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THORPEX ICSC
DAOS Working Group
Third Meeting

UQAM, Montreal
8-9 July 2010

REPORT FROM THE THIRD MEETING OF THE THORPEX DAOS WORKING GROUP

1. Organisation of the meeting

At the invitation of the *Université du Québec à Montréal (UQAM)*, the 3rd meeting of the DAOS-WG was held in Montréal, on 8-9 July 2010. The main objective of the meeting was to review the recent results obtained with targeted data and revisit the conclusions on the value of targeted data presented at the previous meeting in September 2008 in Geneva. It was also to agree on a writing team that would be tasked to write a review paper on adaptive observations.

The working group also reviewed of a number of activities relevant to the mandate of the DAOS-WG.

The presentations made at the meeting can be found at the following location:

http://web.sca.uqam.ca/~wgne/DAOS/DAOS3_meeting/

1.1. Objectives of the meeting

The main objectives of the meeting were discussed and summarised:

- Review of adaptive observations
- Review results from T-PARC
- Update on other field campaigns
- Agree on who will contribute to writing an overview paper on observation targeting to be published in peer review literature
- Review working group membership and actions

Other topics included updates on satellite and surface observations and advances in data assimilation.

1.2. Adoption of the Agenda

The agenda was discussed and agreed.

1.3. Working Arrangements

Local arrangements for the meeting were outlined and agreed.

2. Reports and actions

2.1. Outcome of ICSC 8.

The eighth session of the ICSC was held in the DWD (Offenbach, Germany; 2 to 4 November 2009). This meeting of the ICSC was held in parallel with the 25th meeting of the WGNE and a joint ICSC/WGNE session was organised to discuss closer collaboration between the THORPEX and the WGNE.

The ICSC 8 decisions and the draft ICSC 8 report have been sent to all ICSC 8 participants and Working Group members. The decisions/actions from the ICSC 8 report which are of direct relevance to the DAOS Working Group were outlined as follows.

- Mid-term review

The ICSC has requested a review of the THORPEX programme. This should be completed during 2010 and involve all the THORPEX Working Groups and the Regional Committees (the action required from the DAOS Working Group is set out in section 2.2 below).

- Scientific leadership of THORPEX

Following disbandment of the THORPEX Scientific Advisory Board, the ICSC recognised the need for better, and independent, scientific leadership for the THORPEX programme as a whole. To this end, the ICSC agreed that a strengthened WWRP Joint Scientific Committee (WWRP/JSC) could provide the appropriate scientific leadership that THORPEX requires. In this case the WWRP/JSC would advise the ICSC on the key scientific directions of the programme. The ICSC noted that similar proposals for strengthening the WWRP/JSC would be considered by the Commission on Atmospheric Sciences (CAS) and the ICSC would await the decision of CAS (see item 2.4 of this report).

Other DAOS Working Group actions arising from ICSC 8

(i) The DAOS WG is encouraged to produce an overall authoritative statement on targeting taking account of T-PARC results and other experience gained over the last 10 years.

(ii) The DAOS Working Group should ensure that THORPEX figures prominently in the next IUGG meeting (Melbourne 2011) and IAMAS meeting (Davos, 2013).

(iii) The further involvement of the DAOS/PDP/SERA Working Groups in the analysis of T-PARC data sets is strongly encouraged (see item 5.0 of this report)

(iv) The early publication of the draft science plan for T-NAWDEX was encouraged as was the full involvement of the DAOS Working Groups in its further evolution (see item 6.3 of this report)

(v) Regarding THORPEX Africa, the DAOS and other THORPEX Working Groups were asked to continue to support this initiative.

(vi) It was decided that a workshop should be convened to develop proposals for an IPY follow on THORPEX polar project. This decision was strengthened further at the fifteenth session of the Commission of Atmospheric Sciences (CASXV).

2.2. Progress with the mid-term of THORPEX

The IPO is continuing to make detailed arrangements for the review. Timescales have been adjusted in the light of other demands on IPO time. However, it is expected that the IPO will

soon invite contributions to this review from the THORPEX Working Groups, Regional Committees and Field Experiment PIs and will produce a first draft for review for the WWRP/JSC in January 2011. A revised review will then be presented to the THORPEX ICSC 9. Subject to agreement from the ICSC, a few independent scientists will be invited to assess the review and to provide further input.

Action 1: DAOS WG to provide input to the THORPEX mid-term review

2.3. Outcome of the CASXV meeting

The fifteenth session of the Commission of Atmospheric Sciences (CASXV) was held in Incheon, Republic of Korea (18 to 25 November 2009). The main recommendations of interest to the THORPEX Community and the Working Groups in particular may be found in the following paragraphs of the CAS XV report:

ftp://ftp.wmo.int/Documents/PublicWeb/mainweb/meetings/cbodies/governance/tc_reports/english/pdf/1050_en.pdf

Amongst other things, the following decisions were taken by CAS:

- *Scientific leadership of THORPEX*

The WWRP Joint Scientific Committee (WWRP/JSC) has the following terms of reference:

(i) To provide the overall scientific guidance for the World Weather Research Programme (WWRP), including The Observing System Research and Predictability Experiment (THORPEX)

(ii) The Joint Scientific Committee of OPAG-WWRP shall consist of up to ten scientists selected for their scientific knowledge, capability and breadth of vision. The members of the Committee should be drawn to ensure geographical representation and an appropriate gender balance. The chairs of the working groups and expert teams of WWRP including THORPEX are ex-officio members of the Joint Scientific Committee.

The THORPEX Working Group Chairs have been informed of this decision and will be invited to report and participate in the next meeting of the WWRP/JSC (which is planned for the week beginning 17 January 2011).

- Data assimilation and observing systems

The THORPEX DAOS WG is invited to sponsor publication of a review paper on the results of obs. targeting inc. A-TREC, E-TREC, T-PARC etc.,).

- Sub-seasonal to seasonal prediction.

The Commission requested the JSCs of the WWRP and the WCRP and also the THORPEX ICSC to set up an appropriate collaborative structure to carry out an international research initiative on sub-seasonal to seasonal forecasting. It recommended that this is closely coordinated with the present existing CBS infrastructure for long-range forecasting (with centres producing long-range forecasts and regional climate centres) and with the future developments in WMO climate service delivery and the Global Framework for Climate Services called for in the High-Level Declaration of WCC-3 (see agenda item 6.7).

2.4. Scientific leadership of THORPEX

The new arrangements outlined above in sections 2.1 and 2.3 will be implemented by the IPO.

2.5. Report and actions from previous DAOS WG meetings

These were reviewed and agreed in sec. 12 outlined below.

3. Impact of Targeted Observations

3.1. Initial review of the DAOS authoritative statement on the impact of targeted data in NWP

The main focus of the meeting was to review the previous statement agreed by the WG on targeting and to initiate the production of an authoritative comprehensive review paper to be published in the open literature (e.g. BAMS). This session started that process; later sessions would return to it after presentations of results from relevant research such as the Winter Storms Reconnaissance (WSR) and T-PARC.

Pierre Gauthier (co-chair) led the discussion of the current document setting out the DAOS position on the impact of targeted data in NWP. There was discussion of work that was needed to evolve it towards a review paper. The following points were made:

- There is a consensus that extra-tropical targeted data are about 2-3 times more valuable than the same number of observations deployed randomly. This should be stated.
- Results from the adjoint-based observation impact calculations can be used to explain why we cannot consistently get large impacts from a few targeted observations.
- Targeted observations aimed at improving forecasts of tropical cyclone track have provided demonstrable positive impact. The impact of targeted observations aimed at improving forecasts of extra-tropical storms is less clear to date.
- Targeting for longer-range forecasts is an interesting research topic, but results are not mature enough to make an authoritative statement. However, the paper should state the current position on this topic. Broader-scale regime-based targeting seems the most promising approach.

3.2. Observability of precursors to atmospheric instability

Pierre Gauthier presented results on the observability of precursors to atmospheric instability, such as “key analysis errors” and singular vector (SVs) structures. It was concluded that such structures were not generally observable by operational observations. This is an issue for targeting that aims at characterizing a signal of precursors to instability which may be below the level of observation error. Considering the signal-to-noise ratio, reduced-rank Kalman filters focus on the signal associated with the precursors by representing the background-error that project on a subspace spanned by SVs and may not be as appropriate as the evolved covariances from Ensemble Kalman filters.

3.3. Intercomparison of observation sensitivity experiments

Ron Gelaro presented the DAOS intercomparison of observation sensitivity experiments which has been accepted for publication in MWR. Despite differences in detail of the methods, overall qualitative results from 3 different systems were similar, and useful in diagnosing observation impacts and problems. Some results were relevant to targeting: only a small majority (about 52%) of observations at any one time actually improve the forecast, and most improvement

comes from small changes from a large number of observations – large benefits from individual observations were very rare.

3.4. Targeted thinning of satellite and aircraft observations.

Carla Cardinali presented results from trials of the use of targeting to design efficient thinning of dense satellite observations. Generally the trials were successful in showing that the ECMWF system could use denser data for AMSU-A radiances, and that targeting could be used to select where they would be most useful. However in some seasons and areas results were not straightforward, occasionally extra data did not improve the forecast.

4. Results from Winter Storms Reconnaissance Program

4.1. Summary of main results

Yucheng Song presented results from the historic WSR programme. This had been introduced following the FASTEX, NORPEX, CALJET and PACJET field experiments. The NOAA G-IV was used and flight hours were available from the USAF C130 fleet. The objective was to improve forecasts in the 24-96 hour time frame for significant events. Thus a "threat" was identified using NCEP forecasts. Then sensitive areas were determined in relation to the target area followed by discussions concerning data collection. The operational plan was then implemented and the data supplied in real time. The impact of the additional observations was then determined either in "near" real time or "off –line". Case studies were conducted to compare forecasts with/without the additional data.

Generally speaking it was found that 70% of forecasts were improved with typically a 10-20% reduction in forecast error for these cases of high impact weather. This equated to a 12 hour gain in prediction skill. It was also found that WSR data has 2.7 times more impact per observation than an observation from a random area.

4.2. Future plans on the reanalysis of the results obtained from the WSRP

NOAA and NCEP are sponsoring a re-evaluation of the Winter Storms Reconnaissance (WSR) Program managed by Yucheng Song, Zoltan Toth and Tom Hamill among others for a few recent years. The last assessment of the value of WSR observations to NWP was Toth (2002). The value of observations to a given forecast has however been shown to be dependent on the quality of the NWP system, and given the improvements in NWP over the last decade it was considered that the value of these observations should be reassessed with the most up-to-date assimilation systems and models. This study will focus on the impact on one to four day forecasts over the continental US; the target forecasts for the WSR. While it is not possible to assess the socio-economic impact of individual forecasts the study will assess the feasibility and accuracy of predictions of the impact of adaptive data and how much of the forecast improvement is realized.

While the overall direction of the assessment was accepted, there were considerable discussions as to how to quantify the forecast improvement. The current system is based on comparisons with radio-sondes within a 1000km radius of the initial target area which changes from one case to another. This can pose problems if there are only few observations in the verification domain. Suggestions were made as to using larger fixed domains and using more relevant fields such as total energy norm and/or precipitation (although either of these would require the use of analysis fields). The suggestion was also made that the impact of the observations be judged against the general rate of improvements due to advances in assimilation systems etc., – which historically has been roughly one day gain per decade.

After discussion the DAOS WG made the recommendation for the conduct of re-evaluation studies:

Action 2: The re-evaluation should be performed for at least the two recent years of the WSR, and more if feasible. Various verifications areas should be considered, those used for the original targeting and also larger areas (e.g. East Coast, West Coast and Alaska). To be able to compare with other results, common metrics should be used.

5. T-PARC

5.1. Observation impact in Summer T-PARC and TCS 08

Rolf Langland was unable to attend the meeting although a presentation was submitted.

5.2. Impact of satellite data – especially QUIKSCAT and AMVs

The presentation by Chris Velden highlighted the special efforts to process, distribute, and assimilate AMV datasets from MTSAT during the T-PARC campaign. This included processing AMV datasets at hourly intervals over the western Pacific domain (as opposed to the routine operational AMV production and assimilation at 6-hour intervals). In addition, JMA made available short periods of rapid scan imagery at 15 and 4-minute intervals. CIMSS also processed these images into AMV datasets. All of these special datasets were used in data impact experiments conducted with NRL using the NAVDAS-AR and NOGAPS, with a goal to analyze impacts on typhoon tracks during the experiment period.

Results showed the hourly AMVs had a notable impact on the NOGAPS 3-5 day forecasts of typhoon tracks. Incorporation of the rapid-scan AMVs had an additional significant impact at these forecast lengths. The next experiments will involve mesoscale data assimilation with the NCAR WRF-DART system, with a focus on optimizing satellite data assimilation to improve tropical cyclone intensity analysis/forecasts.

The accompanying presentation by Sharan Majumdar on Ocean Surface Vector Winds (OSVW), and in particular Quikscat, covered the evaluation of the data impact in the GFS system. His study concluded that although the loss of QuikSCAT will be noticed by forecasters, it is unlikely to result in significant degradations to the NCEP global model forecasts of tropical cyclone track. However, for TC intensity prediction, future assimilation of OSVW data may have a significant impact, especially provided the vertical error correlations are optimized in TC applications. He recommended an inter-comparison of how operational DA schemes treat OSVW data. Roger Saunders remarked that the Met Office had shown significant degradations in their model forecasts when QuickSCAT OSVW were denied even though the METOP ASCAT OSVW were used.

5.3. Impact of dropsonde and other aircraft data

The impact of special aircraft-deployed dropsondes during T-PARC has also been analyzed. Sharan Majumdar reported on studies relating the dropsonde information and impact in the context of objective targeting to optimize TC track analysis/prediction improvements. These studies seem to indicate that the dropsonde information in general improves track predictions, but the magnitude of the impact varies with assimilation system and quality of the first guess. Carla Cardinali used the ECMWF system to examine the impacts of satellite radiances (subject to various options for thinning) and dropsondes. In terms of selective satellite data thinning, forecast scores are best for experiments with increased data density in SV-based areas that are updated continuously for each analysis. For typhoon track forecasts, extra-satellite data gave a

more consistent impact due to homogeneous coverage and data diversity (moisture, temperature, clouds, precipitation and surface wind). Dropsondes provide the most beneficial value per observation, but this big impact can produce more extreme beneficial/detrimental impacts for different cases.

6. Brief updates on other campaigns and activities

6.1. AMMA

Carla Cardinali described investigations conducted at ECMWF aimed at increasing and improving the impact of AMVs from Meteosat-8 during AMMA. Closer attention was paid to screening observations based on the quality indicator (QI) from the data provider. The normal procedure is to include only observations with QI ≥ 50. A revised set of experiments was conducted in AMVs over Africa (only) were assimilated with QI ≥ 30. In terms of the impact on the analysis, this resulted in the usage of many more observations and a notable increase in the observation influence measured in terms of DFS. Synoptically, when compared with ancillary observations, the revised assimilation showed improved representation of the low-level monsoon circulation, heat-low circulation and Somali jet. It was suggested that operational centres tend to be overly conservative with their use of these observations, and that closer collaboration with the data providers would likely help make the best use of observations. The possibility of tuning the treatment and usage of AMVs on a regional (vs. global) basis was proposed for possible future study.

Action 3: Operational centres to consider the treatment and tuning of AMVs for regional models.

Florence Rabier described the impact of assimilating observations from the AMMA radiosonde data set in the Météo-France forecast system. The AMMA data set included additional observations that were not received in real time, with enhanced vertical resolution. A bias correction for relative humidity observations, developed at ECMWF, was also tested. The bias-corrected radiosonde data were found to be beneficial, with improved QPF forecasts over Africa. The improvements were found to last on the order of 24 hrs locally, but downstream impacts on geopotential height over Europe were found at forecast ranges of up to three days.

The impact of AMSU-B radiances over land (Africa), which are not currently used operationally, was also investigated. Preliminary indications are that the increased use of satellite data over land may have a large positive impact in the tropics as seen in geopotential scores and comparison of humidity analyses with a GPS network over Africa.

6.2. HyMEX

Alex Doerenbecher gave a brief overview of MEDEX DTS 2009, which involved observational targeting of events heavily oriented toward Mediterranean weather events during 2008 and 2009. Observational resources included additional radiosonde launches, focused over Spain, Italy and Turkey. Sensitive areas were computed at ECMWF and Météo-France.

Differences in the ensemble- and adjoint-based guidance over the Mediterranean were a significant problem during targeting. The major source of disagreement seemed to be associated with shifts in the location and strength of the Mediterranean jet. OSEs and other impact studies are planned at Météo-France. Both global and limited area models will be used.

HyMeX is a multi-year program of modelling and observations aimed at high-impact events related to the hydrological cycle, including drought and heat waves. The program emphasizes the predictability and evolution of intense events, and will monitor events over one decade:

2010-2020. Key questions include: What are the ingredients and their interactions for producing extreme events? How do we reduce impacts of these events?

The implementation strategy involves both observations and modelling. A nested approach will be taken to tackle a wide range of processes. Three regional focus areas: NW Mediterranean, Adriatic, SE Mediterranean. SOPs in different seasons will target different phenomena. Hi-resolution regional EPS coupled to hydrological models and regional climate models will be employed. The HyMeX organizational structure will eventually include 20 countries and 5 working groups, with international links to numerous other programs and projects.

The first draft of the implementation plan is now available. The HyMeX LOP is scheduled to begin in Sept 2010.

6.3. T-NAWDEX

Roger Saunders outlined the developing plans for T-NAWDEX - a European-US collaborative field experiment designed to examine physical processes involved in the triggering, propagation and breaking of wave-guide disturbances and their representations in models and analysis. The inability to capture these disturbances is believed to have a significant detrimental effect on forecasts. The North American THORPEX interests in T-NAWDEX will focus on the trigger of wave-guide disturbances by different dynamical processes. The European science focus will be the downstream evolution of these disturbances.

Partners and funding will come from several countries. It is proposed the UK will contribute the FAAM BAe146 aircraft, ground-based profiler and radar network. The German high altitude long-range aircraft (HALO) will also be involved. Additional contributors and collaborators are being sought. Roger Saunders is also advising on maximising the utilization of satellite data in this effort.

The current schedule calls for completion of the science plan in 2010. A 2nd T-NAWDEX workshop in expected in 2011 and the field campaign should begin in 2012.

6.4. THORPEX Polar project

Jim Caughey noted that at the eighth session of the ICSC it was decided that a workshop should be convened to develop proposals for an IPY follow on THORPEX polar project. This decision was strengthened further at the fifteenth session of the Commission of Atmospheric Sciences (CASXV) when “The Commission concurred with the Executive Council Panel of Experts on Polar Observations, Research and Services on the requirement for effective collaboration and therefore recommended that any efforts to develop a future prediction system includes outcomes from the IPY-THORPEX cluster of projects and from the planned THORPEX Legacy Project”

The main outcome of the workshop to be held in Oslo in early October is the design of a WMO **THORPEX Polar Prediction Research Project** that provides an efficient framework for co-operative international research and development efforts to improve operational weather and environmental prediction capabilities for the Polar Regions and facilitate climate predictions up to a season.

Action 4: The DAOS WG is invited to send comments on the workshop announcement and suggestions for the agenda and speakers to the IPO ASAP.

6.5. ConcordIASI

Florence Rabier gave a presentation on the ConcordIASI experiment which has been a part of the THORPEX-IPY cluster, with the aim to make better use of satellite data over the Antarctic and understand ozone depletion (especially in relation to modeling of gravity wave processes). Concordia is an excellent location to validate satellite data assimilation since it is flat, and has clear skies most of the time.

The program will be from 2008 to 2011, with the main field program in autumn 2010. Super-pressure balloons will be among the new observational resources along with dropsondes.

Preparation for ConcordIASI has already yielded improvements in the forecast systems at ECMWF (albedo over snow) and Météo-France (snow modeling). The improvements at Météo-France have led to an increased and improved use of IASI data. Météo-France is also improving its assimilation of satellite data over sea-ice, which appears to have an impact at lower latitudes as well.

During Autumn 2010, CNES will launch 18 stratospheric super-pressure balloons that measure T and p from a gondola, and will deploy up to 600 dropsondes over several months. The balloons will fly at a height of approximately 25 km height, and stratospheric winds will be deduced from the balloon position. Some balloons will include other instrumentation, including GPS receivers for occultation and ozone sensors. There also will be additional radiosonde ascents at various Antarctic locations to coincide with balloon drops.

Some drops will coincide with METOP overpasses, and drops also will be made in real-time SV-sensitive regions computed at ECMWF.

Pre-ConcordIASI test data over the Indian Ocean was provided on the GTS in Feb. 2010 and were evaluated by some operational NWP centres and found to be of good quality overall.

6.6. YOTC

Jim Caughey indicated that YOTC has been established as an international project coordinated by WWRP-THORPEX and WCRP to address tropical convection and its interaction with the global circulation. YOTC provides the framework and infrastructure for a unique integrated observational-computational resource for research into weather and climate prediction.

The scientific focus is on precipitation systems organized on meso-to-large scales. The emphasis is on time scales up to seasonal and thus enables critical issues at the intersection of weather and climate (seamless prediction) to be addressed at the process level. Key uncertainties in the prediction of global weather and climate are the main targets – the MJO and convectively coupled waves, intra-seasonal variability of monsoons, easterly waves and tropical cyclones, tropical-extra-tropical interaction, and the diurnal cycle.

The major specific elements of YOTC are:

(a) High-resolution deterministic global prediction model analyses, forecasts and diagnostics from ECMWF, NCEP and GMAO;

(b) Satellite, available field-experiment and in-situ observations;

(c) Cloud systems in global data sets;

(d) Parameterized, super-parameterized and explicitly modelled convection;

(e) Theoretical studies.

The original “Year” has been extended to cover a two year period, 1 May 2008 to 30 April 2010, to include the Summer and Winter phases of the T-PARC field experiments and what turned out to be a developing El Niño in winter 2009-10 – prior to that La Niña conditions had prevailed.

6.7. Sub-seasonal – seasonal prediction

Jim Caughey noted that this topic is strongly supported by CAS XV and ICSC-8. A Workshop hosted by the Met Office will be held from 1 to 3 December in Exeter, UK. Proposed topics include establishing current capabilities, defining a high-priority research project and working to establish an international research project on this subject. The Workshop planning team is led by Julia Slingo. Further information is provided in Paper 6.7.

Action 5: The DAOS WG was asked to send any comments on the meeting announcement and proposed agenda and speakers to the IPO ASAP.

6.8. GEO

Some of the weather activities of the GEO Work Plan (which provides the agreed framework for implementing the GEOSS 10-Year Implementation Plan (2005-2015)) were presented by Jim Caughey. The particular GEO Tasks to which THORPEX contributes to were outlined. Societal Benefit Areas can be related to climate issues (GEO Task CL-09-01) and weather. One objective for weather is related to the development of a Global Interactive Forecast System(GIFS) for Weather (GEO Task WE-06-03) and the second emphasizes the importance of assessing the socio-economic benefits in Africa from Improved Predictions of High Impact Weather (GEO Task WE-06-03). GEO is also promoting a seamless approach to climate and weather prediction. The Working Group noted that these tasks provided broad support for three main PDP themes – seamless prediction, ensemble prediction and capacity building for Africa.

6.9. Data assimilation issues in the WWRP-FDP/RDP the Sochi- 2014 Winter Olympics

Michael Tsyrulnikov described some of the emerging plans for the next Winter Olympics. Sochi is on the NE coast of the Black Sea. COSMO will provide the data assimilation/forecast model. A data assimilation system is not yet built; nudging has been used, ETKF is being built and a 3D-Var system in development. The intention is to use a variety of observations, geostationary, MODIS, AMSU-A & B, etc. There may be some supplemental local data e.g. radiosonde observations and some possible new Russian radars and wind profilers.

6.10. Hurricane mesoscale satellite data assimilation

The assimilation of hi-resolution satellite data into mesoscale prediction models for improving TC forecasts was discussed. GFDL used bogus vortex initialization and no satellite DA. HWRF interpolated GFS analysis, removes the vortex then includes a relocated vortex perturbation and then adds via the GSI the large-scale observations. Observations on the hurricane scale are not routinely assimilated. There is an interest in using multiple and integrated satellite data sets at the highest possible resolution in a high-resolution analysis/forecast system. This is being explored with the WRF/EnKF system in NCAR's Data Assimilation Research Testbed, assimilating rapid-scan winds from CIMMS but only 6-hourly assimilation. For hurricane Ike, there was a period of intensification in the analyses that matched the TC VITALs. Satellite-derived surface winds, e.g. QuikSCAT, ASCAT have been considered. Microwave SST data could be used in the data assimilation, and structural information from the microwave sounders. There was discussion of the question: is bogusing / relocation still needed as we move toward EnKFs? The hope is to remove the need for bogusing but at present, for short range forecasting at least, some operational centres still find it can add value to the forecasts.

7. Data targeting: Conclusions

7.1. Perspectives on targeting

A summary of the discussion in the WG on data targeting is given below. This will provide a basis for a review article on the value of targeted observations to be submitted to BAMS.

There are two main ways in which targeting has been tested, impacts on mid-latitude winter storms and impacts on tropical cyclone forecasts. For hurricanes (TCs), the 1982-1996 Atlantic basin experiments suggested about a 30% improvement in track forecasts. From 1997 to the present, missions have been conducted by the NOAA G4 aircraft. Since 2003, a similar program called DOTSTAR has been instituted by Taiwan in the western North Pacific basin

The targeting process for TCs was outlined. Steps include the case selection, quantifying the forecast uncertainty and sensitivity, decision making on targets, and evaluation. Important general questions remain to be fully answered. For example, does ensemble spread accurately indicate predictive uncertainty? Can we identify a priori the low-predictability, high-impact cases?

There are also many other issues to be considered, such as case selection, observation types, the potential adaptive use of the routine observational network (e.g. less thinning of satellite data, or the launch of available raobs at asynoptic times), the effect of the data assimilation scheme and forecast model used, and the method for predicting the influence of the targeted observations.

Some common targeting techniques were reviewed, including singular vectors, adjoint-based, ensemble–based and ensemble variance. Often these determine that maxiumum sensitivity is located in cloudy areas that are not well sampled by satellite data. Other issues concern the lead times needed to arrange flights and the fact that sensitive areas may be broad with multiple sensitive zones.

Regarding the value of targeted data, in mid-latitudes the benefits still need to be quantified. One issue is agreement on an evaluation metric. Small region or large region? Middle-tropospheric variables or variables that related more to weather impact, such as precipitation? The socio-economic community (e.g. SERA) may be able to help here. Early WSR results at NCEP show a 12-h gain in lead time using a norm that measured a reduction in total-energy in a pre-selected verification region of 1000-km radius. Most cases were improved and data collected in sensitive areas are more effective than those from outside the area. There were concerns associated with the use of a flow-dependent metric on which these conclusions are based. To be able to make a more conclusive assessment, it would be preferable to have fixed “objective” criteria, but on the other hand, assessing the impact on intermittent localized high-impact weather event is inherently flow-dependent. The use of different norms explains some differences in the assessment between different experiments. It would be important to make such nuances when making statements on the value of targeted data. As discussed earlier, work is planned for a re-evaluation of some recent years using the current operational version of the GFS model and seeking peer review of the results.

For TCs the value is clearer, but value estimates still vary from model to model, with most models showing an improvement. There is also some evidence that TC targeted observations can have some positive influence far from the observation location (e.g., west Pacific observations) can slightly improve Atlantic basin forecasts. However, the signal from a few observations can be weak, cluttered or contaminated. Evaluation using short period case studies during the field campaign limits understanding. There is a lot of dependence on the previous first guess field which has been affected by the prior targeted observations. Ideally

evaluations should be performed both with continuous data assimilation and on a case by case basis. It is expected that the value of targeted observations to TCs will depend strongly on the data assimilation method used; modern methods such as 4D-Var and the EnKF that can estimate the highly anisotropic structure of the background-error covariances should provide a greater impact, but this has not yet been conclusively demonstrated over a sufficiently large sample size.

Another new diagnostic tool is “observation sensitivity” which can diagnose the improvement or degradation by observation type. It would be useful to extend this to high-impact events. Current results indicate that a systematic sampling of key areas and not at any point in time is the way to go to get the most from observations.

Many studies compute average improvements in a verification region, but is it better to focus on individual cases, especially for high-impact events? It was noted that annual campaigns require annual evaluation to justify their benefit and to derive further benefit as observations, models and DA evolve. Since verification can be performed readily using a variety of norms, future studies should evaluate targeted-observation impact using a wide variety of established and suggested norms. Data should be archived to permit the testing of other norms that may be proposed.

Another issue is making better use of the existing operational observational networks. Examples include on request rapid-scan satellite data, targeted satellite channel selection, adaptive data thinning, increasing observations from commercial aircraft and/or requesting additional radiosonde obs. This area is important for the evolution of the WMO GOS and needs to be fully considered.

In terms of the future, it was noted that propagation/growth of error has historically not been compared to the dynamics of signal evolution, i.e., the predicted change in variance as a result of the data assimilation and subsequent forecast with and without the observations. Regarding targeting for the longer range, model error is important, and non-linearity effects become more significant. There are few results – one shows little impact in mid-latitudes, another bigger impact in zonal flow regimes. Some planned experiments will give further information e.g. HyMEX.

OSEs and OSSEs can be useful e.g. to test new satellite data and thinning algorithms, but there are well known challenges in setting up and maintaining an OSSE development. One must potentially predict the impact of future NWP/DA schemes when assessing the value of the new observation or sampling technique.

7.2. Review of the DAOS authoritative statement on the impact of targeted data in NWP

From the discussions summarized above, the DAOS response would be in the form of a peer-reviewed paper to be completed before the next ICSC meeting where it will be presented. There are several nuances that need to be clearly stated before being able to make any firm statements. The discussions also indicated that more research is needed which relates to our ability to correctly sample a weak precursor signal in the atmosphere that could lead to significant weather development.

Following the discussion above it was agreed that Sharan Majumdar would take the lead in drafting the authoritative comprehensive paper on targeting with contributions and review by the WG members. This paper would then be presented for publication in the open literature.

Action 6: Sharan Majumdar to prepare a draft of the paper during the next few months seeking input as appropriate from WG members and others. The target should be for a definitive draft agreed by the WG for the next ICSC meeting in Jan 2011.

8. General Observational developments

8.1. Satellite

Roger Saunders outlined some recent developments and issues for satellite observations. JMA had switched from MTSAT-1R to MTSAT-2R. Korea had recently launched a geostationary satellite COMSAT 1. The data were awaited with interest. The failure of QUIKSCAT was noted with no immediate replacement although ASCAT on METOP was performing well and provision of data from the Indian OCEANSAT-2 scatterometer was under negotiation. The SSM/I tape recorder on DMSP F-13 had failed leading to the loss of global data but the F-18 SSMIS performance was better than previous SSMIS sensors. The microwave sounders on the Chinese FY-3 series were looking good for NWP use but operational real time access was now required. It was noted that the NASA EOS and ESA ENVISAT research satellites were planned to operate for at least another 5 years i.e. well beyond their expected lifetime, now providing useful long term datasets for climate in addition to NWP. On the other hand not all instruments had a continued nominal performance with the MODIS imager on Terra deteriorating slowly.

Finally the point was made a significant challenge remained of how to best assimilate satellite data in high resolution NWP models.

8.2. Use of IR sounder data in cloudy regions

One recent development to extend the use of advanced infrared sounder data over cloudy regions was to assimilate cloud affected radiances which has led to significant improvements in NWP forecast skill. Florence Rabier showed results from the comparison of the assimilation of cloud affected IASI radiances for 12 hours of data on 18 Nov 2009. About 10 centres participated. Some centres showed better coverage of cloud retrievals than others especially over Antarctica. For cloud top pressure some centres were much lower than other centres. Most centres have pretty similar performance except over Antarctica. ECMWF may look at the adjoint sensitivity of clear+cloudy radiances versus clear radiances.

8.3. Polar Communications & Weather (PCW) Mission

Louis Garand from Environment Canada presented a space mission proposed by the Canadian Space Agency to launch two satellites on a Molniya orbit which would provide uninterrupted coverage of the Arctic region similar to what is obtained elsewhere with geostationary satellites. This fills a gap in frequent observations over the Arctic and would be beneficial for weather, climate and air quality applications. The primary payload would include an imaging spectrometer with 20 channels in the visible and infrared. Other possible instruments for this mission are also explored (e.g. Fourier transform spectrometer similar to IASI). The launch of this mission is anticipated to be some time in 2016.

8.4. Surface based in-situ and remote sensing observations

Bertrand Calpini reviewed the status of Lidar backscattering ratio for water vapour profile measurements. He also showed some results from monitoring of the Icelandic volcanic ash plume top and base from Payerne. It had been possible to extract absolute concentrations of ash using lidar measurements.

The 2010 CIMO radiosonde intercomparison, which is now underway in China, includes MODEM, Vaisala and Chinese radiosondes.

Raman lidar shows vertical water vapour at very high time and vertical resolution and can be available 24 hrs a day. This would be an interesting observation for assimilation into the new high resolution mesoscale NWP models.

8.5. Radar

Tom Keenan outlined the use of radars in NWP. He showed the impact of rain radar data in the ECMWF model indicating positive impacts over Europe even after 7-8 days. NWP assimilation with radar allows the NWP models to be useful down to ranges of 2hr for forecasts overlapping with nowcasting tools. The WG action on providing a universal format for radar data needs to be driven by the NWP community. The lead for this is the WWRP mesoscale working group. One question posed by the WG was does radar really have an impact at longer range as shown recently by ECMWF?

9. Advances in data assimilation

9.1. Recent advances in data assimilation

Andrew Lorenc and Peter Steinle summarised the main outcomes from the 3rd WMO Data Assimilation Symposium in Meteorology and Oceanography held last year in Melbourne, Australia. They noted the number of attendees and the distribution of papers over different data assimilation topics. In particular, substantial interest in advanced data assimilation techniques was mentioned. Another interesting issue appeared to be the lack of effort being made by the meteorological/oceanographic community in the area of coupled data assimilation.

The format of the Symposium was considered appropriate and should be maintained in the future (one big section, oceanographers listen to meteorologists and vice versa, etc.)

9.2. Report on ECMWF Workshop on assimilating satellite observations of clouds and precipitation into NWP models.

Carla Cardinali reported on the joint ECMWF and JCSDA workshop on the assimilation of cloud/precipitation affected satellite observations held at ECMWF on 15-17 June 2010. Issues in satellite data assimilation of cloudy and rainy areas were mentioned. In particular, the rapid loss of observational information gained in the analysis during the subsequent forecast limits impact of cloudy data on atmospheric dynamics and large-scale forecast skill. While satellite data has a large potential for verifying cloud and microphysics parameterizations, the scale mismatch produces noisy statistics. The continued need for linearised/regularised cloud models was emphasized. Other issues include significant non-gaussian statistics and non-linearity inherent in cloud modelling, representativeness problems, and the need for more advanced flow-dependent (cloud vs. clear) background-error covariance modelling.

The model-error issue was briefly discussed and ensemble approaches addressed. New assimilation techniques for non-linear satellite data assimilation were welcomed. The ECMWF effort in "all-sky" satellite radiance assimilation was outlined as relevant to improving the forecasts for cloud and precipitation.

10. Working Group issues

10.1. Membership

At the first meeting of the DAOS in 2006, the rules for establishing membership were discussed. It was decided then that the mandates of the members would be of 3 years and could be renewed only once. One third of the members should be renewed each year to insure a smooth turnaround and bring new ideas to the group. To initiate the process, all members were nominated for two terms, the second term being of one year for one third of the members, two for the second third and three years for the others. At the second working group meeting in September 2008 in Geneva, the Observing Systems working group merged with the Data assimilation working group and increased the membership of the working group. As we enter a more mature phase, it is now important to have clear rules of the nomination process for new members. Track should be kept of the duration of the membership and the process for nomination is for the working group to make recommendations to the ICSC who has the final say in the matter. Currently, the membership is decided on expertise needed for the group to function and it also requires a good representation from all regions (e.g., Asia, Europe, America). The group however is not made up of representatives from organizations (e.g., Meteorological Services). It is formed of renowned individuals with expertise essential for the group.

It was noted that Ko Koizumi resigned from the WG. Jochen Dibbern has also stepped down as he has taken a new post at DWD. Pierre Gauthier is also stepping down as the WG Co-Chair but will remain until a new Co-Chair had been appointed. The current Co-Chairs agreed to consult informally with the membership concerning forwarding a recommendation to the IPO and ICSC for a replacement Co-Chair.

In view of the significant effort and interest in China to support the THORPEX programme, It was agreed that Prof. Bin Wang (China) should be invited to join the WG. This would also maintain the representation from Asia within the working group. Prof. Wang attended the DAOS meeting and presented an overview of the THORPEX related activities planned in China.

Action 7: the DAOS-WG recommended that the ICSC accepts the nomination of Prof. Bin Wang as a member of the DAOS-WG.

Action 8: In consultation with WG members the Co-Chairs should make a recommendation for the appointment of a new Co-Chair to the IPO as soon as possible.

The working group felt no other nominations were necessary at the present time.

10.2. Review of previous actions

Actions from the previous meeting of the WG held in September 2009 in Monterey were reviewed and the status is given in Annex A. Nothing significant emerged with all actions being completed or superseded by new actions of this group.

10.3. Future meetings

It was noted that the WG had met roughly once per year. To keep costs low some of these had been held in the margins of other meetings. Possibilities for a meeting in mid to late 2011 associated with another meeting would be considered by the Co-Chairs.

11. Any Other Business

Prof. Bin Wang gave a short presentation on the work and composition of the Chinese DAOS Group and outlined some of the priorities in advancing 4D-VAR in China. A seminar is planned for Nov. 2010 in order to recommend to CMA some possible ways forward. Activities include DRP (dimension reduced projection) 4D-Var compared to 3D-VAR and 4D-VAR. They are also considering new metrics for targeted observations.

Annex A: DAOS WG Actions Status

The following actions from the previous DAOS WG meeting at the TTISS in Monterey and the ICSC-8 meeting in Offenbach were reviewed at the DAOS WG-3 meeting in Montreal and their status is recorded below.

Actions from TTISS:

- *Links to Africa* The links with the African regional plan and legacy of AMMA were discussed. EUCOS plans to equip Air France aircraft flying into Africa with AMDAR but this is on-hold at present due to technical problems. The DAOS group would evaluate the additional observations if they become available. *Status: There was a technical problem with equipping the Air France aircraft and so it has not been possible to obtain any data. DAOS should continue to monitor this. Closed.*
- Input to observational campaigns. A new action which arose during TTISS was to advise T-NAWDEX on the use of satellite data. R. Saunders will discuss this with the T-NAWDEX team and the DAOS WG will review the science plan when available. *Status: R. Saunders met with Sarah Jones and gave some inputs but still awaiting sight of the T-NAWDEX science plan. Open.*
- Targeting, intercomparison experiment report on value of TIGGE data for estimating model error covariances. A. Lorenc reported that the Met Office is using their own ensembles as the TIGGE data do not have high enough resolution fields. Jim Hansen has reported on diagnosing model error using the TIGGE ensemble forecasts. *Open*
- To pursue with WMO a standardized format for exchange of radar data. OPERA in Europe is a good example of this. T. Keenan is pursuing this action with the relevant WMO groups on data formats. *Status: The WWRP mesoscale group are pursuing this. Closed.*

Actions from ICSC-8:

- The DAOS Working Group is encouraged to produce an overall authoritative statement on targeting taking account of the T-PARC results and the experience gained over the last 10 years. *Status: This was discussed and a lead author appointed at the DAOS-3 meeting in Montreal to draft a paper for BAMS. Underway*
- The ICSC encourages NMHSs to analyse the PREVIEW case studies identified by EUCOS. *Open*
- The further involvement of the PDP /DAOS/SERA Working Groups in the analysis of T-PARC data sets is strongly encouraged. *Further results from the T-PARC datasets were presented at the DAOS-3 WG meeting (see 5 above). Closed.*
- The Impact of satellite data in T-PARC studies needs special attention, especially Quickscat data, which could be important to help maintain continuity of this data stream. *This was addressed by a presentation in the DAOS-3 WG meeting (see 5.2 above). Closed.*

Actions from DAOS-3

Action 1: DAOS WG to provide input to the THORPEX mid-term review

Action 2: The re-evaluation should be performed for at least the two recent years of the WSR, and more if feasible. Various verifications areas should be considered, those used for the original targeting and also larger areas (e.g. East Coast, West Coast and Alaska). To be able to compare with other results, common metrics should be used.

Action 3: Operational centres to consider the treatment and tuning of AMVs for regional models.

Action 4: The DAOS WG is invited to send comments on the workshop announcement and suggestions for the agenda and speakers to the IPO ASAP.

Action 5: The DAOS WG was asked to send any comments on the meeting announcement and proposed agenda and speakers to the IPO ASAP.

Action 6: Sharan Majumdar to prepare a draft of the paper during the next few months seeking input as appropriate from WG members and others. The target should be for a definitive draft agreed by the WG for the next ICSC meeting in Jan 2011.

Action 7: the DAOS-WG recommended that the ICSC accepts the nomination of Prof. Bin Wang as a member of the DAOS-WG.

Action 8: In consultation with WG members the Co-Chairs should make a recommendation for the appointment of a new Co-Chair to the IPO as soon as possible.