generated at every 5 day interval, starting from 16 May. Based on 16 May initial condition, the monsoon onset over Kerala was forecasted on 29 May 2013 which was well in agreement with the observed onset. Rapid advancement of monsoon and the Uttarakhand heavy rainfall event were also predicted well in advance by the models. Moreover, models could capture the reduced rainfall activity at the end of August as well as the revival of monsoon at the end of September.

\textbf{Keywords:} Extended Range Prediction, Indian Summer Monsoon
Poster Session

SCI-POM1211 - Relative Merit of CFSv2 Improvement versus Availability of Retrospective Forecasts for MJO Prediction

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We analyzed retrospective forecasts of the new NCEP Climate Forecast System out to 45 days from 1999-2009 with 4 members (00Z, 06Z, 12Z and 18Z) each day. The new version of CFS (CFSv2) shows a big improvement over the older CFS (CFSv1) in predicting the Madden-Julian Oscillation, the skill reaching 2 to 3 weeks in comparison with the CFSv1 for nearly one week. Diagnostics of experiments related to the MJO forecast show that the systematic error correction, possible because of the enormous hindcast data set, and the ensemble aspects of the prediction system (four times a day) do contribute to improved forecasts. But the main reason is the improvement in model and initial conditions between 1995 and 2010.

Keywords: the Madden-Julian Oscillation, model predicting skill, CFSv2
The Sub-seasonal to Seasonal Prediction project (S2S) is a new WWRP/THORPEX-WCRP joint research project which main goal is to improve forecast skill and understanding on the sub-seasonal to seasonal timescale, and promote its uptake by operational centres and exploitation by the applications community. Specific attention will be paid to the risk of extreme weather, including tropical cyclones, droughts, floods, heat waves and the waxing and waning of monsoon precipitation. Work will be guided by a steering group that will work in conjunction with appropriate WMO bodies and other relevant structures. To achieve these goals, an extensive data base of sub-seasonal to seasonal (up to 60 days) forecasts and reforecasts will be established, modelled in part on the THORPEX Interactive Grand Global Ensemble (TIGGE) database for medium range forecasts (up to 15 days). The S2S database will be a very useful resource to investigate sub-seasonal predictability and the potential benefits of multi-model sub-seasonal prediction for user applications. The project will also focus on specific case studies.

**Keywords:** sub-seasonal prediction, extreme events, Multi-model database
Negative phases of the Arctic Oscillation (AO) sometimes result in extreme cold conditions over hemispheric-scale regions in boreal winter, and give significant impacts on various socioeconomic sectors. Reliable forecast of such events in a few weeks advance is important. In this study, we investigated the predictability of negative-phase AO events using a suite of hindcasts with the latest Japan Meteorological Agency One-month Ensemble Prediction System. Three phases, namely negative, normal and positive phases are defined using AO index with thresholds of -0.5, 0.5 standard deviations of the index. The AO index is computed by projecting daily sea level pressure (SLP) fields to the first leading mode of empirical orthogonal function analysis of monthly SLP. Using anomaly correlation coefficients (ACCs) as measures of prediction skill and stratifying ACCs of 28-day averaged forecasts for SLP and geopotential height at 500hPa (GPH500) for three phases, a rate of ACCs above 0.7 for SLP (GPH500) in the negative phases is roughly 30 (15) percents higher than that for normal phases. This suggests that the negative phase events are more predictable. Though that in the positive phases is also higher than that for normal phases, we found that the predictability of negative phase events was even higher. Further diagnostics indicate that synoptic and planetary wave-mean flow interaction is a key dynamical basis for high predictability. Analyzing negative phase events in which forecast model showed high ACCs, the wave-mean flow interaction enforced negative phases of the AO. These features were successfully simulated in the forecast model.

**Keywords:** Arctic Oscillation, subseasonal prediction, predictability
Sci-POM1218 - CalWater 2 – precipitation, aerosols and pacific atmospheric rivers experiment

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Emerging research has identified two phenomena that play key roles in the variability of the water supply and the incidence of extreme precipitation events along the West Coast of the United States. These phenomena include the role of (1) atmospheric rivers (ARs) in delivering much of the precipitation associated with major storms along the U.S. West Coast, and (2) aerosols—from local sources as well as those transported from remote continents—and their modulating effects on western U.S. precipitation. A better understanding of these processes is needed to reduce uncertainties in weather predictions and climate projections of extreme precipitation and its effects, including the provision of beneficial water supply. This presentation summarizes science gaps associated with (1) the evolution and structure of ARs including cloud and precipitation processes and air-sea interaction, and (2) aerosol interaction with ARs and the impact on precipitation, including locally-generated aerosol effects on orographic precipitation along the U.S. West Coast. Observations are proposed for multiple winter seasons as part of a 5-year broad interagency vision referred to as CalWater 2 to address these science gaps (http://esrl.noaa.gov/psd/calwater). In the near term, a science investigation is being planned including a targeted set of aircraft and ship-based measurements and associated evaluation of data in near-shore regions of California and in the eastern Pacific for an intensive observing period between Jan-Mar'15. DOE’s ARM program and NOAA are coordinating on deployment of airborne and ship-borne facilities for this period in a DOE-sponsored study called ACAPEX to complement CalWater 2.

Keywords: atmospheric rivers, precipitation, aerosol-cloud
Poster Session

SCI-POM1221 - Seamless forecasting of sectoral application on a global scale

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Early warning systems of extreme events such as floods, droughts, fire as well as vector-borne diseases at a global scale are essential due to the combined threat of increased population settlement in vulnerable areas, such as those prone to flooding or water shortage, and the possible risk of an increase of the intensity of extreme weather due to climate change. The recent availability of long-term global gridded datasets of precipitation and temperature alongside with improvements in skill of weather prediction provide a unique opportunity to invest in sectoral applications. The European Centre for Medium Range Weather Forecasts (ECMWF) is a recognised world leader organization in numerical weather predictions and provides operational forecast products from the short-range (few days) up to the seasonal scale. In the last years ECMWF has been particularly active through EU research founded projects in demonstrating the capability of its forecasting system to drive impact modelling systems. This work therefore reviews the outcome of this effort by assessing the performance of the new prototype early warning systems to predict floods, droughts, forest fires and malaria transmission. By providing a comprehensive skill assessment both on a global level and in selected regions we aim at judging their suitability to be eventually integrated in decision support framework.

Keywords: Hazard forecast, drought forecast, flood forecast, fire forecast
Poster Session

SCI-POM1223 - Improving drought predictions for local decision-making using a new hybrid downscaling approach

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Drought is a critical challenge faced by communities around the world, exacerbated by growing demands on water resources in an era of climate variability and change. As such, there is great interest in how drought may change in the future, especially at the local scale where adaptation decisions are made. Global climate model (GCM) projections suggest that drought will increase across large areas of the globe, but they lack skill at assessing precipitation details at small scale. This research aims to provide support to local drought adaptation efforts by developing a hybrid approach that capitalizes on the predictive capabilities of both dynamical and statistical downscaling. In this study we combine temperature predictions from dynamical regional climate models (RCMs) with precipitation estimates that are derived from empirical relationships with large-scale patterns. The approach is developed and demonstrated for a case study that examines summer drought risk, as measured by the Palmer Drought Severity Index, in south-central Oklahoma. We explore a suite of large-scale features, and find the relationship with precipitation and sea level pressure in the Eastern north Pacific to have a significant correlation and robust physical explanation. Using summer temperature estimates from multiple RCMs and sea level pressure from one GCM, we assess local drought changes between current and future time slices. Further, to enable integration with existing decision-making activities, we also include anthropological data from stakeholder interviews about drought risk perceptions. We implement the hybrid approach to better understand the connections between drought risks, water management, and projected climate.

Keywords: Drought, Hybrid approach, precipitation, large-scale patterns
Introduction of wind energy in the power sector causes challenges due to the variability and uncertainty of the wind power generation. Numerical wind power forecasting has been identified as an important tool to address these increasing uncertainties. We are trying to introduce improvements by developing a more accurate wind forecast system for complex terrain. High resolution wind forecasting is operational for Bessaker Wind Farm located in the middle part of Norway. The forecasting system for Bessaker is based on a multiscale nesting starting from forecasts by ECMWF (0.125 degrees resolution) as boundary conditions for the 2.5 km resolution operational NWP model AROME-MetCoOp (a version of the non-hydrostatic HARMONIE model with AROME physics). The CFD model SIMRA with an average resolution of 100 m is used in the inner nest. The results are promising. SIMRA is able to capture important features of the air flow through the complex terrain. A Kalman filter has successfully been tested to correct for forecasting biases. The concepts can very well be utilized in an offshore context. Ongoing research for offshore forecasting includes coupling of AROME-MetCoOp with the ocean wave model WAM. The work is conducted under the project FSI-WT (Fluid Structure Interaction for Wind Turbines) and is a collaboration between research and industrial partners in Norway. The project also covers comprehensive design methodology for wind turbines that includes modelling the aerodynamics of the wind turbine blades.

**Keywords:** Multiscale models, Power forecasting, Wind energy
Poster Session

SCI-POM1229 - Large-scale circulation anomalies conducive to weather-related hazards

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Weather-related hazards are frequently associated with certain circulation conditions. We demonstrate that these conditions can be evaluated by combinations of anomalies of properly selected meteorological variables (e.g., moisture flux, temperature advection). The study is based on reference events from the second half of the 20th century. First, we identify extreme events (e.g., heavy rains, cold spells) using station data from a given region (e.g., the Czech Republic). To account for the variability of synoptic conditions leading to the given hazard, the events have to be clustered into several variants. Using meteorological reanalyzes, we detect anomalies in thermo-dynamic fields that have repeatedly occurred during the given variant of historic extreme events. We search for such a combination of these anomalies which best reflects the extremeness of the reference events. Independent data in our study indicate that significant circulation anomalies regularly result into extreme events. Therefore, if detected in Numerical Weather Prediction outputs, significant anomalies could support risk management decisions. The research presented in this study is supported by the Czech Science Foundation under the project GACR P209/11/1990.


Keywords: Weather extreme, Synoptic-scale cause, Re-analysis, Circulation anomaly
Severe freezing rain hit Liaoning Province over northeastern China in February 2010. This freezing rain event produced large ice accretions on power transmission lines and railway express power network which resulted in a long time railway delay. In order to mitigate the damages caused by freezing rain, numerical model are used to simulate the freezing rain process and ice accretion of this event. We use WRF as the numerical weather prediction model and an ice accretion algorithm to simulate the development of ice load. We compare the simulated meteorological variables to observations and ice load is also compared with data collected by local power company and meteorological stations. The duration and timing of the freezing rain event that occurred between the night of 24 February and the morning of 25 February are simulated well in all model runs. Analysis of simulated cloud microphysics indicates that cloud water matches well with the vertical inverse temperature and remain in liquid phase before hitting on the ground which favors the producing of freezing rain. Surface temperature, precipitation and wind velocity are used in the ice accretion algorithm and ice accretion is output in every simulated grid. In comparation with the observed ice load in this event, the simulated ice load is slightly larger than the observation and reasons caused the difference are discussed.

**Keywords:** Freezing Rain, Icing Model, WRF Simulation
Poster Session

SCI-POM1233 - Nowcasting of North Foehn in Switzerland

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Foehn is a dry, warm wind on the lee side of a mountain range. In Switzerland it occurs during Southerly and Northerly wind flow. While providing alpine and pre-alpine valleys with sunny weather, it frequently produces strong wind gusts. Foehn situations may thus represent a hazard for aviation, navigation, cause damage to infrastructure and trees and increase forest fire danger. High resolution NWP models are still not able to accurately forecast Foehn timing and intensity in the valleys. An automatic Foehn identification system based on 10-minute surface weather stations data was thus developed for South Foehn in recent years. It is however not directly applicable to stations South of the Alps. For North Foehn a statistical study of atmospheric parameters at seven alpine surface weather stations South of the Alps during opposing wind conditions on the crest of the Alps was carried out to identify skillful predictors. Northerly wind direction on the crest of the Alps is the main precondition, but it is not sufficient to distinguish Foehn from mountain breezes. Further predictors are the wind direction, velocity and gusts, relative humidity and potential temperature difference between station and alpine crest as well as the pressure gradient between station and across the alpine chain. The identified cases of North Foehn from 1990-2012 are employed as database for the development of a statistical system for wind gusts nowcasting in the following 1-4 hours during Foehn. This statistical algorithm was tested on an independent year. First verifications thereof give encouraging results.

**Keywords:** foehn, nowcasting, mountain meteorology, wind gusts
SCI-POM1240 - Modelling the multiphase chemical processing of monoethanolamine from industrial CCS processes with COSMO-MUSCAT

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CO2 capture and store (CCS) technologies are designed to reduce anthropogenic CO2 emissions into the atmosphere. At present, amine-based post-combustion CO2 capture techniques of power plants will release discharged air into the environment, which will contain a small but still significant amount of amines and their oxidation products. Moreover, it is known that the atmospheric oxidations of amines can lead to the formation of harmful (potentially carcinogenic) compounds such as nitramines and nitrosamines. Both detailed chemical process model studies are performed in order to develop a reduced chemical mechanism for MEA and complex 3 dimensional dispersion model COSMO-MUSCAT investigations were carried out focusing mainly on the multiphase chemical fate and lifetime of MEA and its reaction products such as nitramines and nitrosamines as well as their removal. The study is aimed to provide detailed and conclusive concentration/deposition charts. The performed annual simulations were attended by extensive sensitivity and process studies to evaluate the associated uncertainties. Overall, the model results might allow future evaluations of possible environmental impacts and human health effects of pollutants emitted from CCS processes. For this study, realistic concentrations of reactants (OH, NO3, NO2) for MEA chemistry were provided by applying the RACM chemistry and anthropogenic emission inventories. The physical loss processes of dry and wet deposition are described in dependence on meteorological conditions and land use properties.


Keywords: air quality modelling, amine chemistry, environmental impacts of harmful pollutants, chemistry transport modelling
Poster Session

SCI-POM1241 - Using synthetic satellite observations to evaluate the performance of PBL and cloud microphysical parameterization schemes

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In this study, the ability of several cloud microphysical and planetary boundary layer parameterization schemes to accurately simulate cloud characteristics within 4-km-grid-spacing ensemble forecasts over the contiguous U.S. was evaluated through comparison of simulated synthetic GOES infrared brightness temperatures with real observations. Four double-moment microphysics schemes and five planetary boundary layer (PBL) schemes were evaluated. Large differences were found in the simulated cloud cover, especially in the upper troposphere, when using different microphysics schemes. Overall, the results revealed that the two microphysics schemes that predicted two moments of all five cloud-hydrometeor species tended to produce too much upper level cloud cover, whereas simpler schemes did not contain enough high clouds. Smaller differences occurred in the cloud fields when using different PBL schemes, with the greatest spread in the ensemble statistics occurring during and after daily peak heating hours. Results varied somewhat depending upon the verification method employed, which indicates the importance of using a suite of verification tools when evaluating high-resolution model performance. Finally, the large differences between the various microphysics and PBL schemes indicate that there remains large uncertainty in how these schemes represent subgrid-scale processes.

Keywords: cloud microphysics schemes, planetary boundary layer schemes, numerical weather prediction
Poster Session

SCI-POM1243 - The diagnosis of the hollow potential vorticity tower on the intensity change of Hurricane

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In this study, the characteristics and evolution of the potential vorticity (PV) tower are described using a high-resolution simulation of Hurricane. The PV tower, featuring deep convections and positive high PV values in the inner core region, can reflect the intensity change in the different stages of Hurricane. In the initial stage of Hurricane, the PV towers are dispersed, most of which are relatively independent of each other. However, in the later period of the Hurricane, the PV towers merge into a hollow PV tower (HPVT) around an eye with the appearance of horizontal high PV ring and two vertical deep PV columns at the both sides of eye. The radial structural evolution of the azimuthal mean PV shows the establishment of an HPVT indicating that the Hurricane enters the notable intensification period. In this period, obvious PV radial mixing occurs in the high PV column, especially at the top of the boundary layer, which leads to the size decreasing of the HPVT. Once the low-value center of the HPVT is filled, which means that the high value PV column moves into the eye, the speed of intensification is significantly reduced. This phenomenon can be understood by considering the wave stability from a barotropic nondivergent vorticity equation. This instability caused by the inflexion point of the PV results in an increase in radial wind velocity, enhancing the radial PV mixing, impelling the concentration of high PV toward eye, inducing the eyewall contraction, and finally accelerating the intensification of the Hurricane.

References: Acknowledgements: This work is supported by the National Natural Science Foundation of China (No.41175054 and No.41275002), and Natural Science Key Foundation of China (No.41230421).

Keywords: hollow PV tower (HPVT), intensity change, Hurricane
Poster Session

SCI-POM1244 - Decomposition of planetary waves into standing and travelling components, with application to stratosphere-troposphere coupling

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Classical wavenumber-frequency analysis decomposes longitude and time dependent signals into contributions for distinct spatial and temporal scales. This study describes an additional decomposition of the spectrum into standing and travelling components. Previous methods [Pratt 1976; Hayashi 1977, 1979] divide the power spectrum into exclusively standing and travelling parts with no allowance for the covariance between the two. This study provides a simple method for the decomposition that allows for the calculation of the variance of each of these components and the covariance between them, which we show is typically a significant portion of the variance of the total signal. The technique is applied to reanalysis wintertime geopotential height anomalies in the Northern Hemisphere in order to investigate planetary wave interference effects in stratosphere-troposphere coupling. The results show that for planetary waves 1 to 3, standing waves explain the largest portion of the variance at low frequencies. Furthermore, the antinodes of the standing waves have preferred longitudes that tend to align with the extremes of the climatological stationary wave, suggesting that standing waves contribute to a linear interference effect that has been shown to be an important part of stratosphere-troposphere interactions. Implications for the prediction of the wintertime Northern Annular Mode will be discussed.

Keywords: Stratosphere-troposphere coupling, planetary waves, Northern Annular Mode, Fourier analysis
A 4-dimensional ensemble variational data assimilation scheme (4DEnVAR) has been developed for a limited area model. The scheme establishes a bridge between the variational and ensemble data assimilation schemes utilizing the advantages from both approaches. The scheme avoids need of tangent linear and adjoint model, which are expensive to run and maintain, and replaces them with the information extracted from the non-linear evolution of the ensemble of the model states. At the same time the scheme employs variational framework treating efficiently non-linear observations. We demonstrate the potential of the 4DEnVAR scheme in handling of flow-dependency in the single simulated observation experiment and in the real data assimilation experiments carried over the six weeks period. The 4DEnVAR scheme outperforms standard 4DVAR and Hybrid 4DVAR data assimilation with regards to forecast quality measured by forecast verification scores. In addition we discuss the extension of the 4DEnVAR scheme with "the locally best member” selection method to allow efficient treatment of non-additive (phase) errors.

**Keywords:** 4DEnVAR, EPS, phase-error correction, predictability
Extreme environmental events, often the result of weather, can cause considerable human, economic and environmental harm. The management of these events undoubtedly needs to be informed by risk assessment but also by public perception of risk as it plays a prominent role in the decisions people make in adopting protective measures and to their response to warnings. The goal of this study was to examine to what extent the risk perception of environmental extreme events varied among Canadians, and what socio-demographics characteristics were significant for the risk management posed by these types of events. The study involved an extensive questionnaire to a representative national survey of 3263 Canadians. Results revealed that risk perception of natural disasters, major flooding and earthquakes was smaller than risk perception of technological hazards such as nuclear power or chemical manufacturing plants, even though the occurrence of natural disasters during recent years in Canada has shown an increase in number in comparison with technological accidents. A series of one-way analysis of variance (ANOVA) suggest that there were notable differences between socio-demographics characteristics like age, gender, education, income and the region of residence in the way Canadians perceive the risks of natural disasters, major flooding and earthquakes. In line with similar research, our findings suggest that risk management needs to shift from a mainly technical characterization of risk to an integrated approach giving more consideration to psychosocial aspects of risk perception.

Keywords: risk perception, socio-demographics characteristics, extreme environmental events
There were three clear snowfall processes because of frequent cold air activities in Hunan on February 6 to 8, 12, and 17 to 18 in 2014, which brought adversely affected to transportation, electric power and winter crops. Based on conventional observation data, sounding data, Doppler radar data and NCEP reanalysis data, analysis of their meteorological characteristics was studied from aspect of real weather, synoptic situation and physical mechanism by means of diagnostic and comparative analysis methods. The results showed that three snowfall processes were caused by upper-level southern trough. Warm and water advection were transported by stronger southwesterly flow at about 700 hPa. Inversion temperature in the middle-low level was existed during three snowfall processes. Southwest flow on inversion temperature superimposed on the northerly flow, which caused increasing of vertical shear was conducive to the occurrence of snowstorm. Differences lie in their cold air paths and the vertical temperature structure. Cold air paths of the first two snowfall processes were east, there has been vertical temperature structure of ice layer near 500hPa, the warm melted layer near 700hPa and supercooled water near 925hPa layer was configured so that there was sleet occurred; while blizzard occurred during the third process but no sleet, because the cold air path was west, and the whole layer temperatures below 0 °C. In addition, mesoscale features of radar echo provided the basis for the snowfall forecast.

**Keywords:** snowfall, diagnosis and comparative analysis, inversion temperature, rain and snow conversion
Seasonal climate forecasts are being used increasingly across a range of application sectors. A recent UK governmental report asked: How good are seasonal forecasts on a scale of 1-5 (where 5 is very good), and how good can we expect them to be in 30 years time? Seasonal forecasts are made from ensembles of integrations of numerical models of climate. We argue that “goodness” should be assessed first and foremost in terms of the probabilistic reliability of these ensemble-based forecasts; reliable inputs are essential for any forecast-based decision making. We propose that a “5” should be reserved for systems which are not only reliable overall, but where, in particular, small ensemble spread is a reliable indicator of low ensemble forecast error. We study the reliability of regional temperature and precipitation forecasts of the current operational seasonal forecast system of the European Centre for Medium-Range Weather Forecasts, universally regarded as one of the world leading operational institutes producing seasonal climate forecasts. A wide range of “goodness” rankings, depending on region and variable (with summer forecasts of rainfall over Northern Europe performing exceptionally poorly) is found. Finally, we discuss the prospects of reaching “5” across all regions and variables in 30 years time.


Keywords: reliability, seasonal forecasts
UAS-POM3014 - Communicating confidence in weather forecasts to encourage probabilistic forecast use in decisions by grid operators

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The growing proportion of renewables in the German energy mix makes weather increasingly important for the power grid. Weather forecasts are rapidly becoming an integral part of decision making processes that transmission grid operators (TSOs) use to ensure energy security and grid security. The EWeLiNE project, a cooperation between the Fraunhofer Institute for Wind and Energy System Technology, the German Weather Service and several TSOs, has the objective of supporting the integration of renewables into the power grid by providing better forecasts for both weather and energy production. Currently, TSOs integrate deterministic weather forecasts into several planning levels. An important part of the EWeLiNE project is aiding the TSOs in the use of new, probabilistic weather products and power forecasts to overcome the challenges presented by renewables to grid security and stability. We are pursuing this goal by iteratively developing our (probabilistic) weather forecast products together with the users. Through discourse between users, product developers and researchers we are developing products that not only contain new information about forecast certainty, but are also understandable for users from a nonmeteorological background. Our use of a web-based development platform enables short development cycles and agile adaptation to evolving user needs. We use the Open Geospatial Consortium's (OGC) web service framework to quickly and efficiently deliver the large amounts of raw data our users need and present it as a user adjustable on-the-fly products. In this way we hope to make the products as accessible as possible, maximizing acceptance while minimizing entry barriers.

Keywords: renewable energy, probabilistic product, user communication, grid integration
Poster Session

UAS-POM3015 – WITHDRAWN - Climatic variability in the Sub–Saharan region

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Background: Climatic variability in the Sub – Saharan region has been monitored, using both systematic rainfall records and proxy information concerning lakes and rivers and the occurrence of famine and drought. Methods: Proxy data have been used to produce a semi-quantitative data set spanning most of the continent and having an annual time resolution. Results: The most significant climatic change that has occurred has been a long-term reduction in rainfall in the semi-arid regions. Few changes in temperature have been demonstrated. These have occurred on a much smaller scale and are of considerably lower magnitude than those over the continents. On the other hand, the processes controlling rainfall over most of the continent are now reasonably well understood. One of the most important factors, particularly in the Sub – Saharan region, is sea-surface temperatures. It has been hypothesized that anthropogenic changes in the land surface, particularly land use change and desertification, have contributed significantly to the decline in rainfall. Current evidence suggests that if changes in the land surface (e.g., vegetation cover, soil moisture) significantly impact climate, they are much more strongly controlled by natural climate variations, such as the recent decline in rainfall, than by human-induced land-use change or degradation. Conclusion: There is no any accurate large-scale assessment of the extent, nature and degree of such changes. The dreaded ‘desertification’ process appears to be confined to relatively small scales.

Keywords: Climatic, variability, Sub – Saharan region
Linear regression and wavelet analysis are performed on wind, air temperature, and precipitation observed at two mountain meteorological stations (Nanyue: 27.30oN, 112.69oE, 1266 m; Lushan: 29.58oN, 115.98oE, 1165 m). Our results indicate that the annual mean wind speeds at Lushan experienced persistent decreasing trends during the study period from 1955 to 2012, and those at Nanyue increased in the late 1950s and through the 1960s, then decreased significantly during 1970-2000. The prevailing wind was northerly at Lushan and northerly and southerly at Nanyue. The air temperatures at both stations experienced significant increasing trends. The temporal variations in wind speed and temperatures are characterized by three quasi-oscillation periods of 2 years, 5-7 years, and 15-16 years at both stations. At Nanyue, the precipitation amounts and rain days experienced a decreasing trend and an increasing trend, respectively, but increasing trends are found in both the precipitation amounts and rain days at Lushan. The diurnal variations of the precipitation amount, frequency and intensity at both stations are characterized by two peaks, with one occurring in the morning around sunrise and the other in the afternoon around sunset.

**Keywords:** mountain meteorological stations, Comparisons, Linear regression and wavelet analysis
Poster Session

UAS-POM3017 - A theoretically guided exploration of people’s hurricane perceptions and response behaviors

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When hazardous weather threatens, people have varied perceptions and behavioral responses. These can include perceptions of the risk, perceptions of one's efficacy, reactions to risk messages received, communication behaviors, and protective behaviors. Relationships among these factors can exist. The Extended Parallel Process Model (EPPM) and Risk Information Seeking and Processing (RISP) model are two risk theories that explicitly examine and posit linkages among some of these factors. Such relationships also can be influenced and/or moderated by individuals’ characteristics, including their socio-demographics, cultural worldviews, and past hurricane experiences. To examine these topics, we gathered data from a survey of coastal Florida residents who are at risk from hurricanes and storm surge. Respondents were randomly assigned to receive different risk messages about a hypothetical hurricane situation. Data also were collected on the aforementioned perceptions and behavioral responses, informed by the empirical EPPM and RISP literature, and on individual characteristics. This poster will present results from this theoretically guided analysis of people’s hurricane perceptions and behaviors, with an emphasis on the role of people’s past hurricane experiences. Identifying and understanding relationships among these factors is important for improving weather risk communication and, more generally, for protecting people’s lives and well-being during hazardous weather events.

Keywords: Risk perception, Response behaviors, Hurricanes, Risk communication
Aerosols emissions have rapidly increased over East Asian since later 1970s. At the same time period, East Asian Summer Monsoon (EASM) showed a weakening trend. In this study, the direct effects of sulfate and Black Carbon (BC) aerosol on the march of the East Asian subtropical summer monsoon (EASSM) are investigated by using a coupled global climate-chemistry model of the Community Atmosphere Model (CAM5.1) and the NCEP/NCAR reanalysis dataset. The CAM5.1 model simulation results suggest that the direct effects of sulfate and BC aerosols have a notable impact on the cooling of land surface and hence affect the time of the reversal of land-sea thermal contrast, while the response of upper-middle troposphere atmosphere to aerosols shows an opposite way as a compensative effect. Because of the different impacts on middle troposphere by the sulfate and BC aerosols, their impacts on the onset of EASSM are different. Sulfate aerosols direct effects lead to a delay in EASSM onset time and an advance in retreat time. On the other hand, the direct effects of BC or combination of sulfate and BC aerosols lead to an advance in retreat time, but have little effect on the onset time. The simulated results are consistent with the diagnostics of the NCEP/NCAR reanalysis datasets by analyzing the zonal land-sea thermal contrasts at 850 hPa and 500 hPa levels and summer monsoon index.


Keywords: Aerosol Direct Effect, Sulphate and Black Carbon, East Asian Subtropical monsoon, Progress of Monsoon
Poster Session

SCI-POT1004 - The Mechanism of onset of discharge related to El Niño

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El Ni\^no related SST anomalies over the tropical Pacific have strong impact on the global climate. Prior to the onset of El Ni\^no accumulated warm water of the western Pacific (WP) is transported eastward along the equatorial gave guide which then increase the east Pacific SST. In the past several speculations were made on the discharge process and the associated El Ni\^no mechanisms. However what causes the onset of discharge process is still an unsolved issue. The study reveals that the discharge process begins in DJF(-1/0) about an year before the peak phase of El Nino. The positive SST anomalies in DJF(-1/0) over the north WP induce strong convection over this region though air-sea interaction. The associated cyclonic circulation induces westerly wind anomalies over the equatorial WP. The onset of discharge process is closely associated with southward shift in trade wind maximum and weakening of zonal winds over and north of the equator. Weakening of the zonal wind over equatorial Pacific and appearance of westerly winds over WP primarily controls the onset of discharge process. The Sverdrup transport which is associated with the recharge-discharge process also shows that onset of discharge process (poleward transport) is initiated from northern hemisphere in DJF(-1/0) where south hemisphere recharge process is still continuing due to prevailing easterly wind anomalies. The pole ward Sverdrup transport in the southern hemisphere is evident from MAM(0) onwards and which persists for longer duration than that of northern hemisphere.

Keywords: El Ni\^no, discharge, north western Pacific, Sverdrup transport
Poster Session

SCI-POT1006 - Mean climate of AMOC, North Atlantic salinity and Arctic sea ice in CFSv2 decadal predictions

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In the framework of seamless prediction, there is clear merit to extend current operational seasonal forecast models to predicting decadal variability and climate change. It is also a challenge because major efforts are required to bring these models up to this task. In this study, we examine the North Atlantic climate simulated by the NCEP Climate Forecast System, version 2 (CFSv2), using a set of ensemble decadal hindcasts and several 30-year simulations initialized from realistic ocean-atmosphere states. It is found that a substantial climate drift occurs in the first few years of the CFSv2 hindcasts, which represents a major systematic bias and may seriously affect the model’s fidelity for decadal prediction. In particular, a major reduction of the upper ocean salinity occurs in the northern North Atlantic. The accumulation of freshwater weakens the Atlantic meridional overturning circulation (AMOC) significantly. This freshening is likely caused by the excessive freshwater transport from the Arctic Ocean and weakened subtropical water transport by the North Atlantic Current, combined with an overly strong regional precipitation. A potential source of excessive freshwater is the quick melting of sea ice, which also cause unrealistically thin ice cover in the Arctic Ocean. Our sensitivity experiments with adjusted sea ice albedo parameters produce sustainable ice cover with realistic thickness distribution. It also leads to a moderate increase of the AMOC strength. This study suggests that maintaining a realistic freshwater balance is crucial for simulating the North Atlantic climate.

Keywords: Mean Climate, Atlantic meridional overturning circulation, North Atlantic upper ocean salinity, Arctic sea ice
Poster Session

SCI-POT1012 - On the thermal roughness length in weather and climate models

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Thermal roughness length (Zot) is a critical parameter to determine sensible heat fluxes exchanged between the surface and the atmosphere in weather and climate models. The sensible heat fluxes have significant effect for the forecast of 2 meter air temperature and the surface skin temperature. Therefore, it is important to understand and parameterize the thermal roughness length. Some GCMs specify the thermal roughness length as the same as the momentum roughness length (Zom). A number of models specify the thermal roughness length to be proportional to Zom. In NAM and GFS at NCEP, Zot is expressed by the Zilitinkevich formula. In this study, analytical analysis is conducted to investigate the effects of the variables and parameters on thermal roughness length. This analysis is very helpful to the understanding and parameterizations of the thermal roughness length in operational weather and climate forecasts.

Keywords: Thermal, roughness, length, models
The Walnut Gulch Experimental Watershed (WGEW) of ~150 km² in Southeastern Arizona receives the majority of its annual precipitation from highly variable and intermittent summer storms during the North American Monsoon. Using the 88 rain gauge network covering WGEW, patterns of precipitation for July through September from 1956-2011 are analyzed (Stillman et al. 2013). We show high spatial and temporal variability in the total precipitation as well as the intensity, frequency, and storm coverage. While no long-term trends are found in any of these characteristics, multidecadal variations of intensity and storm coverage are observed, and found to be significantly correlated with the Pacific Decadal Oscillation and Atlantic Multidecadal Oscillation. Additionally, it is found that 5-11 gauges can reasonably estimate area-averaged monthly total precipitation. WGEW has also measured near surface soil moisture with 19 5-cm depth in situ soil moisture probes since 2002. A water balance model driven by 30 min precipitation and calibrated using the co-located soil moisture measurements is then used to estimate summer soil moisture in order to extend the measurement period to 56 years (Stillman et al. 2014). High spatial variability is often observed after localized rain events, and spatially averaged summer soil moisture has high temporal variability ranging from 0.05 m²m⁻² to 0.09 m²m⁻². No trend in the spatial average surface soil moisture is found. My presentation will cover these results and our current evaluation of various remotely sensed and modeled precipitation and soil moisture products using our value-added datasets over WGEW.


Keywords: precipitation, moisture, variability
Extended-range high-resolution mesoscale simulations are currently being carried out at Environment Canada to produce multi-year surface-layer meteorological fields over Canada. The outputs of the ongoing work are of tremendous interest to weather dependent energy industries, particularly the wind energy sector. Long-term mesoscale simulations over such a large spatial domain require mechanisms to control the deviations in the large-scale atmospheric structures from the coarse-resolution driving fields (obtained from regional analysis). As enforcement of the lateral boundary conditions is not sufficient to restrict such deviations, large-scale features of the simulated high-resolution meteorological fields are therefore spectrally nudged towards the driving fields. During the present work different spectral nudging approaches have been investigated to propose an optimal nudging strategy. Controlling the evolution of the atmospheric large scales in general improves the outputs of mesoscale simulations within the surface layer. The results however demonstrate that divergence of the prognostically evolving surface fields from their expected values resulting from any inherent model bias as well as any lack of correlation with respect to the observations may be compounded by temporal integration over an extended period, leading to substantial inaccuracies in the prediction of surface-layer atmosphere. A forcing strategy based on grid nudging of the relevant surface fields (including surface temperature, soil-moisture, and snow conditions) towards their expected values is devised to limit any considerable deviation. Sensitivity of the near-surface atmosphere to the nudging of the different surface fields has been examined to determine an optimal approach.

**Keywords:** Surface forcing, Mesoscale simulations, Spectral nudging, Grid nudging
Poster Session

SCI-POT1025 - Wintertime sub-kilometric numerical forecasts of near-surface variables in the Canadian Rocky Mountains

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Numerical Weather Prediction (NWP) systems operational at many national centres are nowadays used at kilometric scale. The next generation of NWP models will provide forecast at sub-kilometric scale. Large impacts are expected in mountainous terrain characterized by highly variable orography. In this study, we investigate the ability of the Canadian NWP system to provide accurate forecast of near-surface variables at sub-kilometric scale in the Canadian Rocky Mountains. Observations collected at valley and mountains stations are used to evaluate the forecast accuracy over a period of 15 days in wintertime. The impact of increasing the horizontal resolution is firstly considered. Improvements of temperature forecasts are found at mountain stations due to better orography representation. In contrast, no improvement is obtained at valley stations due to an inability of the model at all resolutions to fully capture the intensity of valley cold pools forming during nighttime. Error statistics for wind speed show large improvements with decreasing grid spacing for mountain stations exposed to or sheltered from wind. However no systematic improvement with decreasing grid spacing is found for all stations similarly to previous studies. The model's sensitivity at sub-kilometric grid spacing is then investigated by evaluating the effects of (i) accounting for additional drag generated by sub-grid orographic features, (ii) considering slope angle and aspect on incoming shortwave radiation, and (iii) using high-resolution initialization for the surface fields.

Keywords: Mountain meteorology, Numerical weather prediction/forecasting, Sub-kilometric resolution
Poster Session

SCI-POT1026 - A weather climate change impact study at extreme resolution (WISER)

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Climate is now a weather scale process problem, and simulation of weather processes is required to understand the rapidly changing climate. The resolution required to include meso-scale features, is still out of the reach of climate model resolution, and this project attempts to include the important meso-scale features. WISER (Weather climate change Impact Study at Extreme Resolution) is a regional climate study to use a numerical weather model (WRF), in a channel formulation (+/- 68 degrees latitude) at a resolution of 20 km at the equator reducing to 9 km. A nested regional model at a resolution of 3-4 km over Western Europe aims at resolving the larger convective scale precipitation events statistically. We compute model climatologies driven by: - (a) ERA interim climate reanalysis study for recent decades, (e.g. 1989-2001) (b) CESM/CAM climate data for the same recent decades, to obtain offset and bias corrections (c) Future climate scenarios in a warmer climate, for decadal periods, 2020-2030 initially and later 2050-2060, with a clearer warming signal. The overall aim is to examine predicted changes in (a) general precipitation over western Europe and the UK, (b) patterns of frontal storm tracks on decadal time scales and the Atlantic storm tracks with associated occurrence of blocking in the North Atlantic, (c) in quantity and frequency of severe and hazardous convective rainfall events. Initial results from the pdfs of precipitation in the inner and outer domains will be compared with observations, and the importance of bias corrections discussed.

Keywords: Regional Climate, Weather Impact, Precipitation patterns
SCI-POT1027 - A climatic precursor towards anticipating major flood events in the Missouri River Basin

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Measurements taken by the Gravity Recovery And Climate Experiment (GRACE) satellites indicated a continued water storage increase over the Missouri River Basin (MRB) prior to the 2011 flood event. An analysis of the major hydrologic variables in the MRB, i.e. those of soil moisture, streamflow, groundwater storage and precipitation, show a marked variability at the 10-15 year timescale coincident with the water storage increase. A climate diagnostic analysis was conducted to determine what climate forcing conditions preceded the long-term changes in these variables. It was found that precipitation over the MRB undergoes a profound modulation during the transition points of the Pacific Quasi-Decadal Oscillation (QDO) and associated teleconnections. The results infer a prominent teleconnection forcing in driving the wet/dry spells in the MRB, and this connection implies the potential for climate prediction of future wet/dry extreme events.


Keywords: Quasi-Decadal Oscillation, Missouri River, Floods, Seasonal Prediction
SCl-POT1028 - Improved ensemble based weather forecasts for renewable energies

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As the share of wind and photovoltaic (PV) power production with respect to the total power production increases, reliable and accurate forecasts of these energy sources are essential for operating transmission systems in a secure way. Considering also the importance of risk management for operational applications, the predictability of forecast risks has also to be explored in a probabilistic framework. In the German research project EWeLiNE, the overarching objective is to improve the forecasts of the power production from these renewable energies. In this context, the regional ensemble prediction system (EPS) COSMO-DE-EPS, operational at the Deutscher Wetterdienst with a 20-member setup, is a natural candidate as supplier of probabilistic forecasts. In a first step, the predictability of renewable energy relevant parameters, e.g. wind speed profiles, global radiation, cloud cover, etc. is assessed. Since quantile-forecasts are key probabilistic products for energy application, quantile-based verification techniques are considered. Secondly, the ensemble generation of COSMO-DE-EPS is revisited and optimized towards energy operations. Finally, statistical post-processing methods are being developed in order to provide reliable ensemble products to the end-users. This paper presents first achievements towards an optimized EPS for wind and global radiation forecasts over Germany.

Keywords: Ensemble forecasts, verification, regional scale, renewable energies
Jeju Island of South Korea has been experiencing beach erosion which was caused by several coastal environmental effects. To find out the reasons behind the erosion processes in the northern and southern regions of the island, we carried out field surveying concerning the beaches on both regions, respectively, based on the DGPS, GIS techniques and seasonal wind data obtained from local AWS observation system from January 2012 to December 2013. To estimate the exact heights of the beaches, we divided them into 21 sections and 18 sections respectively. According to the research, both beaches had the seasonal erosion and accretion variations depending on seasonal wind directions. Interestingly, the variation patterns found between the north and south were different from each other according to the wind directions in which the patterns are vice versa. From the observation and analysis results, we concluded that the seasonal variations of wind directions can play an important role in beach erosion processes on the northern and southern regions in Jeju island, South Korea.

**Keywords:** Beach, Erosion, Wind, Jeju
SCI-POT1031 - Typhoon Haiyan: A Post-Analysis of its Development, Intensification and Track

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Tropical cyclone Haiyan was the 31st disturbance during the 2013 North West Pacific typhoon season. It started as a low-pressure area on November 1, 2013 0600 UTC at approximately 5.2°N, 164.2°E along a monsoon trough. Haiyan then developed into a tropical depression, then into a tropical storm and into a (category 5 equivalent) typhoon in a matter of 4 days. The lowest pressure it attained was around 895 hPa with a peak 10-minute sustained wind speed of ~235 km/h. It made landfall in Guiuan, Eastern Samar, central Philippines on the morning of November 8, 2013 00UTC. Using the Global Spectral Model (GSM), high resolution Weather Research and Forecasting (WRF ver.3.5) model, satellite and ground observations, this study shows the low vertical wind shear, environmental steering, and the locations of the tropical upper tropospheric trough (TUTT) and the North West Pacific high aided Haiyan in attaining its characteristics.

Keywords: Tropical Cyclone, North Western Pacific, Philippines, Haiyan
Poster Session

SCI-POT1033 - The West African Monsoon System Predictability and Prediction

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Tropics and its associated circulations and disturbances play a very important role in the global climate system and in weather regimes in the Tropics and beyond. Deep convective cloud systems in the Tropics are the primary mechanism of transport of energy out of the Tropics to higher latitude and of energy distribution in tropical troposphere. The fact that local and mesoscale effects are more dominant than synoptic influences makes prediction in Tropics quite challenging. In addition to the lack of total understanding of processes and misrepresentation ok key processes in environmental prediction systems, the current operational World Weather Watch over the tropical latitudes exhibits large data gaps, particularly over continental Africa. The AMMA (African Monsoon Multidisciplinary Analyses) programme is a long-term programme that focus on Continental Africa. Its first phases provided unprecedented measures and diagnostics and has successfully addressed the goals i) to improve our understanding of the West African Monsoon (WAM) and its influence on environment regionally and globally; ii) to provide the underpinning science that relates WAM variability to related societal issues. The ongoing AMMA second phase aims to incorporate research outcomes in relevant monitoring and prediction strategies. Particularly, a large effort is being achieved in the last decade to better document, understand, and predict the West African Monsoon Intraseasonal Variability.

Keywords: Tropics, West African Monsoon, Convective Systems, Prediction
A four-dimensional ensemble-variational data assimilation (DA) system (4DEnsVar) was developed, building upon the infrastructure of the GSI based hybrid DA system. 4DEnsVar used ensemble perturbations valid at multiple time levels throughout the DA window to estimate 4D error covariances during the variational minimization avoiding the tangent linear and adjoint of the forecast model. The formulation of its implementation in GSI was described. The performance of the system was investigated by evaluating the global forecasts and hurricane track forecasts produced by NCEP GFS during a 5-week summer period assimilating operational conventional and satellite data. The newly developed system was used to address a few questions. 4DEnsVar in general improved upon its 3D counterpart, 3DEnsVar. At short lead times, the improvement over Northern extratropics (NH) was similar to that over Southern extratropics (SH). At longer lead times, 4DEnsVar showed more improvement in SH than in NH. 4DEnsVar showed less impact over Tropics. The track forecasts of 16 tropical cyclones initialized by 4DEnsVar were more accurate than 3DEnsVar after 2-day forecast lead times. Analyses generated by 4DEnsVar was more balanced than 3DEnsVar. Case studies showed that increments from 4DEnsVar using more frequent ensemble perturbations approximated the increments from nonlinear model propagation better than using less frequent ensemble perturbations. Consistently, the performance of 4DEnsVar including both the forecast accuracy and the balances of analyses was in general degraded when less frequent ensemble perturbations were used. The tangent linear normal mode constraint had positive impact for global forecast but negative impact for TC track forecasts.


Keywords: hybrid data assimilation, Four-dimensional ensemble-variational data assimilation method, GFS, Gridpoint Statistical Interpolation (GSI)
Poster Session

SCI-POT1044 - Modelling of local length-scale dynamics and isotropizing deformations

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Correlation matrix modelling is a challenging issue in variational data assimilation scheme (Background and model error matrices) as well as in ensemble Kalman filter (localization and balance). The goal is to provide fast implementation of anisotropic correlation. Efficient algorithm are existing for isotropic correlation functions (recursive filter, diffusion, spectral space) but it is still costly to construct anisotropic functions. For given anisotropic correlations, a possible strategy to obtain an efficient representation is to find a coordinate change that convert isotropic correlations into the given anisotropic ones. From differential geometry, we propose an algorithm computing such a coordinate change from the simple diagnosis of the length-scale.

Keywords: covariance modeling, length scales, B matrix
Poster Session

SCI-POT1048 - Impact of surface observation nudging on Typhoon Haiyan forecast over the Philippines

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Global analyses that numerical prediction models (NWP) use to produce regional high resolution forecasts contain inherent model errors. One way to minimize these errors is through the inclusion of observed data in order to pull the model closer to reality. In this study, the effect of assimilating surface observations using four dimensional data assimilation (FDDA) on Weather Research and Forecasting (WRF - ARW) model forecast of super typhoon Haiyan was investigated. Comparison of numerical experiments for the domain (3-25N, 115-135E) initialized on November 6 2013 00Z with a 9-h nudging window against synoptic stations showed an error reduction in 2-m temperature, mean-sea level pressure and 2-m wind across the whole domain and provided a better estimate on the strength of Haiyan -- decreased error of approximately 2.5hPa in central pressure and 0.2 m/s in maximum 2-m wind speed. Correlation of hourly rainfall forecast against TRMM 3B42 3-hourly rainfall data, however, slightly decreased by 0.06 upon data assimilation. Moreover, data nudging was found to have minimal impact on the track of the typhoon Haiyan.

Keywords: data assimilation, Haiyan, Philippines, WRF
NOAA SST system, Advanced Clear-Sky Processor for Ocean (ACSPO), simulates top-of-atmosphere clear-sky brightness temperatures at 3.7 (IR37), 11 (IR11), and 12\(\mu \text{m}\) (IR12). Community Radiative Transfer Model (CRTM) is used in ACSPO in conjunction with first-guess SST and atmospheric profiles. Based on earlier sensitivity analysis to first-guess SST (Saha et al., 2012), initial SST implementation (Reynolds) was replaced by the Canadian Met Centre (CMC) product. This study additionally checks sensitivity to atmospheric profiles, by testing the European Center for Medium range Weather Forecasting (ECMWF, 0.25° lat-lon resolution, 97 levels) in addition to the current implementation based on NCEP Global Forecast System (GFS, 1°, 26 levels). The comparisons are performed by analyzing nighttime Model minus Observation (M-O) biases in the Monitoring of IR Clear-sky Radiances over Ocean for SST (MICROS; www.star.nesdis.noaa.gov/sod/sst/micros/) system. Based on one-month of global data for several AVHRR, MODIS and VIIRS sensors, the number of clear sky pixels slightly increases. In IR37, the global mean M-O biases (~0.2K) and standard deviations (STD<0.5K) remain largely unchanged. In IR11 & IR12, the mean biases (0.5-0.7K) and STDs (~0.55K) are reduced, and become closer to those in IR37. This suggests that ECMWF has more moisture than GFS, and therefore mainly affects the longwave bands. The large warm spots in M-O biases in the tropics seen with GFS implementation are reduced and even reverted to negative M-O biases, suggesting that ECMWF may overestimate water vapor. We plan to include ERA-Interim and MERRA profiles in these analyses.


Keywords: ECMWF, MICROS, GFS, CRTM
Poster Session

SCI-POT1056 - Software for monitoring pollutants emissions from aircraft

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The increasing amount of chemicals spread in the nature by humans had contributed to our own discomfort and injury along the last decades. These Chemicals, called pollutants, threaten our quality of life and cause several diseases, since burning eyes to respiratory problems. Such diseases are more frequent on people who live near pollution sources. As we are focusing in pollutants that are formed anthropogenically, the basis of this article will be shaped in the airport and their localities. The advantage there is that we already have ways to measure the amount of pollution in the area, but considering the LTO cycle (landing and take-off), the quantities aren’t well determined. Therefore, we don’t know accurately if that field is according with the air quality standards. This paper presents the research being undertaken to the development of a new software to solve these problems. It should be capable to save and analyse the information of emissions of all the aircrafts that land and take off of an airport. The software will produce several information about the aircraft, and will be able to answer questions like: Which aircraft was the most polluting of the day? Which enterprise? Which LTO period had the biggest concentration of NO of the month? Thereby, the findings of this project will be of such value that will put on stake the quality of the aircrafts and their enterprises. Such results will benefit the aircraft workers and people who live near the area, giving them a healthy place.

Keywords: aircraft, pollutants, meteorology software, LTO cycle
The Infrared Atmospheric Sounding Interferometer (IASI) measures radiances in 8461 channels covering the spectral interval 645 - 2760 cm$^{-1}$ at a resolution of 0.5 cm$^{-1}$. Blacklisting is essential to improve the quality of IASI data. To test blacklisting, we analyzed surface types and day/night monthly means and standard deviations of the background innovations of corrected observations. The monthly means of most of the ocean data evenly centered around 0.1 K except window channels, while those of the land data have a comparatively large range of about 0.2 ~ -0.3 K. Bad channels were also identified through a long term analysis for recurring errors in the observed TBs, for example, at channel 6601 and channel 8007. Rejecting these bad regions and channels in the IASI data processing system will enhance effectiveness of the program. A quality control is conducted in each step in the data processing system. After quality check to see if the data satisfy certain preconditions, the data are flagged in a binary manner for each condition. The preliminary results of blacklisting for one month period of November, 2012 as part of the IASI quality control at KIAPS (Korea Institute of Atmospheric Prediction Systems) will be presented.

**Keywords:** IASI, Blacklisting, Quality Control
The sensitivity of precipitable water vapor (PWV) from Global Positioning System (GPS) on constrained variational data assimilation (VDA) was evaluated in terms of influence of radius and weighted covariance. First of all, the PWV obtained from GPS was compared with radionsonde from June to August, 2013 to investigate consistency. The correlation coefficient between GPS and radiosonde was good agreement. The 13 ground-based GPS data of metropolitan area used in the cost function of variational assimilation with variable influence of radius and weighted covariance. One of many terms in the humidity variational minimization step, the GPS total water vapor is used to constrain the integrated water computed every iteration. The PWV was determined a weighted function according to the distance and radius of influence from each GPS sites. The PWV tended to decrease increasing radius of influence and decreasing weighted functions. The results of GPS sensitivity on VDA will provide more useful information to improve predictability of precipitation essentially for very short-range forecast.

**Keywords:** variational data assimilation, ground-based GPS PWV, sensitivity
Poster Session

SCI-POT1069 - Preliminary results with the MEOPAR/HREnKF data assimilation system

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Canada requires rapidly deployable environmental prediction systems to help guide its response to marine emergencies along its coastline and offshore areas. To help meet this need, a Network of Centres of Excellence called Marine Environmental Observation Prediction and Response (MEOPAR, www.meopar.ca) has recently been established. One of MEOPAR's initial projects is to develop a forecast system that can be set up shortly after a marine emergency in order to provide short-term forecasts (hours to days) of atmosphere and ocean conditions. For this purpose, a relocatable high resolution (2.5-km) atmospheric data assimilation and prediction system based on a limited-area Ensemble Kalman filter is currently being developed. Results from this first version will be presented at the conference and also compared with a larger scale Canadian Regional Ensemble Kalman Filter also currently being developed.

\textbf{Keywords:} Data assimilation, Ensemble Kalman filter, Convective scales
Poster Session

SCI-POT1070 - Analysis and forecast impact of tropical cyclone observations with large observation innovations

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The recent improvement of tropical cyclone (TC) track and intensity forecast improvement has been attributed to increased model resolution, improved data assimilation, and the rapid increase in the number of routinely assimilated observations over oceans. In this study we focus on the assimilation of observations that have a direct impact on tropical cyclones: 10 m scatterometer winds, Tropical Cyclone Vitals (TCVitals) minimum sea level pressure and position estimates, and reconnaissance dropwindsondes. In a series of experiments to test the treatment and quality control (QC) of the special TC observations, we show that gainful improvements can be made to the analyses and subsequent forecasts, when using an ensemble-based coupled global-limited-area analysis system with a specialized QC method for observations with large innovations. Huberization, a method by which innovations are capped at some prescribed maximum, is tested as an alternative to discarding observations with large innovations. Given that our analysis system updates the fields associated with TCs through only the assimilation of observations, Huberization offers a mechanism by which these observations may affect the analysis, while leaving the initial ensemble robust to observations with large innovations.

Keywords: ensemble, assimilation, Tropical cyclone
Poster Session

SCI-POT1073 - Pre-Processing and Quality control of surface data for assimilation in KIAPS global NWP model

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Conventional surface data including surface pressure, 2m temperature, 2m relative humidity and 10m wind has been long used for the data assimilation in Numerical Weather Prediction (NWP) model, and has been recognized as very important to improve model performance. Here, pre-processing of surface data for assimilation will be implemented in KIAPS (Korea Institute of Atmospheric Prediction Systems) global NWP model is introduced, and initial observation screening and quality control methods are explained. Currently, surface pressure and temperature over land are used in KIAPS pre-processing system. The height adjustment, observed surface pressure to be adjusted to the level of the background model surface, is performed after reading observation and interpolated background data at the observation location. The simple height adjustment methods are used, which are linear lapse rate for temperature and hydrostatic balance for surface pressure. To retain hydrostatic balance, background surface pressures before interpolation moves to the same background orographic height hydrostatically and then, interpolated horizontally to the observational position. After the height adjustment, data is flagged by several quality controls like temporal consistency, and position consistency check.

Keywords: surface observation, pre-processing of surface data
SCI-POT1077 - AIRS and Weather Prediction

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The Atmospheric Infrared Sounder (AIRS) is an infrared hyper-spectral cross-track scanning sounder onboard the Aqua spacecraft, which is part of the NASA A-Train constellation at a 705-km altitude orbit, and started collecting data in September 2002. The sounder footprint is about 13 km at nadir. Almost global coverage is achieved twice per day from ascending (cross-equator time at 1:30 pm) and descending (cross-equator time at 1:30 am) orbits. Assimilated AIRS radiances have played a critical role in numerical weather prediction. Data-denial experiments have shown that AIRS is arguably the single most important satellite instrument in terms of weather prediction improvement over the last 10 years. Recently, AIRS has been shown to play important roles in a variety of other weather research topics, from cloud and boundary layer physics to extreme weather events. These key contributions by AIRS will be reviewed in this presentation, with a particular emphasis on the future role of IR sounders in weather science and forecasting.

Keywords: Satellite observations, Infra-red sounder, Weather prediction, weather extremes
SCI-POT1090 - Evolution of the severe rainfall cells structure in the LL-MCS and lightning activity

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The data from Doppler radar, SAFIR3000 lightning location system and high-density automatic meteorological stations observations are used to design a variety of radar quantitative parameters and analyze the evolution of cells structures, lightning activity and electrical vertical structure of the heavy rainfall cells structure in LL-MCS. The relationship between convective cells and β-mesoscale LL-MCS is revealed. The conclusions are as follows. At first, the four cells (GUAN in Hebei, SHUNYI and FANGSHAN in Beijing, BAODI in Tianjin) in one squall respectively brought about 23 mm, 50 mm, 27mm and 70mm in 1 hour. In FANGSHAN cell, two smaller cells were merged. The cell of Shunyi was followed by other cell. In Guan and Baodi cell, the development and LL-MCS were feeding, swallowing relationship. Secondly, V40, V40UP-6, Set11 could describe the 3D quantitative structure change of cell, and Fcg and Fic were closely related to the radar parameters, such as the correlation coefficient of V40UP-6 and it between 0.63 and 0.97. Thirdly, the radiant point maximum concentration area of height in the GUAN cell was below 6km, which was far lower than other cells at the same stage. At last, the feature of lightning frequency of CG and lightning frequency of IC and H increased significantly lift after the merger in convective cell, and the characteristics of lightning frequency had relationship with the rainfall intensity increasing and lightning frequency peak maximum of rainfall intensity have positive significance for warning of disaster weather.


Keywords: γ-mesoscale convective cells, Radar parameter, Lightning activity, LL-MCS
Poster Session

SCI-POT1094 - Atmospheric boundary layer height estimation using combined microwave radiometer and lidar data

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The estimation of atmospheric boundary layer height (ABLH) during a full diurnal cycle using ground-based remote sensing instruments is one of the key challenges in atmospheric science. Most of these instruments such as the lidar, the microwave radiometer (MWR), the radar, and the sodar measure one of the physical parameters, i.e., temperature, aerosol concentration, wind speed, and heat flux, within the Atmospheric Boundary Layer (ABL). All these instruments, while performing well under specific atmospheric conditions, are limited in others. Thus, an estimate of the ABLH based on the lidar return signal alone is quite good under convective conditions, where there is a clear interface between a well-mixed concentration of aerosols in the mixing layer (ML) and the free troposphere (FT). In contrast, in night-time conditions, when the convective ML recedes and a stable boundary layer (SBL) develops near the surface of the Earth, the lidar backscattered signal is usually insufficient to resolve the SBL. Similarly, a MWR is limited by its poor range resolution. In this context, a MWR-ceilometer combination is proposed. Temperature-inversion retrievals from the MWR, containing the approximate height range where the SBL is located, roughly guide the Kalman Filter based ABLH estimation algorithm for the lidar return signal, hence resulting in acceptably accurate estimates of the ABLH. The proposed approach is applied to collocated ceilometer-MWR instruments under the simple "clear-atmosphere" cases. Radiosonde data, whenever available, is used as a reference or "physical truth".

Keywords: Atmospheric boundary layer, Microwave radiometer, Ceilometer
Poster Session

SCI-POT1096 - Aerosol and cloud microphysics retrieval using High Spectral Resolution Lidar

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High Spectral Resolution Lidar (HSRL) is the National Science Foundation (NSF) supported, state-of-the-art instrument for sensing the optical properties of aerosols and clouds. It was designed for deployment aboard the NSF Gulfstream V (GV) research aircraft and can also be deployed in a custom built container along with a W-band cloud radar. The aircraft is called the High-Performance Instrumented Airborne Platform for Environmental Research (HIAPER). As part of the instrument suite for HIAPER, NSF funded the development of the HSRL as one of the HIAPER Aircraft Instrumentation Solicitation (HAIS) instruments. The HSRL was designed and built by the University of Wisconsin Lidar Group. The HSRL independently observes backscatter and extinction as a function of range. Molecular scattering is used as a reference for calibrated aerosol backscatter and extinction measurements. The HSRL simultaneously measures backscatter from molecular and aerosol particles using an iodine filter to separate molecular and aerosol scattering. The HSRL also has a channel to measure the depolarization of the aerosol return signal. The instrument was successfully flown on the GV in 2012 as a primary active remote sensing instrument during the Tropical Ocean Troposphere Exchange of Reactive Halogen Species and Oxygenated VOC (TORERO). Ground based measurements from the customized container with a W-band cloud radar were made in 2013. Observations and retrieved scientific products from TORERO and ground-based deployments will be presented.

Keywords: Aerosol, Microphysics, Spectral, Lidar
Poster Session

SCI-POT1098 - Nowcasting Hydrometeor-type using polarimetric radar data

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Dual polarization allows weather radar to determine hydrometeor-type from radar echoes. This capability is combined with traditional radar nowcasting techniques in order to generate short-term, time series nowcasts (1 to 2 hour). The signatures of different radar scatterers, such as hydrometeors, have been determined for polarimetric radar fields such as horizontal reflectivity (Zh), differential reflectivity (Zdr), correlation coefficient (ρhv) and specific differential phase (Kdp). To allow radar range gates to be classified by scatterer-type in sufficient time to be useful in an operational setting, algorithms employing fuzzy logic have been developed. One such algorithm is iParCA (interactive Particle Classification Algorithm) developed by the King City Research Group at Environment Canada. With conventional radar nowcasting techniques, an echo motion field is generated from consecutive CAPPI (Constant Altitude Plan Position Indicator) radar fields by maximizing cross-correlations between them, or by minimizing a cost function. Forecast radar images are then generated with the motion field. Typically, radar reflectivity, or precipitation rate and amount are the variables nowcast. With the hydrometeor-type nowcasting tool, the nowcast field is a hydrometeor-type field generated by iParCA. The nowcast is generated using an existing cross-correlation tracker software program that derives the motion field from subsequent reflectivity images. 2 hour nowcasts are generated for various points of interest near King City radar from the forecast hydrometeor-type fields using an existing point forecast generation tool. The output was assessed with a series of stratiform precipitation cases from both the summer and winter.

Keywords: nowcasting, dual-polarized radar, particle classification, hydrometeor classification

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Using the historical Beijing “7.21” extreme precipitation event, six ensemble techniques (initial condition, multi-physics, 3 stochastic physics as well as a combination of IC and stochastic-physics) were compared in the following three aspects of heavy precipitation forecasts: performance of ensemble means, ensemble ranges and probabilities against the control forecast, characteristics of ensemble spreads including scale decomposition, and spread-forecast error relations. The results obtained from this research are meaningful and can shed lights for future ensemble prediction system development. The main conclusion includes: (1) The superiority of ensemble forecasts over a single deterministic forecast is apparent in predicting high-impact weather events; (2) it has a long way to go for stochastic-physics approach to fully duplicate the capability of multi-physics approach in ensemble forecasting; and (3) how to perturb either model physics or/and IC to produce adequate small-scale spread to be matched with small-scale forecast error is a challenging task.

Keywords: ensemble forecasting, IC perturbation, multi-physics, stochastic physics
Poster Session

SCI-POT1121 - Latest developments to the UK ensemble forecasting system, MOGREPS-UK

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MOGREPS-UK is the Met Office's regional high-resolution ensemble prediction system for the UK. The 12-member ensemble is run four times a day for 36h at 03, 09, 15 and 21 UTC with a 2.2 km grid over the UK. Currently MOGREPS-UK is run as a downscaler of the global MOGREPS-G ensemble, i.e., both the initial and boundary conditions for each member are taken from 3h forecasts by MOGREPS-G. This study aims to evaluate the impact on the performance of MOGREPS-UK of using initial conditions from the high-resolution analysis from the UKV (the Met Office's high-resolution deterministic UK model). The use of the UKV analysis will enable the use of fresher and more detailed initial conditions. This study will also evaluate the results of using an updated dynamical core, ENDGame (Even Newer Dynamics for General atmospheric modelling of the environment) which will replace the previous Unified Model dynamical core (New Dynamics).

Keywords: Ensemble prediction, MOGREPS-UK, regional forecasting
SCI-POT1123 - The impact of forecast error growth on the medium-range predictability of a European cyclone

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The skill of medium-range (5-10 day) forecasts has increased significantly over time; however, some forecasts are still characterized by large errors of high-impact events. Perfect examples of this are the medium-range forecasts of a cyclone that was predicted to impact Northwestern Europe on 16 Dec. 2011. Medium-range forecasts for this event consistently predicted a sub 940-hPa cyclone would impact Northwestern Europe, while shorter-range forecasts (> 5-days) predicted a much weaker cyclone, which ultimately verified. The goal of this study is to investigate the source of the noted large, medium-range forecast errors associated with this event through the use of ECMWF (European Center for Medium-Range Weather Forecasts) ensemble forecasts within TIGGE (THORPEX Interactive Grand Global Ensemble). To accomplish this goal, two distinct subgroups within the ensemble were objectively identified: 1) 8 members that forecast the strongest cyclone as measured by minimum sea-level-pressure (named “strong forecast” subset) and 2) 8 members that predicted a cyclone with the lowest track error (named “good forecast” subset). Results show that the formation of a strong cyclone over Europe is dependent on the relative phasing between a northern and southern stream trough over the western Atlantic Ocean, with the degree of phasing being dictated by how ensemble members handle a series of ridge building events over the North Pacific that occur early in the forecast period.

Keywords: Predictability, Ensembles, ECMWF, TIGGE
The TIGGE (THORPEX Interactive Grand Global Ensemble) project, led by the THORPEX GIFS-TIGGE working group, has developed a database of global ensemble forecasts collected in near real-time. The data are available from three archive centres (ECMWF, NCAR and CMA) to facilitate research on a variety of topics, including ensemble prediction methods, and methods to combine ensembles and to correct systematic errors. The GIFS TIGGE WG established the TIGGE LAM to cover limited-area ensembles, with the aim of establishing a complementary dataset of higher-resolution regional ensembles. Funding support from the European GEOWOW project has now allowed work to be started on the development of the TIGGE-LAM archive. During the first phase of the project, and thanks to the work of the data providers (acknowledged in the poster), the TIGGE archive at ECMWF was extended to include regional ensemble forecasts from several European contributors. Contact was made with potential data providers of limited area European Ensemble Prediction Systems. Five systems are already in the archive and around other five data providers are working to contribute. The second phase of the project development will also improve the accessibility of TIGGE data by developing efficient access to long time series of forecast data at specific geographical locations.

References: TIGGE portal at ECMWF. Available at: [http://tigge.ecmwf.int/index.html] TIGGE-LAM data portal at ECMWF. Available at: [http://apps.ecmwf.int/datasets/data/tigge_lam/]

Keywords: TIGGE, TIGGE-LAM, EPS archive
HarmonEPS is the ensemble configuration of the convection permitting Harmonie model that is developed by the Hirlam consortium, and is based on the Arome model from Meteo France. In its most basic form, HarmonEPS is a downscaling of perturbed members from the ECMWF global ensemble. Under this basic downscaling strategy, a key weakness in the ensemble forecast is under-dispersion of near-surface parameters, such as 2m temperature and humidity and 10m wind. In an attempt to improve the dispersion of these near-surface parameters, strategies to perturb model surface fields in the initial conditions are being investigated. Candidate fields for surface perturbations include soil moisture content, soil temperature, sea surface temperature and snow cover. Furthermore, as forecast lead time increases, fine scale perturbations in the initial conditions are typically ‘washed-out’ due to the influence of coarser resolution data at the lateral boundaries. In order to maintain spread at fine scales throughout the forecast length, the impact of perturbations to the surface energy flux parametrizations via the roughness lengths and exchange coefficients is investigated. Here we present initial results from these perturbation experiments at 2.5km horizontal resolution with the performance of both the initial conditions and the surface physics perturbations assessed in terms of ensemble spread and RMSE. Additionally, probabilistic verification scores for a range of relevant thresholds are computed using the HARP (Hirlam Aladin R-Package) verification package.

Keywords: ensemble prediction, perturbations, uncertainty
Forecasting severe weather events is a key object for National Meteorological Services around the World. Due to the large amount of processes involved in those events and their non-linearity, a probabilistic approach is required. Ensemble prediction systems are a feasible framework and the most useful tool to improve such forecasts. But resolution also matters, because the effect of soil characteristics and orography, as well as the impact of explicitly resolve some physical processes may become very important in the location and intensity of the event. AEMET, the Spanish Agency of Meteorology, has started the development of its new generation ensemble prediction system. A multimodel-multiboundaries system using two NWP models, Harmonie and WRF, running at 2.5 Km (meso-γ) as horizontal resolution several times a day. In this presentation the first results of the research needed to define the γ-SREPS characteristics are shown. LETKF is used to compute the perturbations of the initial conditions while boundaries from several global models are used as perturbations at the lateral boundaries. SPPT (Stochastic Perturbed Parameterization Tendencies) is included to keep the spread of the ensemble during the integration time. The system is focused on the forecast of surface parameters (precipitation, wind and 2m temperature) and the performance assessment of these parameters is also subject to scale issues at these resolutions.

**Keywords:** Predictability, Mesoscale, Ensemble Prediction Systems, Severe Weather
Three approaches of multi-model ensemble (MME) prediction systems based on distinct simplified Numerical Weather Prediction systems (NWPs) are tested to identify particular characteristics of forecast error growth and to compare their potential skill of prediction. One approach is the traditional MME where each model and its associated reforecast dataset are generated independently. Examples of this approach include NAEFS, TIGGE, NMME and EUROSIP-IMME prediction systems. A second approach allows interaction among ensemble members from different NWPs as they are integrated forward in time. That is, each ensemble prediction system has its own initialization procedure but exchange information after initial time. This approach would be similar to adding stochastic perturbations but with amplitudes driven by differences in total tendencies among the forecast members. In a third approach the models are coupled at each time-step of the forecast integration and the background error covariance matrix is produced from forecasts of the coupled model. For sufficiently long reforecast lengths the two latter methods have marginal skill improvements with the third one outperforming the other two. Nonetheless, the latter two approaches require shorter reforecasts to outperform the first method and they can be optimized to increase further their prediction skill.

Keywords: Model drift, simplified dynamical systems, Ensemble perturbations, Multi-model ensembles
Poster Session

SCI-POT1134 - Climatic impacts of a stochastic parameterization of air–sea fluxes

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The atmosphere and ocean are coupled by the exchange of fluxes across the ocean surface. Air-sea fluxes vary partly on scales that are too small and fast to be resolved explicitly in numerical models of weather and climate, making them a candidate for stochastic parameterization. This presentation proposes a nonlinear physical mechanism by which stochastic fluctuations in the air-sea buoyancy flux may modify the mean climate, even though the mean fluctuation is zero. The mechanism relies on a fundamental asymmetry in the physics of the ocean mixed layer: positive surface buoyancy fluctuations cannot undo the vertical mixing caused by negative fluctuations. The mechanism has much in common with Stommel's mixed-layer demon. The presentation demonstrates the mechanism in climate simulations with a comprehensive coupled atmosphere-ocean general circulation model (SINTEX-G). In the SINTEX-G simulations with stochastic air-sea buoyancy fluxes, significant changes are detected in the time-mean oceanic mixed-layer depth, sea-surface temperature, atmospheric Hadley circulation, and net upward water flux at the sea surface. Also, El Nino Southern Oscillation (ENSO) variability is significantly increased. The findings demonstrate that noise-induced drift and noise-enhanced variability, which are familiar concepts from simple climate models, continue to apply in comprehensive climate models with millions of degrees of freedom. The findings also suggest that the lack of representation of sub-grid variability in air-sea fluxes may contribute to some of the biases exhibited by contemporary climate models.


Keywords: stochastic, fluxes, parameterization, climate model
Poster Session

SCI-POT1136 - Calibration of the stochastic multicloud model using Bayesian Inference

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The stochastic multicloud model (SMCM) was recently developed (Khouider, Biello, and Majda, 2010) to represent the missing variability in general circulation models due to unresolved features of organized tropical convection. In the SMCM parameterization scheme, convective elements are viewed as Markov processes with state transition probabilities that are conditioned on the large scale environmental variables, like the convective available potential energy (CAPE) and middle troposphere moisture content, and a set of cloud timescale control parameters. We present a robust calibration methodology for the SMCM to estimate these key cloud timescale parameters from simulated and in situ data. We formulate the calibration problem within a Bayesian framework to derive the posterior distribution over the model parameters. The model likelihood function involves the repeated calculation of large matrix exponentials, which we maintain computationally feasible using a parallel version of a preconditioning technique known as the uniformization method. Sampling of the high dimensional posterior distribution is achieved using the Markov Chain Monte Carlo technique. The robustness of the calibration procedure is tested using synthetic data produced by a simple toy climate model. A sensitivity study to the length of the data time series and to the prior distribution is conducted, and a sequential learning strategy is also tested. Finally, we present some preliminary inferential results using the Giga-LES dataset (Khairoutdinov et al., 2009), an idealized GATE Large-Eddy Simulation of deep convection over the tropical atlantic.


Keywords: sub-grid parameterization, tropical convection, stochastic methods, bayesian inference
Poster Session

SCI-POT1138 - Optimizing physical parameterization in COSMO-DE towards renewable energies

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The growing amount of renewable energies in modern power supply requires further research in this new interdisciplinary field. There within, the role of Numerical Weather Prediction (NWP) is to reduce forecast errors and to provide an a priori estimate of remaining uncertainties associated with the large share of weather-dependent power sources. For this purpose it is essential to optimize NWP model forecasts with respect to those prognostic variables which are relevant for wind and solar power plants. The German Weather Service has started two projects to optimize its weather forecasts for power production variables. These projects, titled EWeLiNE and ORKA, are funded by the Federal Ministry for the Environment (see talk “Optimizing the COSMO-DE Ensemble towards renewable energies” by J. v. Schumann). This poster presentation is focused on the identification of critical weather situations and the associated errors in the German deterministic regional NWP model COSMO-DE. First steps leading to improved physical parameterization schemes within the NWP-model concerning solar and wind forecast deficits are presented.

Keywords: physical parameterization, renewable energie, COSMO-DE
Poster Session

SCI-POT1140 - Impact of horizontal resolution and turbulence parameterization on high-resolution simulations of deep convection

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Idealized simulations of deep moist convection are performed with the Meso-NH model at kilometric and sub-kilometric scales, i.e., at intermediate scales for turbulence (Verrelle et al. 2014). The model is used without a surface scheme, radiation scheme, orography or Coriolis force. The horizontally uniform initial state is derived from analytic profiles for temperature, humidity and wind, given in Weisman and Klemp (1982). An ellipsoidal thermal perturbation is inserted in the low levels to trigger convection. First, the impact of horizontal resolution (4-km, 2-km, 1-km and 500-m grid spacings) is assessed. Then, the turbulence scheme is also evaluated (one-dimensional turbulence (T1D) scheme versus three-dimensional turbulence (T3D) scheme). The simulations generate one cell which splits into two convective systems: a leftward-moving multicellular system and a rightward-moving supercell. The accumulated rainfall and the size of convective systems increase with increasing resolution. The area of updraft cores also increases but their intensity decreases. T3D induces more mixing and enhances the microphysical processes compared to T1D, producing larger amounts of cloud cover and precipitation. The ratio between resolved and total turbulent kinetic energy (TKE) decreases with increasing resolution for both T1D and T3D, which is unexpected and shows the limit of the turbulence parametrization in convective clouds. The main explanation is the insufficient turbulent mixing inside clouds, especially at coarser resolution. At 500-m horizontal resolution, the subgrid TKE is mainly due to dynamical processes. Thermal production is mostly negative, underlying the lack of entrainment at the cloud edges.


Keywords: deep convective cloud, turbulence, horizontal grid spacing, Meso-NH model
Poster Session

SCI-POT1144 – WITHDRAWN - The decay of tropical cyclone over the South China Sea offshore during summer

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In this paper, Typhoon best track data from "tropical cyclone Yearbook"(CMA), fnl 1 ° × 1 ° analysis data, NOAA0.25 ° × 0.25 ° AVHRR SST daily optimal interpolation data, were used. The characteristics of dissipation of tropical cyclone over the South China Sea during summer period were analyzed. And the Diagnosis characteristics of the vertical wind shear, moisture transport and the marine environment were studied. The result showed that 7 tropical cyclones cases can be divided into two categories. The first one, which always appeared in the first half of July, decay almost by middle and high latitude weather systems such as westerly trough, Subtropical high pressure. And the decay of the second one primarily related to the interaction of two or three tropical cyclones and appeared in August.

Keywords: Tropical cyclone over the South China Sea, summer, decay, environment
Poster Session

SCI-POT1148 - The role of interactions between multi-scale circulations on zonal wind variability associated with the MJO

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The mechanisms driving the upper tropospheric zonal mean intraseasonal zonal wind associated with the Madden-Julian Oscillation are examined through budget analysis during the boreal winter. In order to diagnose the role of nonlinear and cross-scale interaction forcing, the wind fields are decomposed into three temporal bands, including the intraseasonal time scale (20-100 days), and periods shorter and longer than the intraseasonal time scales. The intraseasonal zonal mean circulation and its driving mechanisms are first examined based on the leading EOFs of the intraseasonal zonal wind. Consistent with previous studies of intraseasonal atmospheric angular momentum, the upper troposphere zonal mean intraseasonal zonal wind anomaly begins in the tropics and propagates poleward. Results show that interaction between the background state and intraseasonal time scale zonally symmetric and asymmetric circulation help drive changes in the tropical intraseasonal zonal wind and its poleward propagation. The intraseasonal anomalous circulation also modulates the characteristics of the transient eddies that induce anomalous momentum flux convergence and helps to accelerate further intraseasonal zonal wind in the extratropics. However, results suggest that the feedbacks between the anomalous intraseasonal circulation and the transient eddies have some sensitivity to the event-to-event variability of the MJO.

Keywords: Madden Julian Oscillation, Tropical-Extratropical Interactions, Multi-scale interactions, Zonal Mean Circulation
The period preceding the tropical cyclogenesis of Hurricane Helene (2006) was accompanied by several marked dust outbreaks. This study investigates the transport of mineral dust from its source regions towards the developing tropical storm Helene and aims to diagnose the properties of the air influencing the tropical cyclonegenesis. The model system COSMO-ART (Aerosols and Reactive Trace gases) in which emission and transport of mineral dust and the radiation feedback are taken into account, was used. The emission of mineral dust between 9-14 September 2006 occurred in association with the relatively strong monsoon flow and northeasterly trade winds, with gust fronts of convective systems over land, and with the Atlantic inflow. Additionally, increased surface wind speed was linked to orographical effects at the Algerian Mountains, Atlas Mountains and the Hoggar. The dust is transported at low levels by the monsoon flow, the Harmattan, the northeasterly trade winds and the monsoon trough, and is transported upwards in the convergence zone between Harmattan and monsoon flow, in the baroclinic zone along the West African coastline, and by convection. At around 700 hPa the dust is transported by the African easterly jet. Dry and dust-free air formed to the north-northwest of the developing tropical depression due to descent in an anticyclone. Based on the model data it was possible to distinguish between dry (from the anticyclone), dry and dusty (from the Harmattan and northeasterly trade winds), and dusty and moist air (from the monsoon flow and in the tropical depression due to convection).

Keywords: Tropical cyclone, Mineral dust transport, COSMO-ART, AMMA
SCI-POT1164 - The effect of temperature advection on atmospheric stratification in two sandstorm processes

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Based on two processes of the severe sandstorm and the strong wind with dust, the study on spatial distribution characteristics of temperature advection aimed at the atmospheric stratification in Inner Mongolia. The results show that the cold advection is stronger than normal, but there are different vertical distribution characteristics of the cold advection. The temperature advection differences between higher and lower level since the surface layer weaker cold advection stacks with the cold advection of the center located in the 600-700hPa level. The increasing vertical temperature lapse rate is good at the formation of the deep unstable stratification in the sandstorm process. After the unstable energy is releases in the process of the dry convective windstorm formation, the atmosphere stratification tends to the neutral or mixed layer. In the strong wind process, the cold advection center is located in the lower 850hPa level, which is not conducive to the formation of unstable stratification. The mixing layer height is consistent with the sandstorm height is located in the upper 600hPa level, when the strong cold advection center (-45×10⁻³ ℃·s⁻¹) is in the 600-700hPa level. This weather process can influence to the South of the Yangtze River and the coastal areas of China.

Keywords: temperature advection, sandstorm, atmospheric stratification, mixing layer
Poster Session

SCI-POT1166 - A novel metric to assess the “extremeness” of cyclones

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Mid-latitude high impact weather (HIW) is often caused by extratropical cyclones. Despite the overall progress in the representation of the general large-scale mid-latitude flow, the correct prediction of individual cyclones, their track, structure and intensity, and their associated HIW is still a challenge for general circulation models. In this project we explore a novel metric to assess the extremeness of cyclones. In a feature-based approach, extremeness of an individual cyclone is defined as the accumulated area along the track affected by extreme 2m temperature, precipitation, or 10m windgust. Grid-point based thresholds are used to determine the local extremeness of these surface variables. Moreover, general cyclone properties are traced along the cyclone tracks. Globally the most extreme cyclones are predominantly tropical cyclones undergoing extratropical transition. Focusing on Europe, extreme cyclones tend to be more intense, have a stronger deepening rate, form further equatorward, and track more in meridional direction than non-extreme cyclones. It is further demonstrated that a combination of cyclone properties derived from sea level pressure alone is a useful predictor for accumulated extremeness. This novel feature-based diagnostic and database enables further investigations of the role of cyclones in triggering HIW in different world regions, e.g. stratified by cyclone properties, type of extremes, or cyclone categories. Extending the database by the representation of the individual cyclone objects in forecasts allows a feature-based forecast verification. In a future step the diagnostic will be applied to datasets covering larger periods, e.g. the ERA-Interim reanalyses and to other weather systems (e.g., blocking anticyclones).


Keywords: cyclone, high impact weather, extreme, tracking
Poster Session

SCI-POT1168 - The ENDGame dynamical core: impacts on extra-tropical variability and predictability

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The Met Office Unified Model (MetUM) is used by the Met Office and its collaborators for weather and climate prediction in both global and limited-area simulations. In 2014, we will upgrade the dynamical core used in our production configurations of the MetUM from the so-called “New Dynamics” to “ENDGame”. Both cores use a semi-Lagrangian semi-implicit formulation to solve the non-hydrostatic, fully-compressible deep-atmosphere equations of motion, but ENDGame is an evolution of New Dynamics designed to improve its accuracy, stability and scalability. The improved stability allows us to run the model with less off-centring in the semi-implicit time stepping, which reduces the numerical damping in the model. We also run the model with less explicit diffusion, which further reduces the damping applied. We present the impact of this upgrade, as part of a wider package of improvements, on the mid-latitude variability of the deterministic global NWP model. We assess broad measures of variability such as components of the Lorenz energy cycle and regional power spectra, as well as more synoptic-scale assessments using quantitative methods and subjective analysis by scientists and operational meteorologists. The upgraded model sustains deeper extra-tropical cyclones, stronger jet-level winds and sharper gradients in synoptic-scale features. This improves the evolution of these features through the forecast by maintaining their intensity with increasing forecast range, rather than smoothing them as happens with the previous dynamical core. This is achieved without degrading more traditional NWP scores, which tend to penalise such increases in variability.

Keywords: Dynamics, NWP, Upgrade, Variability
Poster Session

SCI-POT1172 - Evaporative moisture sources of the diabatically produced parts of cyclones' PV towers

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The development of extratropical cyclones can be seen as an interplay of three positive potential vorticity (PV) anomalies: an upper-level stratospheric intrusion, low-tropospheric diabatically produced PV, and a warm anomaly at the surface acting as a surrogate PV anomaly. In the mature stage they become vertically aligned and form a “PV tower” associated with strong cyclonic circulation. Several studies showed that the diabatic part of the tower is a very important ingredient of extremely strong cyclones. In this study, we identified evaporative sources of moisture that was involved in PV production through condensation in cyclones in the Northern Hemisphere using Lagrangian backward trajectories. The main contribution from surface evaporation to the specific humidity of the trajectories is collected 12-72 hours prior to the time of PV production. The cyclones in the eastern part of the oceans collect their moisture over a much larger area than those in the western parts. The uptake region for weaker cyclones with less PV in the centre is typically more localized with reduced uptake values compared to intense cyclones. However, in a qualitative sense uptakes and other variables along single trajectories do not vary much between cyclones of different intensity in different regions.

Keywords: potential vorticity, moisture sources, Lagrangian trajectories
Poster Session

SCI-POT1176 - Impact of the inflow moisture on the evolution of a Warm Conveyor Belt

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During a THORPEX-PARC (Pacific Asian Regional Campaign) aircraft mission that was conducted east of Japan on 19 September 2008 the humidity structure in the inflow of a Warm Conveyor Belt (WCB) was observed by a high resolution Differential Absorption Lidar. The comparison of observed humidity profiles with ECMWF analysis fields showed an overestimation of the low level moisture content. To investigate the sensitivity of the forecast of the cyclone, the associated WCB and the downstream weather evolution to the diagnosed uncertainty of the moisture fields, the water vapour profiles were assimilated into the European Centre for Medium Range Weather Forecasts (ECMWF) Integrated Forecasting System (IFS). In this way the inflow moisture humidity in the analysis could be corrected. Two ECMWF model runs are compared which are initialized from the operational observations and the analysis with additionally assimilated high resolution lidar water vapour observations. The reduced transport of moisture into the WCB affected the latent heat release along the WCB as well as the PV production at lower levels which subsequently caused a lower WCB outflow height and a reduced tropopause height. This led to a weaker ridge building and reduced jet stream wind speeds downstream. Comparisons with the operational analysis show that the better representation of the initial humidity field in the inflow region leads to an improvement of the forecast. Although the impact on the developing surface cyclone was small, improvements of the PV structure as well as of the kinetic energy could be identified.

Keywords: T-PARC, differential absorption lidar, data assimilation
SCl-POT1180 - Identification of extreme precipitation threat across midlatitude regions

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The most severe thunderstorms, producing extreme precipitation, occur over subtropical and midlatitude regions. Atmospheric conditions conducive to organized, intense thunderstorms commonly involve the coupling of a low-level jet (LLJ) with a synoptic short wave. The midlatitude synoptic activity is frequently modulated by the circumglobal teleconnection (CGT), in which meridional gradients of the jet stream act as a guide for short Rossby waves. Previous research has linked extreme precipitation events with either the CGT or the LLJ but has not linked the two circulation features together. In this study, a circulation-based index was developed by combining (a) the degree of the CGT and LLJ coupling, (b) the extent to which this CGT-LLJ coupling connects to regional precipitation and (c) the spatial correspondence with the CGT (short wave) trending pattern over the recent 32 years (1979–2010). Four modern-era global reanalyses, in conjunction with four gridded precipitation data sets, were utilized to minimize spurious trends. The results are suggestive of a link between the CGT/LLJ trends and several recent extreme precipitation events, including those leading to the 2008 Midwest flood in U.S., the 2011 tornado outbreaks in southeastern U.S., the 2010 Queensland flood in northeastern Australia, and to the opposite side the 2012 central U.S. drought. Moreover, an analysis of three Coupled Model Intercomparison Project Phase 5 models from the historical experiments points to the role of greenhouse gases in forming the CGT trends during the warm season.


Keywords: Arctic warming, extreme precipitation, Circumglobal teleconnection, prediction
Poster Session

SCI-POT1184 - Identifying U.S. Post THORPEX Research Initiatives

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The US THORPEX Science Steering Committee is planning to conduct a workshop in June, 2014, with a
goal to identify research projects and themes that map well onto the three WMO international THORPEX
legacy projects, US agency programs and interests, as well as US academic community research
initiatives and emerging research interests. Outcomes of this workshop will be presented in this
presentation.

Keywords: US research initiatives, workshop
The predictability of intra-seasonal characteristics over the all-year rainfall region of South Africa (bounded by 35°S-33°S and 21°E-27°E) are assessed by utilizing an ensemble of simulations performed by the atmosphere-ocean coupled model administered by the UK Met Office. Hindcasts of 14 austral spring (September-October-November (SON)) seasons of which each is initialized in August are used to assess the model's ability to capture archetypical daily sea-level pressure (SLP) circulation as represented in reanalysis data. SON is within the South African context an important season as it is during this season that the highest rainfall totals occur over the all-year rainfall region while it is also during SON that the onset of rainfall over the summer rainfall region occur. In this research, the focus is on the all-year rainfall region of South Africa as this region has traditionally not received sufficient attention with regards to the skill of seasonal forecasts. This may be partially attributed to most of South Africa being a summer rainfall region with a well-pronounced El Niño Southern Oscillation (ENSO) signal. The ability of the model to skillfully predict intra-seasonal variability during SON is evaluated. This is accomplished through the objective evaluation of synoptic types as simulated by the model that occur over the region, using self-organising maps (SOMs). The predictability of rain-producing systems such as ridging high pressure systems and tropical-temperate linkages during SON is presented.

**Keywords:** predictability, intra-seasonal, self-organising maps, South Africa
SCI-POT1191 - Double ENSO signatures in the northern extratropical troposphere and stratosphere

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The cross-correlation between El Niño/Southern Oscillation (ENSO) signals in the tropical Pacific and atmospheric anomalies in the Northern Hemisphere (NH) is analyzed. It is shown that there are two related and distinguishable ENSO signatures in the NH extratropical atmosphere. The principal signature is the well-known ENSO-induced tropospheric planetary wave pattern across the Pacific/North American section in the winter season, which also propagates upward and strongly modifies the polar vortex when the anomalous wave breaks in the stratosphere. The anomalous forces induced by the wave breaking insert a secondary ENSO signature in the Brewer-Dobson circulation that pumps air upward from the tropical lower stratosphere and pushes it poleward and downward into the extratropical troposphere. The associated atmospheric anomalies first appear in the tropical stratosphere around the globe in the winter season. The anomalous ring gradually shrinks poleward through the following spring and collapses into the stratospheric polar cap in the following summer. This secondary ENSO signature then propagates downward to form a noticeable tropospheric wave pattern across the North Atlantic and the Eurasian Continent in the following late summer/early autumn. Both signatures can be considered as delayed responses to the tropical ENSO signals in the previous summer and autumn seasons. Their applications in seasonal prediction are discussed.

Keywords: ENSO-induced planetary wave, Polar vortex, Stratospheric wave breaking, Brewer-Dobson circulation
Poster Session

SCI-POT1204 - Seasonal prediction of the Indonesian precipitation in the NCEP Climate Forecast System using WRFv3.5.1

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This research focuses on the seasonal prediction of the Indonesian precipitation in the NCEP Climate Forecast System (CFS). The CFS, the fully coupled ocean-land-atmosphere dynamical seasonal prediction system, which became operational at NCEP in August 2004. The prediction have been performed using one lateral boundary forcing CFS from the National Centers for Environmental Prediction (NCEP), at 25 km horizontal resolution for the whole archipelago and focuses mainly on the period December-January-February 2014 for three months. The Weather Research and Forecasting (WRFv3.5.1) has been used to research for seasonal prediction at Research and Development Center, the Indonesian Agency for Meteorology Climatology and Geophysics (BMKG). The model’s performance in seasonal prediction over Indonesia region was evaluated against the monthly Tropical Rainfall Measuring Mission (TRMM) Multisatellite Precipitation Analysis 3B43 product (1998-2012) and rain gauge station data. The results show, WRFv3.5.1, in general, reproduces the spatial pattern of monthly over land areas but overestimated the rainfall over sea. The results show that high specific between the results of observations TRMM3b43 with the prediction results. The highest suitability is achieved when comparing between models with observations in Grell 3D Scheme (cumulus convection).


Keywords: Seasonal prediction, NCEP Climate Forecast System, TRMM3B43, WRFv3.5.1
SCI-POT1210 - Extended-Range (~1-35 day) Forecasts of Convective Variability for the North Australian Monsoon region

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We examine extended-range (~1-35 day) predictions of area-averaged convection over northern Australia with the Bureau of Meteorology’s Predictive Ocean-Atmosphere Model for Australia (POAMA). Previous work has shown that the Madden-Julian Oscillation (MJO) is well forecast by POAMA to a lead of ~3 weeks. However, the global scale MJO does not necessarily reflect local conditions in the monsoons, so here we consider the prediction of a more local index of convection. Hindcasts with an ensemble of 33 members have been performed for the period 1980-2010, initialised on the 1st, 11th and 21st of each month. The measure of convection we use is outgoing longwave radiation (OLR) averaged over the box 120\textdegree E-150\textdegree E, 5\textdegree S-17.5\textdegree S. This averaging serves to focus on the intraseasonal and longer time scales, and is an area of interest to forecasters. The POAMA hindcasts of daily OLR show a strong systematic adjustment away from their initial values during the first week, and then converge to a mean seasonal cycle of similar amplitude and phase to observations. Hence, forecast OLR anomalies are formed by removing the model’s own seasonal cycle of OLR, which is a function of start time and lead time. Skill is assessed against both climatology and persistence. Over all hindcasts, POAMA beats climatology out to a lead of at least 35 days, and beats persistence at all lead times beyond 2 days. Similar results are found for just those hindcasts beginning in the "wet season" months from December through to March, when the greatest variability in convection occurs.

Keywords: Extended-range, forecasts, prediction, monsoon
SCI-POT1212 - Prediction of tropical cyclone frequency in the Global Seasonal Forecasting System, Korea

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Tropical cyclones are a type of natural disaster bringing violent weather such as very strong winds, heavy thunderstorms and torrential rain. The combined effects of increasing population, urbanization and the occurrence of tropical cyclones have caused a marked rise in human and economic damage to many coastal areas. Therefore, it is of great interest of scientific and societal importance, to understand how TC frequency and intensity would change due to the climate change. In this study, we used Global Seasonal forecasting system (GloSea) for seasonal forecast of TC-like vortex disturbances. GloSea is the dynamical coupled ocean-atmosphere global seasonal prediction system at UKMO. The dataset used in this study is the experimental hindcasts using GloSea4 for 14 years (1996-2009). Hindcasts are initialized from the ERAinterim reanalysis. Three hindcast ensemble runs are initiated at fixed calendar dates - 1st, 9th, 17th and 25th – for each month and integrated up to 7 months. Horizontal resolution of the GloSea model is not sufficient to simulate the detailed structure of tropical storms, however, the larger-scale features are sufficiently realistic using a parametric approach. The methodology used to track tropical storms will be briefly introduced, and the skill of dynamical prediction systems will be compared with that of observation, focussing on predictions for the North-East Pacific sector.

\textbf{Keywords:} Tropical Cyclone, Global Seasonal Forecasting System, TC frequency
Poster Session

SCI-POT1215 - The new JMA's one-month ensemble prediction system and its performance

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The Japan Meteorological Agency (JMA) updated its One-month Ensemble Prediction System (One-month EPS) in March 2014. Major changes include as follows: 1) increasing horizontal resolution of atmospheric general circulation model (AGCM) from TL159 (110km) to TL319 (55km); 2) using “Merged satellite and in situ data Global Daily Sea Surface Temperatures (MGDSST; Kurihara et al., 2006)” and its sea ice concentration data with higher resolution (0.25 x 0.25 degrees) than the current SST and ice data (COBE-SST; 1.0 x 1.0 degrees; Ishii et al., 2005) to calculate prescribed boundary condition; 3) applying initial anomalies of sea ice distribution to calculate prescribed boundary condition of sea ice. Performance of the new EPS is evaluated using hindcast (re-forecast) experiments conducted using the same EPS for the 30-year period from 1981 to 2010. Atmospheric and land initial conditions for the experiments are provided from the Japanese 55-year Reanalysis (JRA-55; Ebita et al., 2011) which is the new advanced reanalysis data produced by JMA. Results from the experiments indicate improved reproducibility of the model climate and a significant improvement for the forecast skills, especially in the extra-tropics. And we expect that the new EPS improve predictability of atmospheric phenomena. More detailed information about the new JMA’s One-month EPS and its performance will be presented.

Keywords: subseasonal prediction, atmospheric general circulation model
As intraseasonal predictions of atmospheric circulation improve, particularly in the 14-day+ window, statistical relationships between the leading modes of low-frequency variability that are well-described by variability in atmospheric circulation, and weather phenomena that operate on shorter time scales, become increasingly more valuable. Already several of these cross-scale relationships have been explored, such as the variability of severe convective storms, which are mesoscale phenomena, and the leading mode of tropical intraseasonal variability, the Madden-Julian Oscillation (MJO). In this present study, these relationships are further examined, with particular attention to regional variability of the primary hazards of severe convective storms in the U.S., namely tornadoes, hail, strong wind, and flash flooding, by phase of the MJO. To frame this variability in a physical context, anomalies of upper-level circulation, surface temperature and dew point temperature, instability, wind shear, and total precipitable water are examined. These statistical relationships provide another important step toward extended-range prediction of extreme weather.

**Keywords:** Intraseasonal variability, Severe convective storms, Tornadoes and hail, Madden-Julian Oscillation
Poster Session

SCI-POT1230 - Synoptic-scale patterns producing cold spells in Central Europe

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The understanding of the relationship between weather-related hazards and circulation is a challenging issue and is a precondition for successful forecast. There is a close relationship between air temperature extremes recorded by surface observations and synoptic-scale meteorological patterns in free atmosphere. A common feature of the patterns is the occurrence of anomalies in temperature characteristics. Nevertheless, the patterns also differ in other attributes determined particularly by the configuration of the wind field. The presented study focuses on cold spells in Central Europe and aims at distinguishing main variants of the patterns using a methodology which makes a quantitative comparison of the events possible. First, we compile the most significant cold spells that occurred in the Czech Republic in the last 50 years. We apply a selection criterion based on the minimum daily temperature. The criterion takes into account the rarity using return periods, the affected area and duration. Second, we employ meteorological re-analyses to evaluate synoptic-scale conditions in free atmosphere during the events. We prove that the events are characterized by the regular occurrence of thermo-dynamic anomalies which vary in terms of their strength, location and duration. Finally, we carry out the cluster analysis of the events. We employ varying attributes of the anomalies as similarity criteria. Variants of synoptic-scale patterns belonging to individual main clusters are introduced and discussed. The research presented in this study is supported by the Czech Science Foundation under the project GACR P209/11/1990.

Keywords: Cold spell, Synoptic-scale pattern, Circulation anomaly, Circulation variant
SCI-POT1232 - Retrieving wind gust information from radar data in Switzerland

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From April to September severe storms regularly affect the Alpine and pre-Alpine region of Switzerland. Heavy precipitation, wind gusts and large hail are the typical characteristics of severe thunderstorms and often cause substantial damage to vehicles, buildings as well as agriculture and forests. They thus represent extremely high costs for insurance companies. Accurate real-time point measurements of wind gusts within Switzerland are available from about 130 weather stations. Due to the high spatial variability of wind gusts they are however of limited use in relation to damages. Estimating wind gusts from Doppler measurements provided by weather radar networks could improve the spatial coverage. With weather radars the 3D development of thunderstorms can be observed in real time with high spatial and temporal resolution. However, the detection of wind gust on a local scale still remains very challenging. Algorithms for wind gust detection which use low-level wind shear derived from radar data have been developed for flat topographic areas. For regions with complex terrain, like the Alpine region, more research and adaptations should be carried out in order to increase the skill of such algorithms. It is therefore of high interest to develop such an algorithm, which provides an approximation of wind gusts from the dual-polarisation Doppler radar data of the available radars in Switzerland. Together with the project presentation, first detailed analyses of wind characteristics of a set of severe storms detected within 10-50km from the radar sites during the convective seasons 2012 and 2013, are presented.

Keywords: radar, wind gusts, severe storms, radar algorithm
Poster Session

SCI-POT1235 - Towards a new chain of models to forecast snow conditions in the French mountains

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Snowpack modelling in mountainous terrain has been used over the last 20 years to support avalanche hazard and hydrological forecasting. In the French mountains, the meteorological analysis and forecast system SAFRAN has been developed to produce atmospheric forcings for the detailed snowpack model Crocus. SAFRAN outputs are provided at various elevations for geographical areas assumed to be meteorologically homogeneous (massif of typical size 600 km\textsuperscript{2}). Under this assumption, the current system cannot capture the variability of meteorological and snowpack conditions within each massif which limits the spatial resolution of avalanche hazard forecasts. An alternative to SAFRAN forecasts is offered by the numerical weather prediction system AROME which provides operational forecasts at 2.5-km grid spacing over France since December 2008. In this study, we used daily AROME forecasts to drive Crocus and simulate the snowpack evolution at 2.5-km grid spacing over the French Alps during five winters (2009-2014). Results are evaluated against ground-based measurements of snow height and snow water equivalent. They are also compared with outputs from a simulation using forcings from SAFRAN analysis distributed over the same 2.5-km grid. This simulation benefits from the analysis of precipitation made in SAFRAN. Finally, to better represent the variability of snowpack, we carried out simulations for winter 2011-2012 at 500-m grid spacing over the Northern French Alps using forcings provided by an experimental version of AROME at 500-m grid spacing. At this resolution, the evaluation of model results is extended using maps of snow covered areas estimated from optical satellite data.

Keywords: Snowpack modeling, Avalanche hazard forecasting, NWP model output, Mountainous terrain
Poster Session

SCI-POT1237 - Analysis of volcanic eruption of Mt. Sinabung in Indonesia using InSAR and landslide model

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Sinabung volcano in Indonesia is a part of the Pacific Ring of Fire, formed due to the subduction between the Eurasian and the Indo-Australian plate. After about 400-year dormancy, Sinabung volcano erupted on August 29, 2010 and January 4, 2014, recently. We study the surface deformation of Sinabung volcano using ALOS/PALSAR and RADARSAT-2 interferometric synthetic aperture radar (InSAR) images acquired from February 2007 to September 2013. Based on multi-temporal InSAR processing, we can generate the ground surface deformation map due to the 2010 eruption. The inflation is constrained to the top of the volcano. Since the 2010 eruption to January 2011, the volcano has subsided for about 3 cm (or about 6 cm/yr). The observed inflation and deflation are modeled with a Mogi and Prolate spheroid source. The source of inflation is located about 0.3 – 1.3 km below sea level directly underneath the crater. Recently, RADARSAT-2 SAR data were applied to new eruption event from September 2013 to January 2014 for frequently eruption during short time period. Landslide model compare to Landsat-7 ETM+ image through supervised classification using GIS technique. We interpret the inflation was due to magma accumulation at a shallow reservoir beneath the Sinabung volcano. The deflation was due to the magma withdrawal from the shallow reservoir during the eruption as well as thermo-elastic compaction of erupted material.

Keywords: Sinabung volcano, InSAR processing, Landslide model, GIS technique
Poster Session

SCI-POT1238 - Application of a fine-scale Aviation Model for Near-term Predictions at the Hong Kong International Airport

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The Hong Kong International Airport (HKIA), one of the busiest in the world, is surrounded by complex terrain. Accurate forecasting of localized weather features so resulted over the airport and its immediate vicinity, which are generally of spatial scales unresolvable by global or even regional numerical weather prediction (NWP) models, is not only of direct concern to efficient airport operations but also contributes to safety during the take-off/landing phase of aircraft. Since late 2013, the Hong Kong Observatory has begun trial operation of a fine-scale Aviation Model (AVM) based on the WRF (Weather Research and Forecast Model) model, providing detailed, hourly-updated forecasts up to 6 – 9 hours ahead for the Pearl River Delta region at horizontal resolution of 600 m and the immediate vicinity of HKIA down to 200 m. This paper presents preliminary performance of the AVM over a variety of weather scenarios including low-level windshear due to sea breeze fronts, terrain-disrupted airflow associated with tropical cyclone passage as well as spring-time significant convection along the South China coast, illustrating the potential value and challenges of sub-kilometer NWP incorporating local observational data in aiding near-term assessment of high-impact weather for both the aviation community and the general public. Plans for future development of the AVM will also be discussed, together with ideas on integration of model output into decision-supporting tools for forecasters’ reference.

Keywords: sub-kilometer, aviation, convection, windshear
Sci-Pot5000 - Estimation of evapotranspiration using Priestley-Taylor and Penman-Monteith Methods for irrigated rice culture in Brazil

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Rice is a grain worldwide consumed and Brazil is one of the main world producers. Evapotranspiration (ET) on flooded rice crops is a key parameter to the management of water consumption. Furthermore ET is a critical regulator during the crop growing stage in addition to other weather conditions. The present study aims to estimate and evaluate different ET methodologies applied to paddy rice cultivation. Meteorological observations including moisture and heat fluxes were collected by a micrometeorological tower installed near the rice plot, located in Paraíso do Sul - RS, Brazil, from July 22, 2003 until July 21, 2004. Rice emerged and grew between November 25th and April 4th of the following year. ET estimates by the Priestley-Taylor method (ET - PT) was compared against ET computed using the Penman-Montelth (ET - PM) methods. In both estimates, heat flux and storage in the soil and paddy water above the ground were considered. Furthermore, ET estimated by both methods was compared against measurements from the Eddy Covariance (ETobs) flux tower. The ET-PT using alpha coefficient = 1.14 had values closer to ETobs (with R² = 0.95; RMSE = 0.44) compared to ET-PM (with R² = 0.89; RMSE = 0.63). These results suggest that the effect of aerodynamic term ET-PM equation can be offset by the constant radiative fraction term (alpha). Therefore, ET-PT method showed more accurate in addition to requiring less parameters when compared to ET-PM, hence this technique seems be a good alternative as a practical approach to be applied for rice paddy cultivation.

Keywords: Evapotranspiration, Rice, Priestley-Taylor, Penman-Monteith
The so-called Cost-Loss approach for the assessment of the economic benefits of weather forecasts is less suitable for assessing the benefits for user groups among which uncertainty about the uptake and utilization of the information is significant. In the Finnish Meteorological Institute (FMI) an approach has been developed which aims to account for these uncertainties by means of decomposition of the information flow ranging from forecast generation to benefit realization, i.e. so-called weather service chain analysis (WCSA; see Perrels et al 2013; Nurmi et al 2013). This approach can be used both in a quantitative and in a qualitative fashion. The qualitative version is meant to support information management and to identify improvement options in each section of the weather service chain. In the quantitative version the product sum of ratings per step (compared to the maximum score) is established. The quantitative version helps to identify those segments of the chain for which improvements will have the highest social-economic pay-off. It also helps to identify actions that raise the leverage of investments in weather forecast improvement. The WSCA method can be embedded in the economic modelling of particular sectors, such as (road) transport (as is done in the EU ToPDAd study; http://www.topdad.eu/). WSCA also incites to develop regular surveying of user groups and weather service use. The poster summarizes the principles of the method and its links to economic models, as well as show results from various applications.


Keywords: socioeconomic benefits, service chain, weather service
**Poster Session**

**UAS-POT3019 – WITHDRAWN - Distribution and sources of respirable particulate matter in central India**

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Particulate matter air pollution, produced primarily by power plants, industry and vehicles is causing short- and long-term cardio respiratory problems such as strokes, heart attacks and cancer. The respirable particulate matter concentration across several Indian cities was found to be several folds higher than the WHO limit. Pollutants of major public health concern include particulate matter, heavy metals, BC, POPs, VOCs, CO, CO₂, NOₓ, SOₓ, O₃, etc. The hazardous air pollutants such as As, Cd, Hg, Pb, etc. can cause serious health effects. The concentration of respirable PM in the indoor and outdoor air of the most industrialized city of central India, Raipur (21.14 oN & 81.38 oE) was measured during winter 2013-14.

The concentration of coarse particulate, PM₁₀ and fine particulate, PM₂.₅ (n=16) in the air was ranged from 107 – 425 and 16 – 305 µg m⁻³ with mean value of 270 and 152 µg m⁻³, respectively. The ratio of [PM₁₀-PM₂.₅]/[PM₂.₅] was ranged from 0.21 – 9.42 with mean value of 1.65. The concentration of the PM₁₀ in the indoor air (n=10) was ranged from 112 – 1332 µg m⁻³ with mean value of 331 µg m⁻³. The I/O ratio was ranged from 0.66 – 13.86 with mean value of 2.64. The emission sources such as cooking, fuming incense materials, mosquito coils, etc. increased remarkably the I/O ratio. The concentration and sources of the metals in the outdoor and indoor environments are discussed.

**Keywords:** Respirable particulate matter, Indoor environment, Central India
Poster Session

UAS-POT3021 - Met Office Global Hazard Map – a GIS Web Map Service for forecasting high-impact weather

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The Global Hazard Map aims to summarise the risk of high-impact weather across the globe over the coming week, currently using ensemble forecasts from MOGREPS-15 and the ECMWF EPS. It is a GIS Web Map Service (WMS) and allows the user to select layers of forecast data up to 7 days ahead. At present forecast layers are available for tropical cyclones, precipitation, snowfall, and wind gust. For precipitation/snowfall/wind gust it currently displays the probability of the 24hr precipitation/snowfall accumulation/maximum wind gust forecast from the ECMWF EPS exceeding the 99th percentile of the ECMWF EPS forecast climatology. For tropical cyclones the multi-model strike probability is displayed and includes both existing storms and those predicted to form during the forecast. Geoprocessing is used to create an “at-a-glance” symbol-based summary map summarising the week ahead, and there is an additional option to underlay population density. The initial research prototype map is now being refined based on user needs and feedback. The current users are Met Office Global Forecasters, but engagement with other potential collaborators in the international humanitarian community would be useful going forward. Additional forecast types, such as extremes of temperature and severe convection diagnostics, are being added, along with further multi-model inputs. Recent geohazards (volcanic eruptions and earthquakes) will also be added, as will additional layers containing vulnerability and exposure information, in order to aid the users in identifying those areas where the greatest impacts are likely to occur.

Keywords: WMS, hazard, vulnerability, high-impact weather
The implementation on characteristics and formation mechanism of weather disasters in Yunnan province

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The major characteristics of weather disasters in Yunnan Province is analyzed by using weather disasters data in the period of 1950-1999, weather disasters in Yunnan Province have characteristics of multi-kinds, high frequency, overlapping, wide distribution, obvious seasonality and regionalization, few disaster formation area and serious accumulated losses. The formation mechanism and occurrence background of weather disasters in Yunnan Province has also discussed. The results show that geographical environment, climate and human activities are main factors to form weather disasters in Yunnan Province. The geographical environment elements to form weather disasters in Yunnan include low latitude plateau, approaching tropical oceans, complicated topographical features, cliffy mountain, few vegetation, concentrated rainfall, complicated geological structure and strong fault actions. The strong or weak monsoon activities and the difference of general atmospheric circulation in winter and summer over Yunnan are the climatic background to form weather disasters. Population increase, excessive wasteland reclamation, denudation forest, serious water and soil erosion are main human factors to intensify weather disasters occurrence frequently and loss seriousness in Yunnan. At last countermeasure of weather disasters prevention and reduction were put forward.


Keywords: weather disasters, geographical environment, climate, human activities
IMGW - PIB is the National Meteorological Service in Poland. For about four years IMGW has actively provided next products to the public through available and popular technologies called the New Media. A weather portal www.Pogodynka.pl was established as well as its mobile version www.m.pogodynka.pl, SMS Alert System, business Meteo B2B portals and weather apps for mobiles. Previous observations made by traditional methods are confronted with those made by amateurs. A major challenge is how to combine professional and amateur (social) observations. IMGW-PIB decided to create mobile apps as the best tool for reaching the public with forecasts and warnings, in particular, new mobile Pogodynka Pro app functionality which provides a weather feedback reported by users. This app is available in the Google Play Store and Apple AppStore. The app is free, but users should report the weather twice daily. New Pogodynka Pro features a simple to use graphical interface for weather reporting via mobile screen. In addition, the app has a "Map" tab, where the user's location can be seen (determined by geolocation) and the area within a radius of 50km from the designated location. On this map appears an information reported by other users on meteorological phenomena occurrence. IMGW-PIB operates an integrated system platform of text messaging and mobile apps to warn the society. While people are in motion, the mobile apps track their position and store information in the central database. Such data is used to send alerts to users who are located in the affected areas.

**Keywords:** Mobile, weather, measurements, communication
Poster Session

UAS-POT3025 - Finnish Meteorological Institute (FMI) open data implementation utilizing Open Geospatial Consortium (OGC) standards

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A new online service for meteorological and oceanographic datasets was built to allow users freely download data as a self-service. New service is part of Finnish implementation of Infrastructure for Spatial Information in European Community (Inspire). Earlier FMI has been actively involved in MetOcean Domain Working Group of the OGC and Inspire Thematic Working Group Atmospheric Conditions and Meteorological Geographical Features. It has been important to ensure coherence in development on these working groups and FMI implementation. FMI’s Open Data implementation consists of three services: Discovery, View and Download. The Discovery service is used to search and discover data sets. The data is described on a high level and also available in machine-readable format. Implementation of the Discovery service was done using GeoNetwork software, which follows Catalog Service for the Web (CSW) standard. The View service is used to view the data in an exemplary manner. In practice it is a Web Map Service (WMS) without a graphical user interface. Implementation of the View service was done using GeoServer software. The Download service is used to download data in a machine-readable format. The interface is done according to WFS 2.0 standard. Standard gives possibility to straightforward interface solution by usage of “Simple Profile”, with pre-defined queries. Implementation of the Download service was done using in-house custom built software. In order to help new developers using FMI data we also provided a Javascript library called MetOLib (available on GitHub) and an animator software as a reference implementation.

Keywords: Open, Data, OGC, Inspire
Poster Session

UAS-POT3026 - The Meteorological Service of Canada's Datamart: open data, open applications

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The Meteorological Service of Canada's Datamart is a public, free and anonymous meteorological data service. Devised as a means to maximise the availability of many generic data products to the greatest number of users while minimizing the associated resource outlay, the Datamart currently serves ten million downloads per day to 500,000 unique users. This makes it one of the most high-traffic public data servers run by the Government of Canada. We shall explore the origin of this success in the context of government services; survey the user community; investigate how the data is used; and discuss how changes are communicated to users.

Keywords: data, open, access, system
Characterizing climate impacts on crop yield is a continued effort aiming at improving the technologies and management strategies of farming, minimizing adverse climate effects and maximizing positive climate effects on yields. South Dakota is one of the major corn producing states in the U.S., however, previous studies of climate effects on corn yield in the state used yields and climate records that were less than a decade and were not specifically on South Dakota. Even though results of those studies pointed to primary meteorological factors influencing corn yields, some questions remain including better adaptation to environmental stresses by newer corn hybrids. In this study, the effect of growing season climate conditions (rainfall, air temperature, solar radiation) on the growth and yield of corn in eastern South Dakota are examined using unique long term (1950-2012) data-set for both corn yield and climate. Other objectives of the study are to quantify the impact of irrigation on corn yield and to develop a relationship between corn yield and Aridity Index (AI). County level corn yields are obtained from the USDA-NASS website and climate data from the South Dakota county weather stations. Preliminary results show positive correlation between corn yield and June, July, August total rainfall both at the long term and decadal scale except for the 90s which showed a negative correlation for almost all the counties.

**Keywords:** Corn yield, Climate variability, Irrigation, Aridity Index
Poster Session

SCI-POW1000 - Projection of the future wave climate changes over the western North Pacific

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This study projected the future ocean wave climate changes based on global climate change scenario using the coupled climate model HadGEM2-AO according to the emission scenarios and using regional wave model. Annual mean significant wave height (SWH) is linked closely to annual mean wind speed during the forthcoming 21st Century. Because annual mean speed decreased in the western North Pacific, annual mean SWH is projected to decrease in the future. The annual mean SWH decreases for the last 30 years of the 21st century relative to the period 1971-2000 are 2~7% for RCP4.5 and 4~11% for RCP8.5, respectively. Also, extreme SWH and wind speed are projected to decrease in the future. In terms of seasonal mean, winter extreme SWH shows similar trend with annual extreme SWH; however, that of summer shows large increasing tendency compared with current climate in the western North Pacific. Therefore, typhoon intensity in the future might be more severe in the future climate.

Keywords: wave climate, climate change scenario, wave model
SCI-POW1002 - Marine cloud brightening: regional applications to the weakening of hurricanes and reduction in coral bleaching.

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This study examines the potential to cool ocean surface waters in regions of hurricane genesis. This would be achieved by seeding, with seawater cloud condensation nuclei (CCN), low-level maritime stratocumulus cloud. Higher cloud droplet density would increase these clouds' reflectivity to incoming sunlight, and possibly their longevity. This approach is a localized application of the Marine Cloud Brightening (MCB) geoengineering technique promoting global cooling. By utilizing a climate ocean/atmosphere coupled model, HadGEM1, we demonstrate that – subject to the resolution of defined but unresolved issues – judicious seeding of maritime stratocumulus clouds might significantly reduce sea surface temperatures (SSTs) in regions where hurricanes develop. Thus artificial seeding may reduce hurricane intensity; but the magnitude of this effect is yet to be determined. Increases in coral bleaching events over the last few decades have been largely caused by rising sea surface temperatures (SST), and continued warming is expected to cause even greater increases through this century. Using the same model to examine the potential of Marine Cloud Brightening to cool oceanic surface waters in three coral reef provinces. Our simulations indicate that under doubled CO2 conditions, the substantial increases in coral bleaching conditions from current values in three reef regions (Caribbean, French Polynesia, and the Great Barrier Reef) were eliminated when MCB was applied, which reduced the SSTs at these sites roughly to their original values. In this study we illustrate how even regional application of MCB can affect the reduce the planetary poleward meridional heat flux.


Keywords: Atmospheric Meridional Heat Flux, Coral Bleaching, Hurricane Amelioration
Poster Session

SCI-POW1013 - Quantitative precipitation estimation by combining observations and a high-resolution numerical weather prediction model with 3DVAR

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Quantitative precipitation estimation and forecasting (QPE and QPF) are among the most challenging tasks in meteorology and are fundamental for many end users as flood forecasting centers or agricultural holdings. This work is part of the Collaborative Research Unit “Catchments As Organized Systems” (CAOS) of the German Research Foundation (www.caos-project.de). The aim is to investigate the potential of combining high-resolution numerical weather prediction and state-of-the-art observations for QPE by means of 3D-variational data assimilation. Key components are the WRF-NOAH-MP modeling system operated on the convection-permitting scale over Central Europe. With different sets of sensitivity studies, an optimal physical configuration has been derived. This model system has been improved by many means with respect to model physics focusing mainly on the surface energy balance closure. In addition, a more sophisticated data set of the soil texture in Europe is applied. WRF-NOAH-MP is operated with a 1-h rapid update cycle and the assimilation of a large set of standard observations is complemented by additional observations such as from French and German radar systems, a European GPS network and radiances and atmospheric motion vectors from different satellite sensors. Selecting a challenging synoptic situation with a frontal passage and post-frontal convective precipitation, the performance of QPE applying numerical weather prediction on two different horizontal resolutions will be demonstrated on the conference. Extension to additional observations and ensemble-based assimilation are planned as future tasks.

Keywords: quantitative precipitation estimation, observations, data assimilation, numerical weather prediction
SCI-POW1015 - Possible effect of land and atmosphere interaction over Mongolia

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Over territory of Mongolia, sharp changes of air temperature and precipitation have been observed in summer season especially since 1990th. Their spatial distribution shows that more intensive increasing of temperature and decreasing of precipitation have been observed in central part of the country compare to other regions. This might be indicated real fact that impacts of the land change affects to the regional weather and climate. Therefore, research study is involved with mechanism of the atmosphere and land cover interaction using regional model, RegCM3, in terms of mesoscale with 30 km grid resolution. The land cover category of the model grid was modified according to possible current land change and summer climate has been simulated for the wet, dry and normal years, and their output is considered and compared to control run. Abnormal condition of precipitation decreasing in central part of Mongolia is reasonably simulated by model and explained by physical mechanism of interaction between atmosphere and land cover change as weakening of west and north-west circulation of the atmosphere, reducing moisture convergence and intensifying of downward motion. Finally, overall study shows that abnormal summer condition over Mongolia is explained by both of global climate warming and regional climate change due to effect of land change, which is explained by feedback mechanism of climate system such as interaction between atmosphere and land.


Keywords: precipitation, interaction, feedback
SCI-POW1030 - The use of the GPI to seed TC-like Vortexes on GEFS

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In a given area, the skill of monthly precipitation forecasts is highly dependent upon the model’s ability to capture the occurrence of heavy precipitation events. During the hurricane season in some regions of North America, tropical cyclones (TC) can contribute up to 50% of their annual precipitation. Thus, missing these extreme weather events can result in a wrong monthly forecast. We examined several cases of TC formation to test the GEFS skill to forecast cyclogenesis regions based on the non-dimensional Genesis Potential Index (GPI). We found that applying GPI to the GEFS outputs provides a useful guidance tool to identify regions of high likelihood of cyclogenesis occurrence several days prior to the TC formation issued by NHC. Given this source of predictability, we seeded a TC-like vortex in a region where the GPI exceeded a given threshold. We tested this approach in the 20-member ensemble of the GEFS and varied the center location in space and time. We computed precipitation mean of the vortex-enhanced GEFS ensemble runs into the monthly forecasted precipitation and compared with corresponding control GEFS runs. We found that the GPI can enhance TC predictions in the GEFS for short lead times. It is limited for longer lead times because the signal diminish considerably compared to sporadic transient fluctuations. This is a step forward in the direction of assessing the contribution of tropical cyclones in sub-seasonal precipitation forecasts over North America.


Keywords: GPI, vortexes, GEFS
SCI-POW1032 - Tracking monsoon low pressure systems in reanalysis and climate model simulations: A new methodology

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The westward propagating synoptic systems popularly known as Low Pressure Systems (LPS) are the main rain bearing systems of the Indian Summer Monsoon (ISM). The systematic bias of the Coupled General Circulation Models (CGCM) in simulating seasonal mean ISM rainfall is often linked to the inability of the models to simulate the correct frequency and propagation of LPS. Here we present a new method to objectively identify and track LPS, which mimics the conventional identification and tracking algorithm based on detecting closed isobars on surface pressure charts, and thereby we can make a fair comparison between the observed and simulated LPS. Our analysis shows that the ERA-interim and MERRA reanalysis were able to reproduce the observed frequency and structure of LPS with a fair degree of accuracy. Further, the newly developed LPS detection and tracking algorithm is applied to the CGCM simulations of the Coupled Model Inter-comparison Project phase five (CMIP5). The simulated LPS characteristics and interannual variability in the historical all forcing simulations are compared with the available observations. The trends in LPS frequency and intensity in various future scenario simulations are explored. The summer monsoon rainfall variability over India and its relationship with the LPS systems in the current and future scenario simulations are also discussed.

**Keywords:** Monsoon, Low Pressure Systems
Poster Session

SCI-POW1034 - The DTC’s Involvement with the HWRF: An Overview of community support, testing and evaluation

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To expedite the transition of research to operations and to aid in the improvement of hurricane models, the Developmental Testbed Center (DTC) provides user support and rigorously tests new experimental configurations of the Community Hurricane Weather Research and Forecasting (HWRF) system. The DTC provides full support for the August 2013 Community version of HWRF (v3.5a), which not only included all of the 2013 operational capabilities, but expansions that made it possible to cover all of the Northern Hemisphere basins, and perform idealized simulations. The code, its documentation, and extensive datasets for the Community release of HWRF can be downloaded from the DTC website (www.dtcenter.org) and, since its original debut in the community, has been made available for more than 700 individual users worldwide. The DTC facilitates HWRF developers from multiple government institutions and universities (e.g. NOAA/NCEP, NOAA/ESRL, UCLA, OU) by providing the infrastructure that makes collaboration and exchanging code more efficient, and allows the DTC to rigorously test new advances in hurricane modeling originating from a variety of sources. This presentation will cover the mechanisms that aid in the transition of research advancements to operations, and the testing activities and procedures at DTC.

Keywords: Hurricane, NWP, Testing, User Support
Poster Session

SCI-POW1035 - The validation of high resolution precipitation reanalyses over Europe within EURO4M project

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This work focuses on the validation of the high resolution surface re-analyses performed within the European Reanalysis and Observation for Monitoring (EURO4M) project. EURO4M has been a collaborative research project under the Seventh Framework Programme, financed by the European Commission, to “develop the capacity for, and deliver the best possible and most complete (gridded) climate change time series and monitoring services covering all of Europe”. As partner in the project, Météo-France has produced surface re-analyses of some essential climate variables at 5.5 km grid on a domain covering Europe. The re-analyses have been derived using MESCAN, an OI based surface analysis system. HIRLAM forecasts initiated from 3D-VAR reanalysis at 22 km grid have been downscaled at 5.5km grid and used as background by the MESCAN OI system together with the available observations. High resolution MESCAN re-analyses of temperature and humidity at 2-m above the ground and daily precipitation are available for the period 2007-2010. The work presents and discusses the results from the indirect validation of the precipitation analysis over Europe and France, using a land surface model SURFEX and a hydrological model. The temporal evolution of the simulated snow characteristics and river flow at the spatial scale of a river basin will be evaluated.

Keyword: re-analysis, high-resolution, Europe,
Poster Session

SCI-POW1036 - Artificial inhomogeneities in the Twentieth Century Reanalysis

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The NOAA Twentieth Century Reanalysis (20CR) Version 2 is the first global atmospheric reanalysis intended for climate studies. It spans the 142-year period from 1871-2012. It has the unique attributes of assimilating only one type of observation (i.e. synoptic surface pressure, while using observed sea surface temperature and sea ice extent for boundary conditions), and documenting the analysis uncertainty (i.e., ensemble spread) at each time integration. In this study, we evaluate its suitability for long-term trend assessment using the Bai-Perron structural change point test. We find that despite assimilating only a single type of observations, a substantial number of large, abrupt shifts persist in the record at varying vertical levels, points in time, and geographic locations. We attribute 72% of the detected shifts to artificial sources based on temporal coincidence with detected breakpoints in the analysis ensemble spread (an estimate of uncertainty). Of the more than 853,376 abrupt shifts detected in 26 variable fields over two monthly time series, approximately 25% exceed 1.8 standard deviations of the preceding time series. Fortunately, a significant fraction of grid points do exist for which the full record is homogenous. And of the inhomogeneous records, often the most modern homogenous segment extends back to a very early date. For example, July 2m air temperature is statistically homogenous (free from non-climate breaks) back to 1942 (1922) for half of all land grids. In this presentation, we will characterize the extent of artificial inhomogeneities in the 20CR on a regional, seasonal, and variable basis.


Keywords: climate trend analysis, inhomogeneities, Twentieth Century Reanalysis, change point detection
Poster Session

SCI-POW1037 - Coupled hindcast shocks and drifts following uncoupled initialisation

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Methods for coupled initialisation of ocean-atmosphere models are currently being actively pursued, but the extent of the benefit that such methods offer over separate, uncoupled initialisation of each model component, and the mechanisms by which these benefits result, are not yet known. We analyse seasonal hindcasts performed with the European Centre for Medium-range Weather Forecasting’s (ECMWF’s) coupled forecast system, with uncoupled initialisation, covering the period 1981-2010, and with a degree of coupling involved in the pre-hindcast analysis. We investigate whether initialisation shocks, occurring due to imbalance in the initial ocean and atmospheric states, degrade the skill of a subseasonal/seasonal hindcast, and how this may be improved by a more balanced initialisation. Near the equator this is closely related to the bias correction method used in the ocean analysis, due to the delicate balance that exists between near-surface winds and the upper ocean horizontal pressure gradient. It is seen that coupled hindcasts rapidly establish this balance if it is not present in the initial conditions, generating waves along the ocean thermocline in the process, though evidence for decreases in skill due to the propagation of these waves seems inconclusive at present. We also look for other regions where uncoupled initialisation may be problematic for forecasting.

Keywords: Coupled data assimilation, Initialisation, Seasonal forecasting
Poster Session

SCI-POW1041 - Initial condition estimation for convective scales using the self-breeding method

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The characteristics of state related uncertainty structures in non-linear systems is strongly dependent on the considered scale. Uncertainty estimates for NWP are commonly generated for the large scale where these structures are connected to global wave patterns. For smaller scales such as the convective scale, variants of the ensemble Kalman filter (EnKF) are the widely-used approaches to generate ensemble initial conditions. However, EnKF methods are not designed to estimate Lyapunov structures which represent the possible regimes of fastest growing errors in a system. The breeding technique represents an approach to assess Lyapunov structures without any assumptions on Gaussianity or linearity as the full non-linear model is used to estimate the leading local Lyapunov vector. However, the method is by design not applicable in limited area models. We therefore introduce the self-breeding technique which is designed to estimate uncertainty structures in a non-linear system at a given time based on the current state only. In addition, an ensemble transform allows for estimating not only one but a set of Lyapunov vectors, thus providing the first N directions of largest error growth with respect to the current state. We further present results from idealized experiments with the Lorenz96 model showing the applicability of the approach to non-linear models in general. We further show case studies with a meso-scale numerical weather prediction model which indicate the ability of the self-breeding cycle to produce reasonable uncertainty structures for convective events in real world scenarios.

Keywords: uncertainty, ensemble, data assimilation, convection
Poster Session

SCI-POW1045 - Inferring on time scale in climate and vegetation dynamic analysis: an entropy-based approach

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The parameter time is critical in dynamic processes of biophysics. Empirically, the appraisal of these dynamic patterns require a minimum time scale. Number of studies conducted on climate and vegetation, employed diverse time scales with less effort of justification. Our study aims to address this gap in biophysics and contribute to the debate on time scale’s choice. We targeted atmospheric variables such as precipitation, temperature and soil moisture as well as a vegetation growth index (NDVI). Inferences on time scales were made through an entropy scaling approach. Particularly, we utilized Tsallis’ entropy and analyzed the goodness of time intervals depending of the variable. At the present stage, the study is still on-going and we are proposing to review and comment on the effects of time scale on the quality of inferences generally made in biophysics.

Keywords: Entropy, time scale, climate, vegetation
Poster Session

SCI-POW1049 - Preliminary investigations on high resolution land data assimilation over CONUS region

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Land surface models (LSM) provide important preliminary condition and feedback in the simulation cycle of earth system models. Data assimilation (DA) brings land observations into the LSM and allows for realistic initializations. There is a known problem of scale mismatch between the LSM grids and observations being employed to DA. Transferring of LSM to higher resolution side of model runs is an option to improve DA features and preserve the heterogeneous details provided by high-resolution observational data and networks. High resolution LSM also provides a better opportunity to evolve LSM into a full-fledged hydrological analysis and utilize improved atmospheric forcing. We have conducted 1-km Noah model runs using Noah 2.7.1 and Noah 3.3 over CONUS region. Noah 3.3 model results have noticeable differences from the Noah2.7.1 (currently operational) primarily due to enhanced LAI parameterization scheme and model improvements. We will also present the usefulness of high-resolution runs in providing drought assessments and model initialization feedbacks.

Keywords: Noah model, CONUS 1-km, LIS
For quite sometime now the Goddard Earth Observing System (GEOS) general circulation model has been using aerosols from the Global Ozone Chemistry Aerosol Radiation and Transport (GOCART) to interact with its radiation physics component (Colarco et al. 2010). More recently, a two-dimensional physical-space analysis of aerosol optical depth assimilates AQUA and TERRA MODIS observations allowing for real-time, three-hourly, improved GOCART aerosols. At present, the fifteen GOCART aerosol tracers are not felt by the underlying GEOS atmospheric analysis system (the Grid-point Statistical Analysis; GSI: Kleist et al. 2010). We have enabled GSI to take the influence of aerosols into its observation operator, and the corresponding Community Radiative Transfer Model (CRTM; Kleespies et al. 2004). Some preliminary studies in the GEOS data assimilation system have shown mild, but noticeable, improvement in temperature fields over large pockets of dust storms when the observation operator calculations related to infrared channels, such as those from, say, HIRS and AIRS, are allowed to feel the effect of the background aerosols. This work will show results from expanding our preliminary studies and provide a more complete assessment of the impact of explicitly accounting for aerosols in the assimilation of all infrared channels currently used in GSI, including those from IASI instruments.


Keywords: GEOS, 3D-Var, Aerosols
Poster Session

SCI-POW1054 - IASI static bias correction at KIAPS observation processing system

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Radiance bias correction for satellite data is essential for better performance of a data assimilation system. The IASI bias correction scheme at Korea Institute of Atmospheric Prediction Systems (KIAPS) is a static method adapted from the Harris and Kelly (2001) algorithm that uses the difference of observed and simulated TBs (i.e., innovation or O-B). This scheme consists of a scan-angle component and an air-mass dependent component. The scan bias is the monthly averages of O-B TBs for each scan position subtracted by each channel mean. Most scan biases are symmetric for the scan positions. Distinct ripple marks appear along the IASI scan positions due to irregular patterns of the viewing angles. For the high peaking channels, the scan biases increase as the scan position is getting far from the nadir. On the other hand, the scan biases show an opposite pattern for the low peaking channels. The air-mass bias is parameterized by two thicknesses, i.e. 850-300 hPa, and 200-50 hPa, based on the NWP model. The slopes of the predictors and global offsets are generated by a multiple linear regression, trained on a representative sample of scan corrected O-B TBs. While the slopes of each thickness are negative values in the high peaking temperature sounding channels, they are positive for the water vapor channels. For the low peaking and window channels, the slopes are near zero and the correlation is less than 0.2, because the O-B TBs of these channels do not depend on thickness.

Keywords: IASI, bias correction, KIAPS
Poster Session

SCI-POW1057 - Correcting evapotranspiration using Eddy Covariance Method over the Korean Peninsula

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The eddy covariance method has been widely used to quantify evapotranspiration. However, independent measurements of energy components such as latent heat flux, sensible heat flux often lead to under-measurements, this is commonly known as a lack of closure of the surface energy balance. In response to this methodological problem, this study is addressed specifically to correction of the latent and heat sensible fluxes. The energy components observed in agricultural and grassland from Mar. 2013 were measured using the eddy covariance method. As a result of the comparison of the available energy (Rn-G) with the sum of the latent and sensible heat fluxes, R-Squared values were 0.72 in the agricultural land, 0.78 in the grassland, indicating that the latent and sensible heat fluxes were under-measured. The obtained latent and sensible heat fluxes were then modified using the Bowen-ratio closure method. After this correction process, the values of the sum of the latent and sensible heat fluxes have increased by 39.7 percent in the agricultural land, 32.2 percent in the grassland respectively. Evapotranspiration will be calculated with both the unmodified and modified latent heat flux values, the results will be then thoroughly compared. The results will be finally verified by comparison with evapotranspiration obtained from energy balance based model.

**Keywords:** Eddy Covariance, Evapotranspiration, Energy balance
SCI-POW1063 - Evaluation of Vaisala RS92 radiosonde water vapor dry bias correction algorithms

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Vaisala RS92 radiosondes are the most widely used radiosondes in the world. Radiosonde data provides one of the most extensive records of water vapor data to atmospheric scientists worldwide for a host of applications including global climate modeling. Radiosonde water vapor measurements (e.g. relative humidity) are long known to have a water vapor dry bias due to solar radiative heating. This research evaluates two Vaisala RS92 solar radiation dry bias (SRDB) correction algorithms, Wang et al., 2013 and Miloshevich et al., 2009, and attempts to determine if one algorithm performs better than the other. Both algorithms correct the relative humidity measured by the radiosonde. Data for this research comes from three distinct climate locations operated by the Atmospheric Radiation Measurements (ARM) program: the Southern Great Plains (SGP), Tropical Western Pacific (TWP) and North Slope Alaska (NSA). Each correction algorithm’s effectiveness is evaluated against two collocated ground-based instruments: a microwave radiometer and a Raman lidar. When comparing precipitable water vapor between the microwave radiometer and corrected sonde profiles, the results suggest an approximately equal correction in the mean sense. Mixing ratio profiles between the Raman lidar and corrected sonde profiles show that the Miloshevich (2009) correction better corrects the mean bias. When compared against each other, the profiles are similar in the lower troposphere but differ significantly in the upper-troposphere. Further research is currently being done to determine which correction algorithm best agrees with satellite-measured upper-tropospheric water vapor data and if the other correction algorithm is statistically significant.

Keywords: Radiosonde, Climate, Vaisala, Dry-bias
Numerous studies have found that incorporating flow-dependent background error information into a traditional variational system, through the use of a hybrid ensemble.variational technique in a data assimilation (DA) system, leads to positive impacts on weather forecasts. The Gridpoint Statistical Interpolation (GSI) based hybrid data assimilation system (GSI-hybrid) was primarily developed by the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction (NCEP) and Earth System Research Laboratory (ESRL). It was implemented operationally at NCEP for global applications in May 2012 and for hurricane applications in June 2013. The Developmental Testbed Center (DTC), beginning in late 2011, is supporting the GSI system (including GSI-hybrid) and complementing these implementations and associated research studies through the sponsorship of the NOAA Hurricane Forecast Improvement Project (HFIP). Testing and evaluating the GSI-hybrid system, particularly for Hurricane Weather Research and Forecasting model (HWRF) applications, were performed in collaboration with code developers and researchers, including the ongoing construction of the community code framework for the GSI-hybrid system. This paper will give a brief summary of the DTC data assimilation activities in recent years. These activities include investigating alternative configurations of the GSI-hybrid system and the potential for improvement of the system performance in a tropical storm environment. Highlights will be given of the ongoing work of testing the GSI-hybrid system for inner core data assimilation in 3-km moving nests, using HWRF high-resolution ensembles, and the associated observation impact studies. This paper will conclude with a discussion of lessons learned and potential directions for further studies.

**Keywords:** hybrid data assimilation, tropical cyclone, moving nests, data impacts
SCI-POW1081 - Eddy statistics and their spatio-temporal variability in the Bay of Bengal from satellite altimetry

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The Bay of Bengal (BOB) mesoscale eddies statistical properties and their spatio-temporal variability have been investigated by analyzing nearly 7500 eddies corresponding to 692 eddy tracks from 17-years of satellite altimetry observations using the combination of closed contour method and Okubu-Weiss parameter. The BOB ocean circulation is unique in the world ocean due to the effect of semi-annual reversal monsoon winds and high volume of river discharge which are believed to be the main reasons behind the development of mesoscale eddies on the western part of the BOB along with the generation of the northward flowing Western Boundary Current (WBC) and the southward flowing East India Coastal Current (EICC). The interseasonal and interannual variations in the occurrence, movement and lifecycles of the mesoscale eddy have been revealed using this automated algorithm. Anticyclonic eddies dominated the cyclonic eddies during post monsoon whereas it reverses in the pre monsoon. The effect of El-Nino Southern Oscillation (ENSO) on the eddy genesis has been found as the number of eddies increases during ENSO years. The influence of mesoscale eddies on the weakening and strengthening of the boundary currents have also been investigated in the bay.


Keywords: Eddy, Bay of Bengal, Spatio-temporal variability, ENSO
Poster Session

SCI-POW1082 - Trends of the sea surface temperature and height in the South Atlantic Ocean.

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Nineteen years of sea level anomaly (SLA) and sea surface temperature (SST) data between January 1993 and December 2011 were used to estimate linear and cubic temporal trends for the South Atlantic Ocean, from 10 oS to 60 oS. The linear trends of SLA and SST in the analyzed period are +3.1 mm.year⁻¹ and +0.014 oC.year⁻¹, respectively. This results point out towards a positive spatial pattern over the entire study area. However, when the time series were divided into two distinct time windows (1993-2002 and 2003-2011), the estimated trends presented negative signals at several regions of the South Atlantic. The sum of the estimated trends for both time windows did not correspond to the original trend estimated for the overall period. At many locations the sum of the trends of both time windows were negative. This result suggests that the linearity misrepresent the regional variability of the South Atlantic Ocean and that the trend signal would change during the overall period analyzed here. For better representing this change, a cubic spline fit was calculated for the region and period of this study resulting in a trend of +3.0 mm.year⁻¹ and -0.024 oC.year⁻¹, respectively for SLA and SST. The time when the cubic trend inverted its signal (positive to negative and vice versa – t₁ and t₂) at each particular region of the South Atlantic was estimated from the original SLA and SST series at each location. We observed that at some regions SST and SLA cubic oscillation occurred in phase.

Keywords: trend, SST, SLA, South Atlantic
Designing an efficient seasonal forecasting system is ensuring that the uncertainty in the forecast’s initial conditions is optimally sampled. In this study, using a recently developed method of computing climatically relevant singular vectors, the error growth properties of initial perturbation over South Asian monsoon region are studied. Forecast simulations using CAM4 atmospheric climate model are investigated by examining the growth of perturbations with different lead times. It is found that reliable climatically relevant singular vectors can be estimated by running an ensemble of model forecasts for optimum initialization of monsoon forecast. The amplification of the perturbations occurs for more than 1 month with possibility of up to 6 months. Indian and equatorial Pacific Oceans are identified as regions of growing perturbations. The results show the growth rates of the singular vectors are very sensitive to the variable of perturbation, number of perturbations and the error norm. Further, it is demonstrated that the predictions with the climatically relevant singular vector have a more reliable ensemble spread, suggesting a potential merit for a probabilistic forecast. This analysis potentially informs the design of reliable forecast system by identifying the sensitive regions where small uncertainties in the atmosphere can grow maximally.

**Keywords:** Singular vectors, Monsoon, Models, South Asia
Poster Session

SCI-POW1116 - Recent developments and operational upgrade of JMA Global Spectral Model

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The Japan Meteorological Agency (JMA) has a plan to implement the next version of the Global Spectral Model (GSM) into operation in the near future, in which we will increase the number of vertical levels from sixty to one hundred and raise the model's topmost level from 0.1 hPa to 0.01 hPa. We will also improve the parameterization schemes such as convection, gravity wave, radiation, boundary layer, land surface, and so on for the aim of improving the representation of atmospheric features. This presentation introduces the specification of the next version GSM and the results of the preliminary sensitivity experiments. An overall improvement has been found in the forecasts of the global mean sea level pressure, 500 hPa height, 850/250 hPa vector wind as well as the model performance for tropical cyclones such as tracking forecasts and their existence with the next version GSM.

Keywords: operational upgrade, vertical layers, boundary layer
Poster Session

SCI-POW1117 - The 3D global semi-Lagrangian atmospheric model on the reduced lat-lon grid

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It is well known that the regular latitude-longitude grid on the sphere cannot be used for building a high-resolution global atmospheric model due to meridians convergence. Many centres use (or plan to use) the cubed sphere, icosahedral or Yin-Yang grid. Here we apply the reduced lat-lon grid (i.e. the latitude-longitude grid with variable number of points along each parallel). This grid is used since long ago in spectral models but it seems to be the first time it is used for full 3D model. The algorithm to construct this grid is described in (Fadeev, 2013). The SL-AV (semi-Lagrangian absolute vorticity) model is the global atmospheric model used for operational medium-range and seasonal prediction in Russia. Its dynamical core (Tolstykh, 2001) is based on vorticity-divergence formulation (in horizontal plane) and uses the 4th order finite differences on the unstaggered grid. Parametrizations of subgrid-scale processes are developed by ALADIN/LACE consortium. The reduced lat-lon grid was earlier implemented for the shallow-water model on the sphere in (Tolstykh, Shashkin, JCP 2012). We present first results of real-data forecasts with 3D version of the SL-AV model on the reduced grid.

Keywords: global atmospheric model, grids on the sphere
This research verified the output temperature prediction model WRF-EMS to the surface temperature observation data of 70 selected observation stations in all regions of Indonesia. Input for the initial and boundary condition used for the operator of WRF is the outcome of the Global Forecasting System (GFS) at 12 UTC. Spatial resolution of the model output is 25 km, and temporal resolution is 1 hour. GFS global domain temporal length is 72 hours forecast. Verification on WRF Model Performa done in a monsoonal period. WRF prediction is a prediction that evaluated the day one and the prediction of the day two. For variable temperature verification is done based on the value of the correlation and mean bias or error. In areas located on small islands showed low correlation values, with low bias and showed better results on the prediction of day one compared with the predictions of day two. For other areas generally showed higher correlation values and showed better results on the prediction of the day one compared with the predictions of the day two with the bias depending on local topography. This research shows that a numerical model, with a horizontal resolution of 25 km, is not able to realistically simulate the near-surface climate for the small island area. For the next improvement of this study, we plan to run much higher resolution and expectedly come up with a better correlation between surface temperature predicted from the model and from the observation data.


Keywords: WRF-EMS, Verification, Temperature Prediction
Poster Session

SCI-POW1122 – Reframe NCEP GEFS Initialization

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The NCEP Global Ensemble Forecast System (GEFS) uses the ensemble transform technique (ET), which is an improved version of the breeding-vector technique (BV-ETR), to perturb initial conditions. The ET technique transforms forecast perturbations to being orthogonal in the inverse analysis error variance norm. The ensemble variance is maintained in as many directions as possible within the ensemble subspace. EnKF brought into NCEP data assimilation system in 2012. A comprehensive study has been completed to compare the initial perturbations of operational BV-ETR and EnKF analyses (and 6-hr forecast). There is an advantage to use EnKF analyses for better representing the distribution of initial uncertainties, but will lost the continuation of flow dependence due to assimilation cycling, such as frontal system, ocean swell and et al. Another disadvantage of EnKF is extra unrealistic uncertainty which degrades the ensemble mean forecast especially over southern hemisphere. In order to take advantages of exist BV-ETR technique and EnKF analysis, a new formula of GEFS initialization has been constructed through optimum application of ETR applied to EnKF 6-hr perturbations, and improved tropical storm relocation (ITSR). This initialization will simulate the effect from observation by rescaling nonlinear growing perturbations through model integration; will guarantee a reasonable perturbation sizes and reliable perturbation distributions in space. To apply this new formation with higher resolution semi-Lagrangian model, a preliminary result indicates that the new initialization improves short-range forecast reliability, and other forecast skill as well.

Keywords: GEFS, Ensemble forecast, EnKF
Poster Session

SCI-POW1126 - Comparison of PEARP with different TIGGE Ensemble Prediction Systems at short range

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PEARP (Prévision d'Ensemble ARPEGE) is the Météo-France global short-range Ensemble Prediction System (EPS). PEARP uses the ARPEGE model which has a varying horizontal resolution. This allows to produce, in a single EPS, high resolution probabilistic forecasts over Western Europe as well as ensemble products for tropical cyclone tracks over the Tropical Atlantic area and Indian Ocean as well. Initial uncertainties are represented by coupling a small Ensemble Data Assimilation System (named AEARP) with singular vectors technique. A multi-physics approach is used to represent model error.  
Up to date, most of the comparisons of global EPS have focused on medium ranges. Using the TIGGE database, the goal of this work is to compare PEARP with four other global EPS focusing on short-range forecasts. Results based on classical probabilistic scores are shown.


Keywords: ensemble prediction, multi-physics, ensemble data assimilation
Poster Session

SCI-POW1128 - Development of a Météo-France ensemble reforecast dataset.

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A 32-year ensemble reforecast database has recently been developed at Météo-France that allows to create the model climate. The reforecast dataset consists of a 10-member ensemble run once every 4 days at 1800 UTC up to 4.5 days. The same resolution as in the operational Météo-France ensemble forecast system is used (T538L65 ~15km grid spacing over France, 65 levels). While the atmospheric and sea surface states are both initialized from ERA-interim atmospheric fields, the land surface state is initialized from offline SURFEX simulations. SURFEX is the Météo-France land surface model that has been driven by 6-hourly near-surface atmospheric fields from the ERA-interim reanalysis in order to provide land surface initial conditions to the ensemble reforecast (or hindcast) dataset. In this study, the forecast skill of this ensemble reforecast is evaluated and compared to the forecast skill of hindcasts using a land surface initialization from ERA-interim. These two types of hindcasts differ from the data used for the land surface initialization only. Overall, the results show that the use of SURFEX simulations allows one to improve the quality of hindcasts. The ultimate goal of this ensemble reforecast database is to build a climatology of the operational ensemble prediction system of Météo-France, which, in turn, will help better forecasting extreme weather events.

Keywords: ensemble prediction system, reforecast
Poster Session

SCI-POW1130 - Early warning products for severe weather events using operational medium-range ensemble forecasts

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Severe weather events have socio-economic impacts on humanity. An accurate prediction of extreme weather events is important for the benefit of society, the economy and the environment. We introduce a prototype of ensemble-based early-warning products for extreme weather events, quasi-operationally available at http://tparc.mri-jma.go.jp/TIGGE/tigge_extreme_prob.html. The early-warning products are based on operational medium-range ensemble forecasts from four of the leading global NWP centres: ECMWF, JMA, UK Met Office and NCEP, available at the TIGGE database with a 2-day delay as part of the THORPEX research programme. Forecast probabilities of the occurrence of extreme weather events including heavy rainfall, strong surface wind, and extreme high/low surface temperatures, is measured by the fraction of ensemble members that predict higher or lower values than each model’s climatological percentile (e.g. 99th percentile) to ensemble size. In a similar way, forecast probabilities by multi-centre grand ensemble consisting of these centres also can be defined. Several case studies to demonstrate the capability of the products will be shown in the poster presentation. The construction of a grand ensemble can improve the forecast reliability regarding probabilistic forecasts for extreme weather events, up to a lead time of +360 hr, especially for strong winds. The grand ensemble can provide more reliable forecasts than single-centre ensembles, although the grand ensemble is still overconfident, especially after the lead times of +216 hr. Thus, the early-warning products can be a useful tool to reliably detect extreme weather events and to avoid catastrophic damages in advance, especially for developing countries.

Keywords: early warning, severe weather events, ensemble forecasts, TIGGE
The present paradigm for constructing initial conditions (ICs) from which the different ensemble members of an ensemble prediction system (EPS) starts contains the following crucial features: (1) a control analysis is assumed to be the uniquely best estimate of the IC, (2) an ensemble member is defined as a perturbation to the control analysis, (3) the sum of all ensemble perturbations add up to zero, that is, they are centered around the control analysis. An analysis of the consequences that follows from the usage of this paradigm is presented. The most important result is that a substantial under-dispersiveness of the EPS thereby is created, which is not only undesirable but also unnecessary. Arguments are presented in favor of an alternative EPS which instead is initialized with ICs that are equally likely to be the truth AND which have the same quality as the control analysis.

**Keyword:** Ensemble prediction system,
Poster Session

SCI-POW1135 - Sensitivity to CMT and entrainment/detrainment in the convective schemes of the Canadian NWP model

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A project focused on improving the forecast of clouds and precipitation from the Canadian operational numerical weather prediction (NWP) models has recently been launched. To achieve this, several aspects of the model physics will be revised and improved. This presentation will focus on the convective schemes. Most Canadian NWP models, i.e the global deterministic (25km), the regional deterministic (10km) as well as the global and regional ensembles use the original Kain-Fritsch deep convection parameterization without convective momentum transport (CMT). In the last decade, based mostly on Large Eddy Simulations, it has been recognized that entrainment and detrainment are key processes to properly represent the effects of deep and shallow convection on the large scale environment. Several new parameterizations of these processes have been proposed in recent literature and successfully implemented in NWP models. Furthermore, an examination of convective schemes used in other operational centers showed that most centers represent CMT both in their deep and shallow convective schemes. However, several centers have had to solve problems related to excessive tendencies on winds in the anvil region. This presentation will show the meteorological impact of including CMT in the deep and shallow convection schemes. Tests are done in the context of series of 5day runs with the global NWP model. The impacts on tropical cyclones is also being closely examined. These initial tests have been promising except for negative impacts in the wind field of the upper troposphere. New formulations of entrainment and detrainment will be tested and discussed.

Keywords: convection, momentum transport, NWP
Poster Session

SCI-POW1137 - A sensitivity study on the effects of entrainment and detrainment in moist convection

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Several previous studies have shown that global model simulations are very sensitive to parameterized entrainment and detrainment processes in moist convection which are still uncertain. In this study, we investigate the sensitivity of simulated clouds and precipitation to the parameterization of entrainment and detrainment processes in moist convection using the initial version of Korea Institute of Atmospheric Prediction Systems-Global Model (KIAPS-GM). The model uses a mass-flux convection parameterization based on the simplified Arakawa-Schubert scheme (Pan and Wu, 1995) to represent the thermodynamic and dynamic effects of sub-grid scale moist convection. The entrainment rate for deep convection is determined as a function of environmental humidity following Bechtold et al. (2008), and the detrainment rate is assumed to be constant with the value of the entrainment rate at the cloud base. Different entrainment and detrainment parameterizations proposed recently based on the results from cloud-resolving model simulations are evaluated and their sensitivity to key control parameters is investigated. For example, the entrainment formulation that accounts for the dependence on the lifting condensation level or the boundary layer depth for land points (Stratton and Stirling, 2012) is applied in the deep convection scheme and its impacts on the simulation results are examined, particularly focusing on the changes in the diurnal cycle of deep convection over land. Detailed results will be presented at the conference.

Keywords: entrainment and detrainment, mass-flux convection parameterization
SCI-POW139 - Introduction of a non-orographic gravity wave forcing parameterization to the JMA Global Spectral Model

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A non-orographic gravity wave forcing parameterization which expresses sub-grid scale momentum transport is introduced to a new version of the Japan Meteorological Agency Global Spectral Model (GSM) which has been in operation since March 2014. The model extends its model lid from 0.1hPa to 0.01Pa and implements various improved physical parameterizations. Among these model improvements, this presentation focuses on an introduction of a non-orographic gravity wave forcing parameterization to the forecast model and its impact on the middle atmosphere climate and medium range forecasts. Model climate in the new version of GSM shows more realistic temperature and zonal wind structure in the middle atmosphere compared to the previous model which uses Rayleigh friction. In addition, the new version of GSM improves tropical variability such as quasi-biennial oscillation in the tropical lower stratosphere. However its period is shorter and amplitude is weaker than reanalyses, so a further optimization will be needed. Experiments in the operational NWP configuration show significant reduction of wind and temperature biases in the middle atmosphere. Verification results in the troposphere are almost neutral for the short-range and slightly positive for the medium-range forecasts.

Keywords: operational model, gravity wave, parameterization, nwp
Poster Session

SCI-POW1141 - Development of the boundary layer parameterization module in KIAPS-GM

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Two parameterization schemes for planetary boundary layer (PBL) processes are implemented to build a Physics Package (PPACK) for the Korea Institute of Atmospheric Prediction Systems - Global Model (KIAPS-GM). A non-local K profile method and a total energy – mass flux schemes has been selected for the current version of the PPACK. Off-line and on-line test simulations are conducted using two PBL schemes and the performances are investigated to check the general function in the physics package. Here we focus on the early responses to initial and boundary conditions of the KIAPS-GM framework and the comparison of mixing components of two schemes. Case studies are performed to validate model, in which surface and near surface variables, boundary layer height, and profiles under day and night boundary layer structure are compared with observation and the effect of boundary layer process on global simulation is discussed.

Keywords: boundary layer process, KIAPSGM, non-local K profile method, total energy mass flux scheme
Poster Session

SCI-POW1142 - Boundary layer parametrization in Environment Canada's NWP models: lessons learned from three GASS experiments

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In the atmospheric models currently used by Environment Canada for numerical weather prediction (NWP), vertical transport in the planetary boundary layer (PBL) due to subgrid-scale turbulence is parametrized in the form of vertical diffusion. The parametrization is based on a turbulent kinetic energy (TKE) closure of order 1.5. Two alternative treatments of subgrid-cloud effects and two optional formulations of mixing length are available, and different combinations thereof are used in the various operational NWP systems, e.g. global versus regional, deterministic and ensemble forecasting systems of Environment Canada. The effect of turbulent hysteresis were recently implemented in the PBL scheme, leading to improved forecasts overall. In this presentation, we discuss the results produced for and the lessons learned from the Canadian contribution to three numerical model experiments, coordinated by the Global Atmospheric System (GASS) panel and related to PBL parametrization issues: (1) the Diurnal land/atmosphere coupling experiment (DICE), which aims to assess the impact of land/atmosphere feedbacks; (2) the Surface Drag project, whose primary goal is to compare various components of surface stress in NWP and climate models; and (3) the Arctic Air experiment, designed to understand how models represent the Arctic winter boundary layer.

Keywords: boundary layer, GASS, turbulence, land-atmosphere
 SCI-POW1147 - Data assimilation experiments of Myanmar cyclone Nargis based on NHM-LETKF

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Data assimilation experiments on Myanmar tropical cyclone (TC) Nargis using Local Ensemble Transform Kalman Filter (LETKF) method and NHM model were performed to examine the impact of LETKF on analysis performance in real cases with sparse observations. NHM is the operational non-hydrostatic meso-scale model of Japan Meteorological Agency. The subsequent forecast based on the original NHM-LETKF analysis showed a good forecast in track and intensity compared to the direct downscaling from the global model of JMA. However the ensemble mean track had a small southward displacement and both deterministic and ensemble mean forecasts underestimated the peak of intensities. Some strategies to further improve the final analysis were considered. They are SST perturbations, assimilation of TC advisories, and Running in Place (RIP). SST perturbations were derived from SST analyses from operational centers. Assimilation of TC advisories requires an implementation of a new observation operator in NHM-LETKF. RIP is equivalent to iterating LETKF several times at assimilation phases. The use of SST perturbations slightly improves the Nargis track and intensity forecast. Assimilation of TC advisories and RIP can have a positive impact with a reasonable choice of their free parameters. The overconfidence on estimated intensities in assimilation of TC advisories or the overuse of observations in RIP can strengthen Nargis considerably. However the subsequent track forecasts exhibited northward displacements.

**Keywords:** cyclone Nargis, LETKF, storm surge, K-computer
Poster Session

SCI-POW1153 - Resolving multiscale processes in tropical cyclogenesis using the parallel EEMD

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The recent advance in high-resolution global models has suggested that improved multiscale simulations of tropical waves may help extend the lead time of tropical cyclone (TC) formation prediction (e.g., Shen et al., 2010ab, 2012, 2013a). In previous efforts in the multiscale analysis of tropical waves, the Ensemble Empirical Mode Decomposition (EEMD) has been successfully parallelized and used to detect atmospheric wave signals on different spatial scales (e.g. Shen et al., 2013b) that include Mixed Rossby Gravity (MRG) waves, Western Wind Belt (WWB), African Easterly Waves (AEWs), etc. We now extend the related studies to examine the evolution of the large scale waves and their association with the formation of tropical cyclones in an entire hurricane season (2006) in the Atlantic. Our goal is to analyze the multiscale interaction in the initiation and early intensification stage of an AEW and its subsequent impact on TC genesis that involves mainly the large scale downscaling processes. Specific focus is on the impact of barotropic instability and critical level (CL, or steering level) that may appear in association with the AEW. The presence of the CL is believed to play an important role in providing a favorable environment in the early TC-genesis stage in the marsupial paradigm scenario.

Keywords: tropical cyclogenesis, EEMD, multiscale interaction, barotropic instability
Poster Session

SCI-POW1155 - A Multi-Scale Model for the Intraseasonal Impact of the Diurnal Cycle of Convection

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Observational data indicates that through the complex interaction of heating and convection, tropical atmospheric flows are organized on a hierarchy of spatial and temporal scales, ranging from the mesoscales to the equatorial synoptic scales to the intraseasonal/planetary scales. A multispacial scale, multitime scale, simplified asymptotic model has been derived systematically from the equatorial primitive equations by Majda, A.J., 2007. We use this model to study upscale contribution from heating on daily scale to intraseasonal scale circulation. In fact, the diurnal cycle is one of the predominant components of atmospheric variations. We focus on such equatorial inertial oscillation occurring on the daily scale and try to figure out how its upscale contribution affects planetary intraseasonal circulation. Due to the analytic tractability of the models, different aspects of upscale forcing on planetary intraseasonal scale are traced to meridionally asymmetry of diurnal heating profile. Considering seasonal variation of diurnal cycle heating, meridionally symmetric and asymmetric diurnal cycle heating are prescribed to mimic equinox case and boreal summer case separately. Two crucial results arise on planetary intraseasonal scale circulation in boreal summer case. One is that upscale contribution from diurnal cycle heating can cool lower atmosphere layer in north hemisphere, providing a favorable condition for convection. The other one is that the consequential planetary intraseasonal response can strengthen winter cell in Hadley Circulation.


Keywords: Diurnal cycle, Multi-scale asymptotics, Upscale flux
Simulations of the Madden-Julian Oscillation (MJO) by 36 climate models participating in the Coupled Model Intercomparison Project phase 5 (CMIP5) are examined using diagnostics developed by U.S. Climate Variability and Predictability (CLIVAR) MJO Working Group. Daily mean data of historical scenario simulation taken from the CMIP5 archive is used in this study. Using the MJO simulation diagnostics, the mean state, subseasonal variance, time series power spectra, EOF, eastward and northward propagation, wavenumber-frequency spectra, Wheeler-Kiladis diagrams, East-West ratio, MJO life-cycle composites are compared to those obtained from observations. Our preliminary results suggest that the BNU-ESM, CCSM4, CESM1-FASTCHEM, FGOALS-g2 and NorESM1-M show relatively high skill in representing the mean state and subseasonal variance over the western Pacific and Indian Ocean. In addition, the GFDL-CM3, MRI-CGCM3 and NorESM1-M show relatively high skill in representing the wavenumber-frequency spectra among the models. The characteristics of better MJO models are also investigated in terms of cloud-radiation interaction. Compared to the other models, better MJO models tend to produce more amount of high-level cloud for a same precipitation anomaly. The high-level cloud can contribute to heat the mid-level atmosphere by reducing the outgoing longwave radiation at the top of atmosphere. The longwave radiative heating in the mid-level can increase an upward motion, which provides a favorable condition to grow the MJO especially for cases of weak precipitation anomaly.

**Keywords:** MJO diagnostics, CMIP5, Cloud-Radiation Interaction
Poster Session

SCI-POW1157 - Intraseasonal asymmetric events in the skeleton model with seasonal cycle

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The stochastic skeleton model is a simplified model for the Madden-Julian oscillation (MJO) involving planetary-scale dry dynamics, moisture, and a simple stochastic parametrization for the unresolved details of synoptic-scale activity. The model captures the fundamental features of the MJO such as the intermittent growth and demise of MJO wave trains, the MJO propagation speed, peculiar dispersion relation, quadrupole vortex structure, etc. Here we further include a simplified seasonal cycle in the model that consists in a background warm pool state displacing meridionally. With this setup, the model reproduces a great diversity of intraseasonal asymmetric events besides the canonical MJO with symmetric quadrupole vortex structure. This includes examples of events with off-equatorial heating and/or with associated meridional propagation. The structure, mechanisms and seasonal modulation of those intraseasonal asymmetric events are discussed.


Keyword: MJO
Current global circulation models exhibit considerable shortcomings in accurate and precise simulation of the Madden-Julian Oscillation (MJO). These shortcomings have been attributed to a variety of factors ranging from the deficient treatment of cumulus convection, the proper phasing and representation of surface fluxes to the fidelity of the model mean-state, or combination thereof. We present a quantitative evaluation of the simulated MJO within the context of a coupled ocean-atmosphere-land data assimilation framework, which has been developed recently at the National Center for Atmosphere Research. This system is based on the Community Earth System Model (CESM) interfaced to the Data Assimilation Research Testbed (DART). Both qualitative and process-based diagnostics identified by the MJO Task Force (currently under the auspices of the Working Group on Numerical Experimentation) are being used to detect the MJO signals and examine the resultant variability and predictability across a suite of coupled data assimilation experiments. Relative to a free run of the coupled CESM model (i.e., CMIP5 style without data assimilation), the more realistic treatment of air–sea interactions in the CESM-DART system improves the model mean state and the simulated MJO signal in terms of the amplitude, the seasonality and the phase speed. We anticipate that the knowledge gained through this study will enhance our understanding of the MJO feedback mechanisms across the air-sea interface, especially regarding ocean impacts on the MJO as well as highlight the capability of coupled data assimilation systems for related tropical intraseasonal variability predictions.

**Keywords:** MJO prediction, gross moist stability, air-sea interaction, coupled data assimilation
Poster Session

SCI-POW1159 - Object-based verification of tropical precipitation forecasts during the YOTC period

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The accurate representation of tropical convection still poses a major challenge to global forecasting systems. However, in particular an improved representation of physical processes in the tropics would have a positive feedback on the medium-range predictability in the extratropics. Therefore, the investigation of forecast error growth and the identification of systematic forecast errors in the tropics is of great interest. This study aims to investigate the extent of the forecast error growth and to identify systematical errors in position and structure of tropical convection in the ECWMF Integrated Forecast System during the YOTC period. Operational 5-day forecast runs are verified against precipitation estimates of the Tropical Rainfall Measuring Mission (TRMM) using two kinds of verification methods, an object-based and an field based approach. In contrast to classical skill scores, these approaches allow to verify the structural characteristics of the precipitation and enable identification of spatial displacement errors. Our investigations suggest that the growth of the displacement error makes a substantial contribution to the overall error growth with lead time. However, error growth shows a strong regional variability, with showing a maximum over oceanic regions like the Western Pacific. Additionally, a significant diurnal cycle of the intensity error is identified, indicating an inaccurate representation of the diurnal cycle of the convection itself. Furthermore, in some parts of the tropics, the intensity error is largest during the first 24 hrs and weakens over the course of the forecast, which hints on the existence of a spin-up problem.

Keywords: Object-based verification, TRMM, YOTC
Poster Session

SCI-POW1160 - Relation between mesoscale convective system life cycles and extreme rainfall signatures obtained by TRMM

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Multiples studies around the globe have been focused on determine the convective climatology using TRMM information. In spite large available dataset, TRMM information due to the low orbit inclination has no constant temporal overpass over the world. Mesoscale convective climatologies present a speculation centered on TRMM precipitation features with the strongest convective signatures are observed in relatively early stages of their lifecycle, and that the precipitation features with the largest rain totals and largest horizontal extents are in mature or early dissipation stages. In this context, the present work focuses on the development of 10-year climatology of mesoscale convective systems with extreme characteristics over southeastern South America applying a compositing method between TRMM and GOES satellite data. An objective and automated algorithm based on GOES infrared data is applied in order to obtain the temporal evolution of the IR cold cloud shields related to different types of extreme storms detected by TRMM using precipitation and intensity proxies (i.e., total volumetric rain, minimum 37 and 85-GHz PCTs, and lightning flash rates). The composite life cycle of MCS confirms the hypothesis and shows the presence of strongest convective signatures during the early stages. A well-marked opposite behavior is observed in the distribution of precipitation features with the largest volumetric rains in mature or early dissipation stages. Against this background, the newest Global Precipitation Measurement core satellite will provide the next-generation observations every three hours and its data will advance our understanding of the precipitation systems over this part of the planet.

Keywords: Mesoscale convective system, TRMM satellite, Life cycles, Extreme rainfall signatures
Orographic flows over and around an isolated volcano are studied through a series of numerical model experiments. The volcano top has a heated surface, so can be thought of as “active” but not erupting. A series of simulations with different atmospheric conditions and using both idealised and realistic configurations of the Weather Research and Forecast (WRF) model have been carried out. The study is based on the Soufriere Hills volcano, located on the island of Montserrat in the Caribbean. This is a dome-building volcano, leading to a sharp increase in the surface skin temperature at the top of the volcano – up to tens of degrees higher than ambient values. The majority of the simulations use an idealised topography, in order for the results to have general applicability to similar-sized volcanoes located in the tropics. The model is initialised with idealised atmospheric soundings, representative of qualitatively different atmospheric conditions from the rainy season in the tropics. The simulations reveal significant changes to the orographic flow response, depending upon the size of the temperature anomaly and the atmospheric conditions. The flow regime and characteristic features such as gravity waves, orographic clouds and orographic rainfall patterns can all be qualitatively changed by the surface heating anomaly. Orographic rainfall over the volcano can be significantly enhanced with increased temperature anomaly. The implications for the eruptive behaviour of the volcano and resulting secondary volcanic hazards will also be discussed.

Keywords: Orography, convection, volcano
Poster Session

SCI-POW1163 - Rainfall runoff modelling for flood forecasting: A case study on West Rapti Watershed

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Floods are the most widespread climate-related hazards in the world, and they impact more people globally than any other type of natural disaster. In Nepal each year, on an average 330 lives are lost due to floods and landslides and infrastructure and property amounting to more than US$ 100 million is damaged causing negative impacts on the social and economic development of the country. Structural solutions are mainly preventative and focusing on curtailing the magnitude of floods using different methods such as dams, embankment, compound channels, widening of river beds, etc. However these solutions have adverse environmental, hydrologic, ecologic or economic consequences. The non-structural mitigating measure places people away from flood. This method is designed to reduce the impact of flooding to society and economy. I used rainfall runoff modeling for the flood forecasting and warning schemes as a non-structural hydrologic method for mitigating flood damages. In this context due to unavailability of detail information of the study area, lumped model NAM is used for simulating rainfall into runoff. Due to lack of hourly interval data of rainfall, development of synthetic unit hydrograph from Snyder method is done to determine runoff hydrograph of the basin. The Snyder coefficients, coefficient of slope (Ct) and coefficient of peak (Cp) are calibrated for each sub basins and the values are found to be in the range from 0.41-0.58 and 0.32-0.43 for Ct and Cp respectively. Mike UHM rainfall runoff model is used to incorporate developed unit hydrograph.

Keywords: Rainfall Runoff Modelling, Unit Hydrograph, flood forecasting, hydrology
SCI-POW1169 - Mechanisms causing structural changes during the extratropical transition of Typhoon Sinlaku (2008): a model study

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Extratropical transition (ET) of tropical cyclones (TCs) has been investigated in several studies. General structural changes and processes involved in the evolution are known. Still, a lot of uncertainty can be found while forecasting ET. During the T-PARC field campaign (autumn, 2008) one objective was observing ET in order to better understand its mechanisms, which was achieved with Typhoon Sinlaku. Other than during characteristic ETs, Sinlaku re-intensified as a tropical cyclone in the course of the first ET phase before continuing its ET. Measurements could be performed during the entire evolution and in different regions of the storm, so that an extensive dataset is available. Sinlaku is therefore an interesting case to get a better understanding of the development of ET and its influence on the midlatitude flow. This study investigates the mechanisms that cause structural changes during Sinlaku's ET. To do so, a reasonable representation of the storm is needed. Piecewise PV inversion, in combination with ECMWF re-analysis data, dropsonde and airborne radar data, is used to create a most realistic analysis that captures the intensity of the typhoon. This analysis is used to initialize the non-hydrostatic regional forecast model COSMO (COnsortium for Small-scale MOdeling). Sinlaku is simulated for a period of two days on a 2.8 km horizontal grid and compared to airborne lidar data. The evolution of ET is evaluated from convective to synoptic scale and the relative influence of the baroclinic zone and of the jet stream on the ET process is analyzed.

Keywords: extratropical transition (ET), Sinlaku (2008), structural changes, COSMO
Poster Session

SCI-POW1173 - Moisture transport between Atlantic and Mediterranean regions leading to extreme precipitation and flooding event

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Extreme weather events such as severe cyclogenesis with heavy precipitation and flash-flooding regularly affect the Mediterranean region. The orography surrounding the basin further enhances the formation of heavy rain. In October and November 2012, during the HyMeX (HYdrological cycle in the Mediterranean EXperiment) special observation period, a series of three Mediterranean cyclones reached the Gulf of Genoa and the Adriatic area bringing large amounts of moisture in this region. They caused extreme precipitation with peaks of up to 400 mm/24 h and severe flooding events with considerable damage and casualties. This study focuses on transport of moisture involved in heavy precipitation. A Lagrangian trajectory analysis has shown large amounts of moist air arriving from 2 sources in the Atlantic, one associated with an atmospheric river along the western African coast and the other associated with a cyclone entering the Mediterranean from the Atlantic and later a large scale trough situated over western and central Europe. The most extreme precipitation occurred after the interaction of the moist air with the Alps and the Apennines. A combination of COSMO model simulations and trajectory analysis enables the distinction between advective and convective moisture transport.

Keywords: extreme precipitation, moisture transport, Mediterranean cyclones
Poster Session

SCI-POW1177 -The role of warm conveyor belts for the intensification of extratropical cyclones

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Warm conveyor belts (WCBs) are strongly ascending airstreams within extratropical cyclones. They are associated with intense cloud formation and latent heating, which in turn has a profound impact on the potential vorticity (PV) distribution within the troposphere. In the lower/middle troposphere the PV within the ascending WCB increases, whereas it decreases at upper levels. The low PV in the WCB outflow produces significant negative PV anomalies, which can strongly influence the downstream flow evolution. Less is known about the role of the low-level positive PV anomaly. A positive PV anomaly goes along with cyclonic circulation, and hence WCBs have the potential to enhance cyclones. In this study we investigate the interaction between cyclone and WCB intensity using statistical/climatological approaches and case studies. The cyclone and WCB climatologies are based on ERA-Interim reanalysis data and Lagrangian methods for WCB identification. Different measures are used to quantify cyclone and WCB strength, and it is analysed how WCBs affect cyclones differently for different cyclone categories. First results show a relatively large scatter between the cyclone deepening and the number of WCB trajectories associated with this cyclone. However, four categories can be distinguished: intense cyclones with strong/weak WCBs, and weaker cyclones with strong/weak WCBs. A case study of a strongly deepening cyclone with many WCB trajectories shows that the WCB continuously produces strong diabatic low-level PV within the cyclone center. It remains to be investigated whether this is usually the case for cyclones in this category, and to assess differences between the four categories.

Keywords: extratropical cyclones, diabatic processes, potential vorticity
Typhoon Choi-Wan (2009) was a major typhoon in the western North Pacific in 2009. It underwent extratropical transition in the second half of September, without making landfall and without having a strong impact on human activities. Some days after the ET of Choi-Wan, significant weather events were recorded in North America. An early autumn heat wave occurred along the West Coast, with record maximum 2m temperatures in California and the Pacific Northwest. In contrast, record minimum 2m temperatures were reported from stations in Colorado, Texas and New Mexico. Additionally, some regions in the southeastern US experienced record-breaking precipitation amounts. In this study we investigate two hindcasts from the mesoscale COSMO model for the ET of Typhoon Choi-Wan. While one hindcast closely follows the analysis, the storm is removed from the initial conditions of the other hindcast, using a PV surgery technique. This enables to investigate the impact of the transitioning storm on the midlatitude flow configuration in the model framework, using an analysis of the eddy kinetic energy budget. It can be shown that Choi-Wan amplified and decelerated the midlatitude Rossby-Wave train, which affected the location, time and intensity of the high impact weather events in North America.

**Keywords:** extratropical transition, high impact weather, PV inversion, eddy kinetic energy
The Madden-Julian oscillation (MJO) influences weather and climate over extratropics as well as tropics. Then MJO could induce an occurrence of extreme weather events which have large social and economic impacts. Reliable forecasts of extreme weather events utilizing forecast signals of MJO are useful for disaster mitigation and risk management in various sectors. We investigated an influence of MJO on extreme weather events and found that a frequency of extreme weather events is modulated by MJO in many regions. For example, in boreal winter, the frequency of extreme warm (cold) events increases by a factor of about two times around Japan, with the eastward propagation of enhanced (reduced) convections in Indian Ocean. The frequency of extreme warm events increases by a factor of more than two times over northeastern America, with the eastward propagation of enhanced convections in Maritime continents. These modulations are likely associated with midlatitude wave response to a tropical forcing due to the MJO. In addition, a relationship between forecast skill of extreme weather events and MJO is investigated using a set of hindcasts with the JMA’s operational One-month Ensemble Prediction System. Forecast skills of extreme events during the active MJO are better over some areas, compared to those during the inactive MJO.

**Keywords:** Madden-Julian Oscillation, Extreme weather
SCI-POW1189 - Cyclogenesis downstream of extratropical transition analyzed by Q-vector partitioning based on flow geometry

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During extratropical transition (ET), tropical cyclones exert a significant impact on the midlatitude circulation. Archetypical features of this impact are jet streak formation, amplification of the downstream trough, and modification of the associated downstream cyclogenesis. This study investigates the relative importance of the jet streak and the upper-level trough for cyclone development by quantifying the respective contributions to mid-tropospheric vertical motion using the Q-vector partitioning by Jusem and Atlas (1998). Their framework is here extended from quasi-geostrophic theory to Alternative Balance. The Q-vector under Alternative Balance involves the non-divergent wind, instead of the geostrophic wind, and therefore represents more accurately the balanced dynamics associated with vertical motion, in particular downstream of ET where the flow often exhibits significant curvature associated with the amplified trough. An idealized ET scenario and three real cases, the cyclones downstream of Hanna (2008), Choi-wan (2008), and Jangmi (2009), are analyzed. In all cases, the trough plays a prominent role in cyclone development. The jet streak plays a prominent, favorable role in the idealized ET scenario and downstream of Hanna. In contrast, the role of the jet streak downstream of Choi-wan is clearly of secondary importance. Interestingly, downstream of Jangmi the jet streak has a prominent but detrimental impact. It is concluded that amplified jet streaks associated with ET have the potential to be of significant importance for downstream cyclone development. The few cases considered in this study, however, point to a large case-to-case variability of the role of the jet streak.


Keywords: ageostrophic circulation, upper-level forcing, omega equation, tropical-extratropical interaction
Poster Session

**SCI-POW1208 - Prediction of the African Monsoon in the ECMWF high-resolution coupled model**

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In a recent set of simulations made in collaboration between COLA and ECMWF, referred to as Project Minerva, the ECMWF coupled climate prediction system has been used to evaluate the sensitivity of climate predictability to different atmospheric horizontal resolutions and ensemble sizes. In this study, we examine the ability of the coupled model to simulate the variability of the African monsoon. Simulated African monsoon is evaluated in detail at a range of time scales, including intraseasonal, seasonal mean, annual cycle, and the interannual variability. In addition, the influence of El Niño-Southern Oscillation (ENSO), the tropical Atlantic and Indian Ocean variability on the monsoon rainfall and circulation are analyzed in order to assess the seasonal mean prediction. Output from high atmospheric resolution (T1279) is compared with lower resolutions version (T319 and T639), to assess the impact of increased horizontal resolution.

**Keywords:** Minerva project, African Monsoon, Predictability
Poster Session

SCI-POW1214 - Impact of a dynamic sea-ice model on the ECMWF medium to monthly range forecasts

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The ensemble forecasting system at ECMWF is coupled to an ocean model for the duration of the forecast. Sea ice representation in the model is far simpler; the field is fixed for the duration of the medium-range forecast and is then relaxed towards a recent climatology for weeks 3 and 4 of the forecast. In autumn and spring when the changes in the ice edge are most rapid keeping the sea ice field fixed for the forecast will introduce errors which have the potential to impact forecast skill. In winter in the Arctic the surface turbulent heat flux between the ocean and atmosphere in an area covered by sea ice is almost zero, whereas open water the flux can be as large as 500Wm⁻². We therefore wish to understand if implementing a dynamic sea ice model in the forecast system is able to provide a more realistic representation of the sea ice evolution in the model and if it can help improve the forecast skill. We have introduced a single category sea ice model (LIM2) to the forecast system. Sea ice predictability depends on the ice distribution both in terms of ice concentration and thickness, but observations of sea ice thickness remain limited. We have developed two sea ice initialisation methods that generate sea ice concentration and thickness, one using a nonlinear nudging scheme and the other using 3DVAR. We present results showing the skill of the sea ice forecast and the impact on the forecast skill in other regions.

Keywords: sea-ice, subseasonal to seasonal, forecasts
Poster Session

SCI-POW1217 - Extending NCEP GEFS from 16 days to 30 days

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The NCEP Global Ensemble Forecast System (GEFS) generates 20 perturbed (plus control) forecasts, 4 times per day, out to 16 days operationally. With statistical post processing, the NAEFS, which combined to Canadian Meteorological Center (CMC) global ensemble, is providing excellent probabilistic forecast guidance for North American Countries and public. In particular, NAEFS is best numerical probabilistic guidance for week-2 precipitation and temperature forecast. Recently, Climate Prediction Center (CPC) is experimentally producing daily probabilistic hazard forecast out to 16-days by using calibrated ensemble forecasts. To improve numerical guidance and prediction capability for week 3 & 4 and build up seamless forecast system across all time scales, NCEP is planning to accelerate the development of extending GEFS to 30 days with the inclusion of one/two way(s) coupling with a thermodynamic ocean. By contrast to NCEP Climate Forecast System (CFS), there are many advantages for extending GEFS to cover the intraseasonal time range, including: 1). Better initial perturbations to represent analysis errors; 2). Higher resolution continuously from weather to extend range to allow more interactions of different scales; 3). Advanced model physics with various stochastic perturbations to assimilate model uncertainties; 4). Large ensemble size to provide reliable and skillful forecast; 5). Acceptable configuration of reforecast/hindcast in real time for calibration; 6). Seamless forecasts across weather and short-term climate. A preliminary study of GEFS extending forecast indicates that there is an ability/skill to predict large scale circulation, high impact weather, important characteristics and phenomena, such as MJO, blocking and et al.

Keywords: Global Ensemble, Sub-season, Probabilistic Forecast
In this study, the variability and actual and potential predictability of the Madden-Julian Oscillations (MJO) is evaluated, using state-of-the-art dynamical coupled and uncoupled models from the Canadian HFP2 (GCM3) and CHFP2 (CanCM3) ensemble. Emphasis is placed on the evaluation of actual prediction skill of the ensembles mean and the information-based potential predictability, and comparison of information-based potential predictability measure with usual signal to noise ratio measures. The comparison of model's upper and lower level wind and precipitation patterns with observations revealed that models have suitable representation of the MJO variability. MJO signal was isolated using combined EOF analysis of upper and lower level winds and precipitation, using NCEP/NCAR reanalysis data from 1979-2001. Using first two PC time series, actual and potential prediction skill is estimated at daily time scale. It is found that coupled model (CanCM3) prediction skill is significantly better than uncoupled model (GCM3). The conclusion is not changed when MJO forecasts were divided into strong and weak MJO and into different phases. The similar interpretation can be given using potential prediction skill estimated by information theory based measure MI. The comparison with conventional potential predictability measures of the signal-to-noise ratio, reveal that Mutual Information (MI) measures characterized more potential predictability when the ensemble spread varied over initial conditions. Further analysis showed that, the intra-seasonal SST prediction skill is significantly better than persistence skill in the tropics which can also explains the difference of actual and potential prediction skill between coupled and uncoupled models.

**Keywords:** MJO, Climate predictability, Sub-seasonal
Poster Session

SCI-POW1239 - Spectral analysis of salt clouds originated at Mar Chiquita lake using remote sensing

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The extent of the water surface of Lake Mar Chiquita (Córdoba - Argentina) experienced increases and decreases over the years. However, after 2003 entered a contraction scheme, leaving large areas of exposed soil covered with salt. Since 2006 observations with several satellites allowed to document the presence of white clouds originated when salt is lifted from the ground by winds of a certain intensity. Various examples of salt clouds are documented in this paper, using images provided by MODIS (Moderate-Resolution Imaging Spectroradiometer) and AVHRR (Advanced Very High Resolution Radiometer) sensors of the NOAA-18 and NOAA-19 satellites. Between 2006 and 2012 several events were monitored and compared in order to observe the evolution of the water surface, with an analysis of two events in particular. For each event the spectral response is analyzed in the reflective channel and brightness temperatures, individually or combined into an index. Although this study is exploratory in nature, the results indicate that certain indexes used in the literature for identifying these clouds do not apply across the board and could be necessary to be obtained locally. For this study in particular it was found that the index that represents the difference of brightness temperatures between channels of 11 microns and 12 microns could be used to distinguish and study the clouds and storms of salt. This paper was presented at CATE (VII Congreso Argentino de Tecnologia Espacial) 2013 to an audience of 40 people.

Keywords: Salt clouds, Remote sensing, Spectral response, Brightness temperature
For this study, data assimilation tests employing different combinations of satellite and radar observations were performed for a severe weather event that occurred across the central U.S. during June 2005. Simulated data include GOES-R ABI brightness temperatures and WSR-88D Doppler radar reflectivity and radial velocity. Assimilating these datasets into convection permitting numerical weather prediction (NWP) models poses many challenges due to observation uncertainties and correlations to model state variables. The study used an Observing System Simulation Experiment (OSSE) framework that provides a useful means to investigate the impact of these observations in a controlled manner. Observations generated using output from an idealized ARPS model simulation were assimilated into a 2-km resolution grid using the Data Assimilation Research Testbed (DART) ensemble Kalman filter (EnKF) system combined with the Weather Research Forecast (WRF) model. Preliminary results documenting the relative benefit of each observation type at convection-resolving scales will be shown.

**Keywords:** GOES-R ABI, Data assimilation, DART, OSSE
Poster Session

SCI-POW5007 - Assimilation of IMS fractional snow cover into NOAA/NCEP’s Land Surface Model over North America Domain

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Understanding and quantifying satellite-based remotely sensed snow cover errors are critical for successful utilization of snow cover products. In order to attain the optimal estimate of snow pack state, it is essential that the assimilation scheme accounts for relative uncertainty of both model predictions and satellite observations. The 4km daily Interactive Multisensor Snow and Ice Mapping System (IMS) became operational in 2004. The IMS product is manually created by a satellite analyst looking at all available satellite imagery, several automated snow mapping algorithms, and other ancillary data. Currently, the IMS data is served as a ‘check’ on the NOAA/NCEP global and regional modeling because it has more accurate coverage, especially in mountain ranges. The uncertainty in the IMS snow product will be fully examined, and a proxy will be found to quantitatively predict the uncertainty in the IMS snow product for data users in their applications (e.g., data assimilation in NCEP operational models). We will use NASA’s Land Information System which integrates NOAA operational land surface and hydrological models (NCEP’s Noah), high-resolution satellite and observational data, and land data assimilation tools. We will test our designed innovative data assimilation techniques for ingesting the daily IMS fractional snow cover (FSC) observations into the Noah land surface model. The algorithm uses the traditional bisection method to study the inverse of the usual problem by finding the snow water equivalent which optimally matches the IMS FSC observations. Results will be evaluated with ground-based measurements.

**Keywords:** Fractional snow cover, Snow data assimilation, IMS snow cover product, Uncertainty
Rainfall trend in Nigeria were examined for secular change and the evidence of dry and wet episodes and its attendant environmental hazards in Nigeria. Rainfall data were obtained from the archive of the Nigeria Meteorological Agency (NIMET). Climate risk and hazards data (flood, drought and acid rain) were collected from National Emergency Management Agency (NEMA), ministries and survey of some affected communities in Nigeria. Descriptive and multivariate statistics were employed for summarizing the data and establishing the synergy between rainfall hazards on the environment. Results revealed a significant decrease in rainfall amount and rainy days over Nigeria. There is the occurrence of drought in the north and wide spread flood episodes in the south and along river channels. It also showed the occurrence of acid rain which decreases from the Niger Delta region to the northern extremities of Nigeria. This observed climate hazards has some effects on crops and animals, man’s welfare and the economy of Nigeria. Nigerian government, non governmental organization, companies and private individuals in the country need to set up adaptation and mitigation options in place to manage these weather hazards.

**Keywords:** Rainfall Hazards, Flood, Acid rain, Drought
UAS-POW3029 – WITHDRAWN - Trends of natural disasters and morbidities in Uganda

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Background: The concepts of natural disasters and complex emergencies are quite distinct, with different strategies for mitigation and response. However, natural disasters and epidemics occur concurrently in the same geographic location. Methods: Natural disasters, complex emergencies and epidemics that met the inclusion criteria were included. Results: The study revealed that 63% of the complex emergencies had ≥ 1 epidemic compared with 23% of the natural disasters. 27% of the largest natural disasters occurred in areas with ≥ 1 ongoing complex emergencies while 87% of the largest complex emergencies had ≥ 1 natural disaster. Conclusion: Epidemics commonly occur during complex emergencies. The data presented in this article do not support the often-repeated assertion that epidemics, especially large-scale epidemics, commonly occur following large-scale natural disasters. This observation has important policy and programmatic implications when preparing and responding to epidemics. There is an important and previously unrecognized overlap between natural disasters and complex emergencies. Training and tools are needed to help bridge the gap between the different type of organizations and professionals who respond to natural disasters and complex emergencies to ensure an integrated and coordinated response.

Keywords: Trends, Natural Disasters, Morbidities
Poster Session

UAS-POW3030 - The October 1891 Cartago floods (Costa Rica) using historical documents and 20CR project data

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The use of historical documentation and data from the 20CR project allowed a reconstruction of events associated with the floods that destroyed the City of Cartago (Costa Rica) on October 27th, 1891. The area of study, the regional climate, and the meteorological phenomena affecting the region are briefly described. Documents from the period tell, with good detail, the development of the rains, the area covered by mud and rocks in the Cartago Valley due to the Reventado River flooding. The destruction of houses, roads and other civil infrastructure are summarized. The research carried out is suggestive of the local and synoptic atmospheric conditions that may have lead up to the disaster. After ruling out, the direct or indirect effects of a tropical cyclone, the intrusion of an early winter cold front, or the convective activity associated with the Inter Tropical Convergence Zone, the study indicates that the most probable cause of the rains was a “temporal”. This is a system of light to moderate rain lasting several days and affecting a region of synoptic scale. The floods and rains left severe economic losses. A woman and three kids were confirmed to have died, however, the total death toll will never be known due to many disappearances.

Keywords: historical floods, river flooding, historical documents, 20CR data
A drought is a period of unusually dry weather that persists long enough to cause serious problems, in the case of Peru those are presented below. The main impacts are: crop loss, livestock mortality, pests and diseases. This affects principally small agricultural producers, so as small urban populations and electric energy production. According to the Water National Authority (Autoridad Nacional del Agua), between 2000 and 2010, 163 drought events have been reported nationally. In this period 66,724 families and 33,208 hectares have been affected. In the Peruvian Andes (highlands) 95% of the cropland (1'200,000 hectares) is rainfed land and drought impacts them directly. In the Peruvian Amazon, decreased river flow affects the fishery (their main animal protein supply) and river navigation which is their main channel of communication. Furthermore, the Amazon drought also has a global harmful effect because it turns this rainforest from a carbon sink into a source of greenhouse gases. It also affects the supply of drinking water to urban and rural populations. Especially in the bottom of a basin in the Pacific slope (70% of the national population lives there) affecting mainly the poor people. Drought events are sometimes related to “El Niño” Southern Oscillation (ENSO) along with other hydrometeorological effects, to give a scope, the ENSO event in 1997-1998 caused an estimated US$.3500 million damage equivalent to the 6.2% of annual GDP in social, productive and infrastructure sectors (Andean Development Corporation, 2000). Therefore, drought generates great risks in this country that need to be addressed.


Keywords: Drought, Peru
The impact of climate change is greater in countries where poverty and diseases remain prevalent. This is the case on the African continent, particularly in the Southern African Development Community where various populations are engaged in agriculture sustained by water-fed rainfall. Although this region has some of the longest and biggest rivers in the world, water scarcity, especially safe water, is not unheard of, water resources (surface and groundwater) are likely to be impacted through increases in temperature, shifts in precipitations patterns, increases in the frequency of floods and droughts; consequently, climate change poses a greater danger to this region. Many simulation models for climate change indicate that the region will be subjected to increased temperature by the end of the century that will in turn impact hydrological cycles of its river basins upon which 260 millions of people from 15 countries are dependent. Many of these models predicted significantly decreased rainfall and runoff that will affect the downstream flow of the rivers and those depending on them. Water quality is expected to alter as a consequence of decreased rainfall or water scarcity. This will affect many in the region where only one country has attained 94.7% access to safe water while the rest are still struggling to deliver safe water to their populations. This scenario will undoubtedly make things almost beyond bearable for the countries in the region. This review analyses the current situation and suggests ways to minimise adverse effects of climate change on regional water resources.


Keywords: Climate change, water scarcity, water resources, Rainfall
UAS-POW3033 - Vancouver Island school-based weather station network

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The Vancouver Island School-Based Weather Station network consists of more than 150 weather stations located principally on schools on southern Vancouver Island as well as the Gulf Islands in the Strait of Georgia, British Columbia, Canada. The Capital Regional District is the most densely monitored part of our network. It includes 13 municipalities, covers an area of 2300 square kilometres and contains 105 weather stations in urban, agricultural and natural areas. Several other urban centres and remote sites are also monitored on southern Vancouver Island. Most of the weather stations have been in operation for seven years or less but the oldest station has been collecting data for twelve years. Minute resolution data is collected from each station and then broadcast back to the community through the website www.victoriaweather.ca where various tools are available to view maps of the measured fields in near real-time and to retrieve subsets of the data. The initial motivation for the network was educational. We wanted to raise the profile of meteorology in the school curriculum and demonstrate to students and teachers that physics (meteorology) has great practical importance. As the network grew, interest and awareness within the community also grew. Numerous applications of the weather station data for scientific, engineering and media purposes have emerged.


Keywords: observations, education, network, local