Ninth Session of the Scientific Steering Committee (SSC) for the World Weather Research Programme (WWRP)

(Geneva, Switzerland, 24-27 October 2016)
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ORGANIZATION OF THE MEETING

The ninth session of the Scientific Steering Committee (SSC-9) of the World Weather Research Programme (WWRP) was held at the World Meteorological Organization (WMO), Geneva, Switzerland, from 24 to 27 October 2016. The session started at 1.30 p.m. with members of the WWRP SSC, the President of the Commission for Atmospheric Sciences (CAS), Chairperson of the WWRP SSC, and Chief of the World Weather Research Division (WWRD) meeting in conference room 6L while those representing WWRP working groups and projects met in conference room 6J.

GROUP A - WWRP SSC MEETING

A.1 Opening and welcoming remarks

The participants (see Annex I) were welcomed to the meeting by the Chairperson, Sarah Jones and by Paolo Ruti, Chief of WWRD.

Oystein Hov, President of CAS, thanked the hosts and expressed his hope for a successful and productive meeting especially at this time that WMO is at a stage which puts more emphasis on the outcomes of its meetings. He expressed his satisfaction on the manner that the WWRP was developing and in particular at the recently published WWRP Implementation Plan (IP) for 2016-2023 which would further promote the progress and realization of the objectives of the programme.

A.2 Global Data Processing and Forecasting Systems (GDPFS)

The CAS President briefed the Committee on new developments in the implementation of WMO’s GDPFS which is a part of WMO’s World Weather Watch under the Commission for Basic Systems (CBS). It is organized as a three-level system of: World Meteorological Centres (WMCs), Regional Specialized Meteorological Centres (RSMCs) and National Meteorological Centres (NMCs), which carry out GDPFS functions at the global, regional and national levels, respectively. GDPFS supports other WMO Programmes and relevant programmes of other international organizations in accordance with policy decisions of the Organization. Its main purpose is to prepare and make available to members in the most cost-effective way meteorological analyses and forecast products. The design, functions, organizational structure and operations of the GDPFS are in accordance with members’ needs and their ability to contribute to and benefit from the system.

Mr Hov reported on the new strategic focus of WMO, the convergence of weather, climate and environment in a seamless model system, the growing expectations of WMO Members, increase in interdisciplinary and programme activities and decrease in the budget allocated for activities. To enhance the benefit of the relationship between NMHSs and the societal sector, GDPFS needs to be Research and Development (R&D) driven, leading to evolution of post-processing models, new or advanced use of observations, and backend data stream delivery into sectoral decision systems. National Meteorological and Hydrological Services (NMHS’s) R&D needs to further build interdependencies with academia and the private sector R&D capabilities to feed the quality and variety of the «science to service»-value chain in the NMHSs. This relationship, it should be noted, is quite advanced in CAS where a significant percentage of the experts are from outside of NMHSs. A threat to the sustainability of NMHSs
is the dominance of routine, rule-driven operations which had remained static over long time periods with little new feedback to and from R&D in their core activities.

CBS is the custodian of the operations in NMHSs in all fields. The 17\textsuperscript{th} Session of the WMO Congress (Cg-17) (Geneva 2015) and 68\textsuperscript{th} Session of the WMO Executive Council (EC-68) (Geneva 2016) had initiated a move towards a new and enhanced (GDPFS), Global Observing System (GOS) and Global Telecommunication System (GTS) driven by the following factors: (a) Operational Numerical Weather Prediction (NWP) is cascading from global down to the national levels which encourages the development of a seamless (GDPFS) (b) a growing technology gap in operational forecasting between developed and developing countries (c) growing requirements in all sectors (aeronautical, marine, agriculture, health, public weather services etc.) and (d) a move towards impact-based forecasting and risk-based warnings which requires information on vulnerability and exposure in the operational process.

Thus the need for a seamless GDPFS which is adaptable to support various applications (e.g. aviation, agriculture, marine operations) and to predict weather-related elements as well as support impact-based forecasts and warnings. In line with this effort, EC-68 (2016) established a GDPFS Steering Group chaired by the president of CBS, and includes representatives of technical commissions and regional associations. CBS and CAS are co-chairing the GDPFS management group. The CAS President noted that as CAS and CBS have the same experts in their groups/teams/committees, both should enhance their efforts to work together towards the development of a seamless GDPFS.

Comments noted after a brief discussion were:

- There is a need for a WMO Statement to encourage NMHSs (especially in developing countries) and the academia to work together.
- To be useful, operations will need to adapt better to user requirements.
- The WWRP Implementation Plan should be well aligned to GDPFS plans to avoid overlap or duplication.
- Abdoulaye Harou, Chief of the Data-processing and Forecasting Division (DPFSD) reported that the Steering Group for the Seamless GDPFS established by EC-68 is preparing a white paper to be submitted to 69\textsuperscript{th} Session of the Executive Council EC-69 (Geneva, May 2017).

A.3 Previous year’s actions and CAS MG inputs

The Chief of WWRD, Paolo Ruti, provided a summary of the actions emanating from the 8\textsuperscript{th} Session of the SSC (SSC-8) (Geneva, 24-27 November 2015) and inputs from the 11\textsuperscript{th} Session of the CAS Management Group (MG-11) meeting (Geneva, 1-3 June 2016).

A.3.1 WWRP SSC-8 Action Items (actions/comments in bold):

- SSC to consider new members for the Polar Prediction Project (PPP) Steering Group (SG)

Two new members from the social science community and one new member leading a European Union Project on the Arctic was added to the SG membership.

**Draft version of the WWRP Implementation Plan was approved by EC-68.**

- Sub-seasonal to Seasonal Project (S2S) SG to link with CBS for fostering transition of research to applications.

**S2S provided input for GDPFS document for 16th Session of CBS (CBS-16) and a member of the S2S SG will be a part of the CBS Expert Team on Operational Prediction from Sub-seasonal to Longer Time Scales (ET-OPSL).**

**Oystein Hov, CAS President, will represent CAS at CBS-16 (Guangzhou, China, 23-29 November 2016).**

- S2S-SG to improve the extent of joint activities with PPP on Tropical to Polar Teleconnections.

**Research Plan of S2S Teleconnection Sub-project was updated and is available online.**

- S2S-SG to strengthen South America and Africa involvement in sub-projects.

An S2S side event was organized at EC-68 which was attended by the new Director-General of European Center for Medium-Range Weather Forecasts (ECMWF).

**Project Proposals for two regional sub-projects (India and South America) was prepared and submitted to the Global Framework for Climate Services (GFCS).**

- High Impact Weather Project (HIWeather) Co-chairpersons to invite stakeholders/donors and representatives of WWRP Working Groups (WGs)/Projects to its kick-off meeting in 2016.

**A number of stakeholders/representatives of donor agencies and representatives of WWRP WGs and Projects attended the HIWeather kick-off meeting (Exeter, UK, 27-29 April 2016.)**

- HIWeather Co-chairpersons to work jointly with World Climate Research Programme (WCRP) on the subject of extremes and their climatological behaviour.

**Jon Polcher attended the HIWeather kick-off meeting as representative of the WCRP Global Energy and Water Cycle Experiment’s (GEWEX) Global Hydroclimate Project (GHP).**

- SSC to appoint a new Co-chairperson for the Working Group on Predictability, Dynamics and Ensemble Forecasting (PDEF-WG) to replace Richard Swinbank whose term ended in 2015.

**John Methven was appointed as new Co-chairperson of PDEF-WG.**
- The Working Group on Nowcasting and Mesoscale Research (NMR-WG)
  Co-chairpersons to propose a strategy to integrate in a broader context the activities
  of Research and Development Projects (RDPs) and Forecast Demonstration Projects
  (FDPs) which they oversee and to link these activities with resource mobilization.

  **This will be taken up during the discussion of the new WWRP Implementation Plan.**

- SSC to review the terms of reference of RDPs and FDPs.

  **This will be taken up during the discussion of the new WWRP IP.**

- Chairperson of Expert Team (ET) on Weather Modification (WM) to propose either
  the organization of a workshop or preparation of a reference –paper analysing all
  experiences on WM and new technologies with the involvement of the WCRP/CAS
  Working Group on Numerical Experimentation (WGNE) and Sand and Dust Storm
  Warning Advisory and Assessment System (SDS-WAS).

  **Report to be presented at the next WGNE meeting (WGNE-32, Exeter, UK, 9-13 October 2017)**

- Chairperson of the Aviation Research and Development Project (AvRDP) and the
  Secretariat to propose a road-map for the transition of the RDP to the Inter-
  Commission Aviation Research Project.

  **Draft Road Map had been prepared in consultation with the Chief of the
  Aeronautical Meteorology Division (AeMD). Plans are underway to organize
  an Aeronautical Meteorology Scientific Conference (AMSC-2017) in Toulouse,
  France from 6-10 November 2017 to provide an overview of the current
  state-of-the-art and foreseen advances in meteorological science and
  technology needed to underpin the changing global aviation industry, in line
  with the International Civil Aviation Organization’s (ICAO) Global Air
  Navigation Plan (GANP) and its Aviation System Block Upgrades (ASBU)
  methodology.**

- Co-Chairpersons of PDEF-WG and Working Group on Data Assimilation and
  Observing Systems (DAOS-WG) to coordinate future initiatives for coupled multi-
  scale systems ensembles and running ensemble data assimilation coupled systems.

  **Members of the WGs (i.e. PDEF and DAOS) attended the HIWeather kick-off meeting in 2016.**

- SSC to endorse the Years of Maritime Continent (YMC) (2017-2017).

  **Letter of Endorsement sent to YMC.**
A.3.2 **CAS MG-11 decisions (related to WWRP and Global Atmosphere Watch (GAW))**

**Decision 1:**

**Decision 2:**
Membership of selected WWRP and GAW WGs:
- NMR-WG – Rita Roberts (USA) Co-chairperson
- Environmental Pollution and Atmospheric Chemistry (EPAC) SSC – to include a UNEP representative (Valentin Voltescu nominated – to be confirmed by UNEP) as ex-officio member
- WGNE – new members: Ariane Frassoni (Brazil), Gunther Zangl (Germany)

**CAS MG-11 (Geneva, 1-3 June 2016) recommendations:**

**Recommendation 1:**
The President of CAS and the Secretariat to discuss with other technical commissions and the GFCS the development of two-three high profile projects that raise the WMO visibility and impact, involving CAS programmes. An initial set could comprise the Integrated Global Greenhouse Gas Information System (IG3IS), HIWeather, Coupled Hydrologic, Hydrodynamic and Atmospheric Modelling Project (CHAMP) and S2S.

**Recommendation 2:**
The CAS Management Group (MG) to prepare a paper for submission to the 17th session of CAS (CAS-17) identifying concrete actions to strengthen collaboration between CAS and CBS.

**Recommendation 3:**

**Recommendation 4:**
CAS to collect best practice guidelines on research from different countries before May 2017 and to consider to propose a document on that to EC-69.

**Recommendation 5:**
The President of CAS, in collaboration with the Secretariat, to propose to the WMO Secretary-General to allocate specialized resources to attract new funds.

**CAS MG-11 Actions Items (related to WWRP)**

**Action Item 1:**
The Chairperson of WWRP SSC and the Chief of WWRD to improve the presence of African Monsoon experts in the WGs, specifically in the Working Group on Tropical Meteorology Research (TMR-WG).

**Action Item 2:**
The Chiefs of Atmospheric Environment Research Division (AERD) and WWRD to set up appropriate communication channels to foster the interaction between the Chairpersons of
WCRP’s Joint Steering Committee (JSC), EPAC Scientific Steering Committee (SSC), and WGNE (e.g. regular teleconferences)

**Action Item 3:**
The President of CAS to propose to the WMO Secretary-General to raise WMO profile in research funding circles (e.g. Belmont Forum, http://www.belmontforum.org/), proposing a focal-point (possibly from the Executive Council), in order to maintain and build momentum in atmospheric research and model development across timescales.

**Action Item 4:**
The CAS and Research Department to interact with the GFCS (i.e. the GFCS Task Team on Operational and Resource Plan (ORP)) in order to improve the support to existing projects.

**Action Item 6:**
The EPAC SSC and WWRP SSC Chairpersons, and Chiefs of AERD and WWRD, to continue to work on the respective implementation plans after EC-68, in order to improve the link with other technical commissions and key external partners (including consultations with these partners)

**Action Item 9:**
All Co-chairs (WGNE, WCRP JSC, EPAC SSC, WWRP SSC) to find the best solution for integrating with two GEWEX panels, namely the Global Atmospheric System (GASS) and the Global Land/Atmosphere System Studies (GLASS) into a WMO modelling improvement perspective.

**Action Item 15:**
The President of CAS to discuss with WMO Executive Management the financial situation of the trust funds of S2S, HIWeather and SDS-WAS.

**Action Item 18:**
The CAS MG Members to brief Permanent Representatives attending EC-68 on the risk of overlap in the structures of GDPFS and WWRP. Chairpersons of EPAC SSC, WWRP SSC and WGNE to review the GDPFS document and suggest the way forward to the President of CAS to better integrate existing WGs for the success of GDPFS. First inputs from the members of the MG are due before EC-68.

**A.4 - Analysis of WGs and projects next two-year detailed plan**

The SSC noted that two booklets on the WWRP Implementation Plan are being prepared. Booklet 1 provides an introduction and a broader vision of the 8-year plan. Booklet 2 provides the detailed activities proposed by the WGs and projects to help achieve the overall WWRP programmatic goals on each of the four themes and 18 action areas for the two-year period (2017-2018).

**Evaluation of feedback from WGs and projects**

- Feedback was received from all WGs and projects. Information provided were sparse except from DAOS-WG.
- Overall, the feedback was quite comprehensive and covers to a good extent most of the four themes (High-impact Weather, Water, Urbanization, and Evolving Technologies).
• Only a few suggestions for concrete activities were received so far on the following action areas:
  AA 7: Water – Integrated Water
  AA 10: Water – Hydrological Uncertainty
  AA 12: Urbanization – Observations and Processes (Chemical Aspects)
• Some feedback received was vague especially on their implementation.
• Some activities are covered only by organizing workshops, more actions with concrete outcomes are therefore needed.

It was suggested that future WWRP activities should also cover the following:

• Contributions to ongoing or future initiatives (e.g. North Atlantic Waveguide and Downstream Impact Experiment (NAWDEX), Mesoscale Verification Inter-Comparison over Complex Terrain (MesoVICT), International Collaborative Experiments for Pyeongchang Olympic and Paralympic 2018 (ICE-POP2018), Understanding and Prediction of Rainfall Associated with landfalling Tropical cyclones (UPDRAFT) etc.).
• Workshops or events to be organized in conjunction with major conferences (e.g. European Meteorological Society (EMS), European Geophysical Union (EGU), American Meteorological Society (AMS) etc.)
• Members attending relevant conferences or are members of non-WWRP bodies/panels/committees.
• Facilitation of access to datasets and information of their usage and accessibility.

Evaluation of feedback from partners and donors

• Many of the challenges of WMO are the same as those faced by other international programmes.
• Working in partnership on shared interests, combining efforts and information exchange will not only be advantageous to all parties involved but will eventually benefit the society, the economy and the environment.
• Feedback from partners helps to generate ideas and increase the relevance of proposed WWRP activities.
• It is important that the WWRP IP identifies and analyse the interests of stakeholders and respond to their needs.

Evaluation of external feedback

• Overall, perception of the WWRP IP was good, indicated by positive comments on the proposed activities.
• The following shared interests were identified:
  - communicating uncertainty
  - transitioning research to operations and their implementation
  - joint activities in developing countries (e.g. observations)
  - coupled modelling
  - link to socio-economic models
  - data exchange and traceability
  - new and unconventional observations
  - development of observations
  - WMO Integrated Global Observing System (WIGOS) 2040
  - understanding and improving cloud processes and cloud-aerosol interactions
- Some missing aspects were also identified:
  - representation of teleconnections and model fidelity
  - role of climate change – anthropogenic influence (e.g. on clouds)
  - data management when it comes to development of future observing systems
  - ground water monitoring.

**Analysis of WGs and projects activities by SSC members**

*PPP (Focal Point: Randy Dole)*

The number of activities undertaken by the project during the past year is remarkable particularly as it reported a featured project activity almost every month. It is also worth noting that PPP had taken into consideration the societal, economic and end-user aspects in their planning which makes it a truly service-oriented research project. The PPP International Coordination Office located at Bremerhaven, Germany is currently staffed by highly-qualified experts and support staff. PPP works in close collaboration with WCRP, S2S, and DAOS-WG and USA’s National Oceanic and Atmospheric Administration (NOAA) had assisted in testing new products of the project. Experts from at least 22 countries are currently involved in the project and many countries are contributors to its trust fund. It is interesting that PPP’s future planned activities includes understanding the role of the polar ocean, sea ice and stratosphere in medium-range and extended range prediction.

*HIWeather (Focal Point: Ben Lamptey)*

The HIWeather kick-off meeting (Exeter, UK, 27-29 April 2016) was a success. It attracted the participation of 84 scientists from 21 countries. A significant number of the attendees were social scientists and there were also a few from funding agencies. During the kick-off meeting, communicating risk and uncertainty was identified as one of the important challenges of HIWeather. The Project will address extreme weather issues at the national level through RDPs and FDPs. HIWeather should capitalize on previous work done at the ECMWF particularly on subjects related to high impact weather events. It would also be to its advantage if it were to establish links to ongoing projects such as the Remote Sensing of Electrification, Lightning, and Meso-scale/micro-scale Processes with Adaptive Ground Observations (RELAMPAGO) Project led by the Meteorological Service of Argentina. There is a pressing need to identify ways to attract more contributors to the HIWeather trust fund as it can barely support the activities of the project. The Global Facility for Disaster Reduction and Recovery (GFDRR), a multi-donor partnership and grant-making facility, was identified as a possible funding option.

*Working Group on Societal and Economic Research Applications (SERA-WG) (Focal point: Celeste Saulo)*

An expert with an impressive background on social science had recently been accepted as the newest member of the working group. Currently, the WG is seeking for another expert to fill one more vacancy, preferably someone with a social science background. It is rather disappointing that no written report was received from the working group before this meeting and that the contribution for the implementation plan was insufficient. It was noted that some SERA-WG activities were on HIWeather but there is a need to identify some activities focused on the urbanization theme.
The WG had been very active the past year, organizing several workshops, preparation of reports, and follow on activities all indicated in their report. One activity worth noting was NAWDEX which ended this month after 15 very interesting Intensive Observing Periods (IOPs) with observations in a diverse set of weather systems. Plans for 2017 included a workshop on systemic errors to be co-organized with WGNE. PDEF-WG activities are focused on five areas which all link well to the WWRP Implementation Plan for 2016-2023. Regrettably, it was not very evident from their report how they will address some issues especially those on big data. Also, it was noted that the WG had no planned activity on urban matters where they could most likely play a significant role. It was suggested that PDEF-WG establish links with DAOS-WG and also consider cross-representation in their meetings.

WM-ET (Focal Point: Michael Morgan)

The ET reported that in recent years, the number of countries operating weather modification technology had increased and because of this the team had recently received more requests from some countries for advice in the evaluation of their activities. Plans are for the ET to prepare a best practices document or guidelines on what constitutes a good weather modification experiment/research study. It was also noted that some countries want to conduct weather modification activities without going through the necessary preparatory work or feasibility studies. It was suggested that the ET establish links with the JWGFVR as operational projects need verification. It was also suggested that the ET consider studies on the programmatic aspects underlying the development of new technologies for use in weather modification activities (i.e. identifying their potential benefits and limitations) and to also focus on urban issues. The ET continues to be extremely concerned by the lack of resources for the team to do their mandated tasks such as conducting research and organizing meetings and workshops.

TMR-WG (Focal Point: Dong-Kyou Lee)

It was interesting to note that the WG had been at its most active in 2016 with overseeing three research projects, two on tropical cyclones and one on monsoons and organizing various meetings and workshops. It was also noted that the WG continues to have strong links with other WMO programmes foremost of which is the Tropical Cyclone Programme and that it had also established links with HIWeather, S2S, Joint Working Group on Forecast Verification Research (JWGFVR), NMR-WG and SERA-WG. It is however desired that links with WGNE should be enhanced. The WG is composed of two panels, one dealing with tropical cyclone research issues and the other on monsoon research. Each panel had regularly published books and scientific articles. Just recently, the Monsoon Panel of the WG completed the manuscript for the third book in the Global Monsoon System series which is due for publication in early 2017. One of the WG’s expert teams is currently preparing materials for input to the sixth Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR-6) . The WG is also actively involved in the Years of Maritime Continent and in assisting in the preparation of two new research projects on tropical cyclones and one on monsoon rainfall. Details of these projects are provided in the WG report. Preparations are also underway to organize two serial events: the 4th International Workshop on Tropical Cyclone Landfall Processes and the 6th International Workshop on Monsoons both scheduled for 2017.
WWRP/WGNE Joint Working Group on Forecast Verification Research (JWGFVR)
(Focal Point: Beth Ebert)

The WG had done remarkably well in 2016, maintaining strong links with most if not all of the WWRP working groups and projects. As it needs to establish links with PDEF-WG, the WG plans to organize a joint meeting sometime in 2017. Most interesting of its cross-cutting activity is the ongoing competition to develop and demonstrate a new user-oriented forecast verification metric in support of the three WWRP core projects (HIWeather, S2S and PPP). Another notable activity is the Mesoscale Verification Intercomparison over Complex Terrain (MesoVICT) project. MesoVICT is a community project which is actually a continuation of the spatial forecast verification inter-comparison project (ICP) which was set up to attempt to sift through the maze of newly proposed methods for verifying primarily high-resolution forecasts. MesoVICT continues with the ICP aim but included more meteorologically complex test cases to compare the various newly proposed methods to give the user information about which methods are appropriate for which types of data, forecasts and desired forecast utility.

As a number of JWGFVR members are due to retire, it was suggested that the WG should consider the following fields of expertise when choosing a replacement: urban meteorology, social media, aviation, monsoon, sea ice, impacts, dust/air quality and climate. During the discussion, it was mentioned that although crowdsourcing can be a valuable tool for improving the quality and usefulness of data, its application still has many challenging issues to be resolved which the JWGFVR can look into.

Nowcasting and Mesoscale Research Working Gorup (NMR-WG)
(Focal Point: Veronique Ducrocq)

The 2016 Nowcasting workshop which was organized by the WG and held in Hong Kong was very successful. It was noted that there are still some membership issues to deal with and that the WG need to establish links with the Severe Weather Forecast Demonstration Project (SWFDP). The WG plans to develop a dedicated website and prepare a nowcasting guidelines document. It needs however to further review its inputs to the WWRP IP and indicate more tangible outcomes of its activities.

Sub-seasonal to Seasonal Prediction Project (S2S) (Focal Point: Randy Dole)

One of WWRP’s strongest links to WCRP is through this project. Its key deliverable in 2016 was the creation of the S2S database, a compilation of sub-seasonal predictions. An article on this database will be published in a 2017 issue of the Bulletin of American Meteorological Society (BAMS). S2S has a strong emphasis on the Madden-Julian Oscillation (MJO) but needs to delve more into studies on tropical convection and address stratosphere issues. It was noted that the number of users of the S2S database continues to increase and that plans are for possible collaboration with PDEF-WG. Most commendable was the training schools that S2S regularly organizes.

Data Assimilation and Observing Systems Working Group (Focal Point: Peter Bauer)

The WG had done significant work in 2016, particularly in research work on larger scales, but it could do more by reinforcing its links with NMR-WG and PDEF-WF. Noting that data assimilation techniques used with operational convection permitting models had done
remarkably well in increasing the skill of forecasts it was suggested that a review, especially on new types of observations, could be very interesting.

A.5 - Feedback from WGs and project sessions

The discussions during the half-day meeting was very productive as after the one-on-one discussion, the group became aware of commonality of some of their activities with other groups/projects which were previously not known or were not given the attention it needed. The group also provided additional ways on how to best gauge the relevance of WWRP. The list of future and ongoing collaborative work between the working groups and projects are summed up in a table (see Annex II).

GROUP B - REPRESENTATIVES OF WWRP WGS AND PROJECTS

B.1 Opening and welcoming remarks

The meeting, attended by representatives of WWRP working groups and ongoing projects was opened by the Director of WMO’s Research Department, Deon Terblanche.

B.2 Implementation plan concrete outcomes

Nanette Lomarda, Senior Scientific Officer of WWR Division, provided the discussion points for the afternoon meeting which included:

- Activities for the next two years (2017-2018)
  The detailed/concrete plan (activities, projects, field campaigns etc that address the selected activities under each action area will be incorporated into Booklet 2 of the WWRP IP. This will be updated on a two-year rolling basis

- Links with other WWRP working groups/projects
  To include ongoing or future collaboration

- Comments received from the group on how to best measure the relevance of WWRP:
  - Quality of work (e.g. number of high level scientific publications)
  - Interest in organized events such as workshops, conferences etc. (number of participants/represented countries/members)
  - Use of/reference to meeting reports/publications etc.
  - WMO Member satisfaction (through surveys)
  - Timely completion of activities (on schedule)
  - Manages to keep within the budget plan
  - Developed guidelines for best practices, applicable in various set-ups/countries
  - Publication of annual report
  - Defining milestones to be achieved in different scientific areas
  - Reception by the scientific community (through surveys)
  - Other WMO Members are motivated to engage with WWRP or support WWRP as a good investment
  - Research results accessible to a broader community
- **Trust by members on the quality of work/service provided by WWRP**
- **Work excellence**
- **Positive impact to society, economy, and the environment**

**B.3 Discussion on the next two-year implementation plan**

As planned, the participants discussed cross-cutting activities and plans for the next two years of each working group/project and the most efficient way they can collaborate with one another.

**WWRP SSC-9 MEETING**

**Opening and welcoming remarks**

The Deputy Secretary-General, Elena Manaenkova, in her welcome remarks informed the participants of the new WMO strategy (2016-2023) and changes that could be expected in the way that the Organization will operate in the years to come. She was pleased to note that the recently issued WWRP IP for 2016-2023 is very much in line with WMO and CAS priorities and the Programme's strong focus on research into high impact weather events including the societal impacts. She wished everyone a successful and productive meeting.

The Chairperson of the SSC, Sarah Jones reported on the significant progress made in the development of the WWRP IP (2016-2023) during the past year and also on some key developments at WMO.

The Chief of WWRD, Paolo Ruti, welcomed all participants to the meeting and mentioned significant new developments in observing and forecasting systems.

The Director of the Research Department, Deon Terblanche, in his welcome remarks presented WMO’s priorities, future research challenges, importance of social science and partnership with academia and the private sector in making our work sustainable and relevant. In closing, he remarked that the experts, the participants in this meeting, is the WWRP and that the Secretariat role is to provide assistance and support to the experts.

The President of CAS, Oystein Hov, made a presentation on the Weather, Environmental and Climate Enterprise (the role of research), the seven WMO priorities (WMO Strategic Plan: 2016-2019) and how WMO is carrying out its mission. He also mentioned the four main key strategic elements presented by the WMO Secretary-General which are mostly driven by changes in the global scene. In his presentation, he mentioned that although weather and climate information is often a requirement for a knowledge-based approach to reach the UN sustainable development goals, the two elements are usually not a main focus. He enumerated the 17 competitive services required to close the gap between research and operations and the six societal challenges of the commission.
Comments during discussion

- Data access, which is critical to operations and research, especially from the private sector remains a challenge.
- Need to work on ways to encourage the private sector to provide much needed operational data to be used for research.
- Substantial research work needs to be done first before it can be used in operations.

PROGRESS AND PLANS OF WWRP WORKING GROUPS AND PROJECTS

The reports of the various WGs and projects are provided below:

1. **Polar Prediction Project (PPP)**
   **Chairperson:** Thomas Jung (remote)

   **Mission**
   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

   **Key highlights in 2016**
   - A paper summarizing the PPP’s approach to advance polar prediction capabilities on daily to seasonal time scales has been published in the Bulletin of American Meteorological Society (BAMS) in January.
   - PPP side meeting at Arctic Science Summit Week (ASSW2016 (Fairbanks, Alaska, 14 March).
   - First Polar Prediction School (Abisko, Sweden, 5-15 April).
   - First meeting of sub-committee PPP-SERA (Christchurch, New Zealand, 18-22 April).
   - PPP Steering Group Meeting (SG-7) (Beijing, China, 22-25 May).
   - Funding was granted in June by the European Union Horizon 2020 for the Advanced Prediction in Polar regions and beyond: modelling, observing system design and LInkages associated with a Changing Arctic climate (APPLICATE) Project and the Blue Action: Arctic Impact on Weather and Climate Project proposals. The two projects will be coordinated by members of the PPP Steering Group.
   - In August, the request for Year of Polar Prediction (YOPP)(mid-2017 to mid-2019) endorsement was launched online and a revised version of the YOPP Implementation Plan was released.
   - YOPP Planning Meeting (Reading, UK, 5-9 September).
   - First PPP Newsletter was published in October.

   **Links with other working groups, projects, international initiatives**

   **DAOS-WG:** discussions are ongoing on contributions to the observing design (e.g. data denial experiments) shortly after the YOPP core phase. Furthermore, coupled data assimilation is a topic where collaboration is being established.

   **NMR-WG:** There is scope for strengthening the collaboration with the WG especially in the area of limited area ensemble forecasting during the YOPP core phase.
PDEF-WG: John Methven, Co-chairperson of the WG participated in the YOPP planning week held in early September 2016. Areas of collaboration include collaboration in NAWDEX and the YOPP core phase.

JWG-:FVR: One of the main outcomes of this collaboration has been a joint report on forecast verification in polar regions which will be published in May 2017.

SERA-WG: The leaders of the PPP-SERA task team have recently contacted Linda Anderson-Berry (Co-chairperson of SERA-WG) with the aim of establishing a strong link between the two groups.

S2S: Plans are for the PPP community to use the S2S database for research purposes. At the same time there is ongoing discussion on the provision of additional PPP-relevant parameters. Coordination is also envisaged with respect to the Year of Tropics-Midlatitudes Interactions and Teleconnections (YTMIT) (mid-2017 to mid-2019).

WCRP-Climate and Cryosphere (CliC): The Abisko Polar Prediction School was jointly organized by PPP and CliC and a joint workshop on Polar Prediction is planned for 2017.

Association for Polar Early Career Scientists (APECS): PPP works closely with APECS on developing educational programmes. Collaboration however can still be strengthened.

Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) (2019-2020): PPP-SG works closely with the planning team for the Arctic drifting station of the MOSAiC initiative.

Future plans (late 2016-2017)

- Planning Meeting on the YOPP Data Component (Oslo, Norway, 10-11 November 2016).
- PPP Steering Group Meeting (SG-8) (Maryland, USA, 27 February – 1 March 2017).
- YOPP Planning Meeting at ASSW2017 (Prague, Czech Republic, 31 March-2 April 2017).
- PPP-SERA meeting (Fairbanks, Alaska, 5-9 April 2017).
- Second YOPP Southern Hemisphere planning meeting (Boulder, Colorado, USA, June 2017).
- YOPP Planning Week (September 2017).

Comments and response to questions during discussion

- Winter School was very successful. Limited area models are very relevant for climate applications especially in the Polar Stable Boundary Layer.
- The PPP Verification Report will be published soon.
2. **Sub-seasonal to Seasonal Prediction Project (S2S)**

**Co-chairpersons:** Andrew Robertson, Frederick Vitart - presented the report

**Mission**
To improve forecast skill and understanding on the sub-seasonal to seasonal timescale with special emphasis on high-impact weather events; to promote the initiative’s uptake by operational centres and exploitation by the applications community and to capitalize on the expertise of the weather and climate research communities to address issues of importance to GFCS.

**Key highlights (from late 2015 to 2016)**

- Build-up of the S2S database (available to the research community through the ECMWF data portal since May 2015).
  - A second data portal opened at the China Meteorological Administration (CMA) in November 2015.
  - Three additional models have been made available in the S2S database (United Kingdom Meteorological Office (UKMO), Institute of Atmospheric Sciences and Climate—Consiglio Nazionale delle Ricerche (ISAC-CNR) and Environment Climate Change Canada (ECCC) which brings the total number of available models to 10.
  - A subset of S2S data is now available from the International Research Institute (IRI) data library.
  - Number of users is increasing with about 12 Tb of data downloaded per month from the ECMWF data server.
  - The list of variables archived in the S2S database has been extended to include the vertical velocity at all pressure levels.
  - A new range of near-real time forecast charts based on the S2S database is now openly available at: http://www.ecmwf.int/en/research/projects/s2s/charts/s2s/

- A manuscript about the S2S database has been accepted for publication in the Bulletin of American Meteorological Society (BAMS) and will be published in January 2017.
- S2S side-event organized during EC-69 (2017).
- Studies have already begun to assess the skill of the S2S models which had been done mostly through the sub-project activities.
- The NOAA Climate Program Office’s Modeling, Analysis, Predictions and Projections (MAPP) Program has organized an S2S Prediction Task Force to advance NOAA’s and the Nation’s capability to model and predict sources of S2S predictability and awarded 14 research projects on S2S.
- A two-week school on S2S Prediction and Application to Drought Prediction was organized in Trieste, Italy from 23 November - 4 December 2015.
- S2S training events were organized at the Association of South East Asian Nations (ASEAN) Specialized Meteorological Centre (ASMC) (Singapore, November 2015), at the Asia Pacific Economic Cooperation (APEC) Climate Center (APCC) (Busan, Republic of Korea, June 2016), and at the Center for International Forestry Research (CIFOR)/Climate for Development in Africa (ClimDev) Africa (Cameroon, July 2016).
- Special sessions on S2S had also been organized at various conferences (namely 2016 American Geophysical Union (AGU), EMS-European Conference on Applied Climatology (ECAC) 2016, Royal Meteorological Society (RMS)/National Centre for Atmospheric Science (NCAS) Conference 2016).
• S2S co-organized the Workshop on Intraseasonal Processes and Prediction in the Maritime Continent (Singapore, 11-13 April 2016) with the WGNE/Madden Julian Oscillation (MJO) Task Force.

**Links with other working groups, projects, international initiatives**

**CBS:** An important link has been established between S2S and the Lead Center for Long-range forecast Multi-model Ensemble (LC-LRFMME) at Korea Meteorological Administration (KMA). The contribution of S2S to this project is the establishment of the S2S database which can also be used for real-time data exchange and research and verification of new S2S products.

**WGNE:** A strong link has been established between the WGNE/MJO task force and the S2S MJO sub-project. A Workshop was organized in April 2016 and S2S is also supporting the YMC initiative. A session on S2S teleconnections will be organized at the WGNE workshop on systematic errors (Montreal, Canada, June 2018).

**PPP/YOPP:** S2S plans to make available additional variables in the S2S database (e.g. sea ice thickness) during the YOPP field campaign. The S2S sub-project on teleconnections is planning to collaborate with YOPP on the planning of a set of experiments to better understand the teleconnections between tropics and high latitudes.

**HIWeather:** There are strong synergies between HIW and the S2S sub-project on extremes. Brian Golding, Co-chairperson of the project is a member of the S2S Extremes sub-project. The contribution of S2S to HIW would be to provide early warnings of extreme weather events, which could be done through case studies.

**SPARC/SNAP:** Stratosphere-troposphere Processes And their Role in Climate/Stratospheric Network for the Assessment of Predictability) SNAP plans to use the S2S database to evaluate the skill of operational S2S models to predict the stratospheric variability and its impact on the lower troposphere. An article on S2S has been published in the Jan2016 SPARC newsletter to encourage the SPARC community to perform more studies with the S2S database. Six projects have been launched by members of the SPARC community to analyse the S2S database for stratospheric studies.

**JWGFVR:** Links have been established with this working group through the verification and products sub-project and common activities are under development.

**DAOS-WG:** A member of DOAS is a liaison member in S2S. S2S has also been involved in the organization of the DAOS workshop on coupled data assimilation through one of his member being part of the conference scientific committee.

**PDEF-WG:** A member of PDEF is now a liaison member in S2S. A collaboration study between S2S and PDEF has also been launched. This study investigates the modulation by the Madden Julian Oscillation of recurving tropical storms in the western North Pacific and the Rossby wave caused by these tropical storms in the Northern Extra-tropics.
Future plans (late 2016-2017)

- WCRP/International Centre for Theoretical Physics (ICTP) School on Climate System Prediction and Regional Climate Information (Dakar, Senegal, November 2016).
- Workshop on Sub-Seasonal to Seasonal Predictability of Extreme Weather and Climate (Palisade, New York, USA, 6-7 December 2016).
- S2S Steering Group Meeting (Columbia University, 8-9 December 2016).
- Special session on S2S at the 2016 AGU Fall Meeting (San Francisco, California, December 2016).
- To complete the development of the S2S database and extend the list of variables archived to add, in particular, more sea-ice and ocean subsurface variables.
- To make available precomputed weather indices to the research community to avoid duplication of efforts.
- To extend the new database to weather regime indices, including North Atlantic Oscillation (NAO), tropical cyclone tracks, stratospheric sudden warming indices etc.
- The analysis of the database and the evaluation of forecast skill and the potential benefit of S2S forecasts will continue in 2017 through the various sub-project activities and through funded projects (e.g. MAPP).
- Special session on S2S at the 7th International Verification Methods Workshop (Berlin, May 2017).
- Special session on S2S at the International Association of Meteorology and Atmospheric Sciences (IAMAS) Conference (Cape Town, August 2017).
- Advanced School on the Tropical-Extratropical Interactions on Intra-Seasonal Time scales (Trieste, Italy, two weeks in October 2017).
- Special S2S session at the WGNE meeting (WGNE-32) (Montreal, October 2017).
- Workshop and Training Course on S2S teleconnections (October 2017).
- The ASMC in Singapore is proposing a 4-5 year programme (Southeast Asian (SEA)-S2S) of workshops/trainings aimed at Association of Southeast Asian Nations (ASEAN) national meteorological services, to build capabilities to issue skillful S2S forecasts.
- A proposal has been developed for a South American training course (in Spanish) in 2017, to be held either in Paraguay or Colombia. Funding is being sought from GFCS through WMO and World Bank.

Comments/answers to questions during discussion

- S2S is organizing a special session on S2S at the Fifth WGNE Workshop on Systematic Errors in Weather and Climate Models (Montreal, Quebec, Canada, 19-23 June 2017). Under the Teleconnections theme, the session aside from papers on errors in the simulation of interactions between high-latitudes, mid-latitudes and tropics will also include presentations on the YTMIT.
- In collaboration with SPARC/SNAP, S2S is currently looking into improved understanding of the role of the stratosphere in tropospheric weather and climate, stratospheric predictability and its contribution to sub-seasonal forecast, topics which although are very important have not been given proper attention to in the past.
- S2S is developing more detailed experimental plans with PPP to better understand the teleconnections between tropics and high latitudes.
- Further research is needed to understand the extent to which hydrological models within coupled S2S forecast systems would benefit S2S forecasts.
- It was noted that GFCS is developing a flood project with India under the Associated Programme on Flood Management.
3. **High Impact Weather Project (HIWeather)**

**Co-chairpersons:** David Johnston, Brian Golding - presented the report

**Mission**
To promote cooperative 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 and utility in social, economic and environmental applications.

**Key highlights in 2016**

- UNISDR post-Sendai Science Meeting (Geneva, Switzerland 25-29 January 2016).
- Fire Weather & Risk Workshop (Melbourne, Australia, 11-12 April 2016).
- ECCC accepted the HIWeather Implementation Plan in June 2016.
- Joint leads Sally Potter and Shannon Parchuk were appointed for the communication theme.
- HIWeather SG has met four times, three by teleconference and once at the April 2016 kick-off meeting.
- Julia Keller has joined the WMO Secretariat, with special responsibility for HIWeather.
- A communications web platform is being developed at Massey University.
- It was agreed to form HIWeather Advisory Board, consisting of representatives of donors, users, United Nations (UN), climate and academia, with Prof. Virginia Murray as first member. Potential members are currently being approached by the Secretariat.
- HIWeather Newsletters were issued (#3 February and #4 September 2016).
- First Meeting of the HIWeather SG (Exeter, UK, 26 April 2016).
- RMS Conference on High Impact Weather & Climate (Manchester, UK, 6-8 July 2016).
- WWRP Nowcasting 2016 Conference (Hong Kong, China, 25-29 July 2016).
- Field phase of NAWDEX (mid-September).
- A funding opportunity from the UK Department for International Development is being pursued to progress a pilot nowcasting demonstration for Lake Victoria in association with the East Africa Severe Weather Forecast Demonstration Project (SWFDP).
- A special issue of the Quarterly Journal has reported results from the Hydrological cycle in the Mediterranean eXperiment (HyMeX) RDP with relevance to HIWeather objectives.
- PhD positions have been identified at Massey University and Eidgenössische Technische Hochschule (ETH) Zurich to take forward the projects on use of unconventional observations for impact forecasting/evaluation of warnings and on the relevance of governance structures to warnings decisionmaking respectively.

**Links with other working groups, projects, international initiatives**

**PDEF-WG, DAOS-WG, NMR-WG, JWGFVR & SERA-WG:** collaboration through cross membership with the HIWeather task teams. Many activities are being developed jointly between HIWeather and one or other of the WGs.

**GURME:** GAW Urban Research Meteorology and Environment (GURME) largely focuses on processes at smaller scales (e.g. street canyon scale) than HIWeather. With the development of the WMO urban focus, this link should develop more strongly, through Veronique Bouchet and Alexander Baklanov.
**PPP and S2S**: HIWeather Co-chairperson Brian Golding is a member of the S2S Extreme Weather sub-project. There is a developing link between NAWDEX and YOPP.

**WWRP FDP/RDPs**: links with NAWDEX, Lake Victoria, RELAMPAGO, ICE-POP2018, Study of Urban Rainfall and Fog/Haze (SURF).

**WCRP**: through the WCRP Grand Challenge on Extreme Events.

**SWFDP**: Co-chairperson Brian Golding keeps close contact with the project through Ken Mylne, Chairperson of the SWFDP Steering Group. The proposed Lake Victoria FDP is closely linked to the Southern & Eastern Africa SWFDPs.

**IRDR**: have been weak during its review period, but with new leadership in place, it is hoped that they can be reinvigorated.

**UNISDR**: The UN International Strategy for Disaster Reduction (ISDR) Science Meeting in January 2016 was used by both Co-chairpersons and head of WWRP to engage with stakeholders. It is hoped to use the UNISDR Global Platform in May 2017 similarly. The possibility of a meeting with stakeholders at that event will be explored.

**Future plans (2017-2018)**

- Workshop on km-scale nowcasting and short-range prediction (Germany, early October 2017).
- Review wind hazard forecasting and prepare Wind hazard review paper by mid-2018.
- Survey the use of unconventional data sources for impact modelling, evaluation & communication. PhD project for completion in 2019.
- Review probabilistic forecasts of Tropical Cyclones and their evaluation with the aim of promoting their better use, outputs to be presented at the 2018 WMO Workshop on Tropical Cyclones.
- Develop a concept and outline plan for a HIWeather Multi-Hazard Early Warning System Demonstration Project (FDP) to be held towards the end of HIWeather.
- Support JWGFVR review of good practice in spatial verification of ensemble forecasts in complex terrain (i.e. MesoVICT).
- Share outcomes of JWGFVR user-oriented verification competition.
- Support planning for Lake Victoria pilot project, RELAMPAGO, ICE-POP2018 and other RDP/FDPs.
- Continue to build relationships with WCRP, S2S,PPP, SWFDP, Integrated Research on Disaster Reduction (IRDR), with FDP/RDPs, and with national/regional HIWeather initiatives.
- UNISDR Global Platform, WMO conference on Early Warnings, HIWeather meeting with stakeholders (Cancun, Mexico, May 2017).
- Special session on HIWeather and Climate at the International Association of Meteorology and Atmospheric Sciences-International Association for the Physical
Sciences of the Oceans - International Association of Hydrological Sciences (IAMAS-IAPSO-IAHS) Assembly 2017 (Cape Town, South Africa).

- HIWeather session at the 9th International Workshop on Tropical Cyclones (2018)
- Task team members have committed to lead or be involved with reviews in short range forecasting and impact forecasting capability in 2017.

Comments/answers to questions during discussion

- At the regional and national level, HIWeather will collaborate with ongoing WWRP RDPs/FDPs especially on training courses/capacity building activities.
- There is a need to attract more contributors to the HIWeather Trust Fund. Currently, the funds are limited and can barely support project activities as only 3 countries had contributed. One area to be explored are three upcoming meetings of the WMO Regional Associations where HIWeather can attract additional donors.
- HIWeather includes studies on the economic value of weather and climate services through the communication process, high-resolution boundary layer phenomena related to wind power generation. Pertaining to specific impact models, limited intercomparison studies will be used.

4. Working Group on Societal and Economic Research Applications (SERA-WG)

Co-chairpersons: Linda Anderson-Berry, Jane Rovins – presented the report

Mission
To advance the science of the social and economic application of weather related information and services and review and assist in the development and promotion of societal and economic related demonstration projects.

Key Highlights in 2016

- Three new members were confirmed in 2016: Juan Pablo Sarmiento, Aida Diongue-Niang and Martin Goeber with Rajib Shaw representing IRDR.
- Started a literature review for the SERA-WG study on “Understanding the societal and economic dimensions of weather-related warning systems”.
- PPP-SERA Meeting (Christchurch, New Zealand, 18-22 April 2016).

Links with other working groups, projects, international initiatives

PPP: A SERA-WG member is working with PPP-SERA to support and provide leadership for the latter’s activities.

S2S: a SERA-WG member is actively involved in the S2S Extremes sub-project and in the Verification sub-project.

HIWeather: SERA-WG members are members of HIWeather Task Teams. It is expected that SERA-WGs study on “Understanding the societal and economic dimensions of weather-related warning systems” will be realized through HIWeather.
**TMR-WG:** A SERA-WG Co-chairperson is a member of the UPDRAFT SSC and another SERA-WG member is in the Southern China Monsoon Rainfall Experiment (SCMREX) and Typhoon Landfall Forecast Demonstration Project (TLFDP) SSC.

**Future Plans (2017-2018)**

- SERA-WG meeting (Cancun, Mexico, 25-26 May 2017) in conjunction with the Global Platform 2017.
- PPP-SERA Meeting (Fairbanks, Alaska, USA, 5-9 April 2017).
- Prepare a paper on Early Warning Systems to be presented at the 2017 Global Platform.
- Joint meeting with the TMR-WG in 2018.
- Preparation of a discussion paper on data in support of impact-based forecasting.

**Comments/answers to questions/suggestions during discussion**

- It was suggested to reduce the number of SERA-WG activities in the WWRP IP (2016-2023) as 39 tasks could possibly not be completed in a two-year period.
- The next SERA-WG meeting will be held in conjunction with the 2017 Global Platform (Cancun, Mexico, May 2017). The networking opportunities with the social science and disaster management groups that are expected at the event could play a vital part in the WGs mission of advancing the science of the social and economic application of weather related information and services.
- SERA-WG role in HIWeather will be on training and provision of advice on social science research aspects of the project.
- It was suggested to test the SERA ‘impact’ methodology with SDS-WAS.

**5. Joint Working Group on Forecast Verification Research (JWGFVR)**

**Co-chairpersons:** Marion Mittermaier, Lawrence Wilson – presented the report

**Mission**

- To plan and implement the verification component of WWRP.
- To serve as a focal point for the development and dissemination of new verification methods for WWRP and EPAC, as required.
- To facilitate and encourage training and dissemination of information on verification methodologies.
- To take into account the needs of users so as to ensure the relevance of the practice of forecast verification.
- To facilitate the development and application of improved diagnostic verification methods to assess and enable improvement of the quality of weather forecasts, including forecasts from numerical weather and climate models.
- To encourage the sharing of observational data for verification purposes.
- To encourage greater awareness in the research community of the importance of verification as a vital part of numerical and field experiments rather than an "afterthought".
- To promote collaboration among scientists conducting research on various aspects of forecast verification as well as with model developers and forecast providers.
- To collaborate on forecast verification with the WGNE and WCRP and in coordination with CBS.
Key highlights in 2016

- User-oriented verification from ECMWF (work by Thomas Haiden)
- 2nd MesoVICT Workshop (Bologna, September 2016)
- JWGFVR Meeting (Bologna, September 2016)
- Roving Verification Tutorial (Jakarta, Indonesia, 17-19 November 2016)
- Special Verification Session at the EMS/ECAC Conference (Trieste, Italy, 12-16 September 2016)
- Ice verification in Polar Regions (work by Barbara Casati at ECCC)
- Cloud Verification Research -user-oriented (led by US Air Force)
- HIGHWAY (project for Lake Victoria basin funded by Department for International Development (DFID) United Kingdom)
- Verification Challenge (competition to develop and demonstrate new user-oriented forecast verification metrics in support of S2S, PPP and HIWeather.

Links with other working groups, projects, international initiatives

**PPP:** (B. Casati and T. Haiden) A document on verification in polar regions is being completed for publication.

**S2S:** (C. Coelho) There are plans for a book on S2S which will include a chapter on verification. Several members of the JWGFVR will be involved in the preparation of said chapter.

**HIWeather:** (M. Dorninger and B. Brown) Several current and past members of the JWGFVR are part of the HIWeather Task Teams.

**NMR-WG:** (L. Wilson and B. Brown) Main joint activity is the development of the Lake Victoria project proposal.

**SERA-WG:** A task for collaborative effort will be the development of impact-based metrics which include risk information.

**TMR-WG:** (B. Brown) Collaboration on recommendations for Tropical Cyclone Verification; SCMREX (Y. Zhu), UPDRAFT (J. Chen), and TLFDP (B. Brown).

**PDEF-WG:** (L. Wilson and M. Mittermaier) collaborative projects will be explored in a joint meeting planned either in 2017 or 2018.

**WGNE:** (M. Mittermaier) Desire to move towards a closer connection as a member of JWGFVR is an ex-officio member of WGNE. Topics of current particular interest to WGNE includes: standardization of verification and exchange of scores among groups; an update to the precipitation verification guidelines (issued in 2009); accounting for high resolution models; cloud verification methods; how to use analyses for verification; working with CBS on guidelines for tropical cyclone verification.

**CBS:** (Y. Zhu and T. Haiden) Both attended the Meeting of the CBS Coordination Group on Forecast Verification (Montreal, Canada, May 2016).

**SWFDP:** (L. Wilson)

**Lake Victoria project:** (L. Wilson, M. Mittermaier, B. Brown, S. Landman)
Aviation Research Project: (B.Brown) member of the project’s SSC

Future plans (2017-2018)

- Polar Prediction Workshop (Bremerhaven, Germany, 27-29 March 2017)
- 7th International Verification Methods Workshop (Berlin, Germany, 3-11 May 2017)
- WGNFVR Meeting (Berlin, Germany, 6-7 May 2017)
- WGNFVR Systematic Errors Workshop (Montreal, Canada, 19-23 June 2017)
- HIWeather Workshop (Fall 2017)
- EMS/ European Conference on Applications of Meteorology (ECAM)/ECAC (Dublin, Ireland, 4-8 September 2017)
- WGNFVR-32 (Exeter, UK, October 2017)
- 3rd MesoVICT Workshop (2018)
- If funding for HIGHWAY is successful will begin work on the project
- Provide advice on verification methods, if requested, to ICE-POP2018
- Prepare verification chapter for S2S book
- Continue active involvement with other WWRP working groups and projects.

Comments/suggestions to questions during discussion

- Urban meteorology and Aviation meteorology are new priorities of the WG
- JWGFVR deals with observational data separate from models
- JWGFVR plans to enhance links with SERA-WG and DAOS-WG

6. Tropical Meteorology Research Working Group (TMR-WG)

Chairperson: Yihong Duan – report presented by Nanette Lomarda

Mission

- To monitor the implementation of existing priority projects within the Working Group and to further develop other appropriate research projects as the need arises, under the main programme components: tropical cyclones and monsoons.
- To identify and support the research initiatives of NMHSs in tropical countries generally including collaboration with groups in universities or research institutes, which are likely to lead to societal and economic benefits.
- To keep developments in research aspects of the Tropical Cyclone Programme (TCP) under continuous review and facilitate the coordination of research at regional levels by maintaining close liaison with tropical cyclone regional bodies.

Key highlights in 2016

- Atlantic Basin Seasonal Hurricane Forecast Website launched on 3 August 2016.
- Global Real-time Tropical Cyclone Activity Tracker developed in 2016.
- TMR-WG Meeting (Shanghai, November 2016).
- TLFDP and UPDRAFT Project Meeting (Shanghai, November 2016)
• Publication of eight SCMREX related-technical papers in scientific journals.

Links with other working groups, projects, international initiatives

**JWGFVR:** (B. Brown) Collaboration on recommendations for Tropical Cyclone Verification; SCMREX (Y. Zhu), UPDRAFT (J. Chen), and TLFDP (B. Brown).

**SERA-WG:** (J. Rovins) UPDRAFT; (B. Jou) SCMREX and TLFDP

**NMR-WG:** (Yong Wang) UPDRAFT

**HIWeather:** (A. Tyagi)

**S2S:** (P. Klotzbach)

**PDEF-WG:** (Z. Meng) SCMREX

Future plans (2017-2018)

• First SCMREX Workshop (Beijing, April 2017).
• Plans are for Expert Team on Impacts of Climate Change on Tropical Cyclones to begin work on the next Intergovernmental Panel on Climate Change) Assessment Report (IPCC AR) in 2017 with a target publication timeframe of 2018, in time to be used as input to IPCC AR-6.
• To expand seasonal hurricane forecast website launched in August 2016 to include all tropical cyclone basins.
• Continuous development of Seasonal Tropical Cyclone Forecast Website.
• 6th WMO International Workshop on Monsoons (IWM-6) and associated Monsoon Training Workshop (Singapore, 9-13 November 2017).
• Cooperation with Years of Maritime Continent (July 2017-July 2019).
• 4th International Workshop on Tropical Cyclone Landfall Processes (Macau, 5-8 December 2017).

Comments/answers to questions during discussion

It was suggested to consider including the following topics in the work of the TMR-WG:

• Studies on hydrological studies in the monsoon context
• Prediction of conditions for wild fires/vegetation fires
• Tropical cyclone seasonal forecast (S2S timescale)

7. **Predictability, Dynamics and Ensemble Forecasting Working Group (PDEF-WG)**

**Co-chairpersons:** Craig Bishop – presented the report, John Methven

**Mission**

To advance the science of dynamical meteorology and predictability research, and their application to ensemble forecasting promoting the development of ensemble applications and the transition into operations.
Key highlights in 2016

- PDEF/ECMWF model error uncertainty workshop (Reading, UK, 11-15 April 2016) has resulted in summary and guidance reports which now reside on the ECMWF website.
- NAWDEX field campaign.
- NAWDEX preparation workshop (Oberpfaffenhofen, Germany, 4-6 April 2016).
- PDEF/SPARC workshop on blocking (Reading, UK, 6-8 April 2016).
- PDEF-WG meeting (Exeter, UK, 25-26 April 2016).
- Workshop on the role of diabatic processes in weather systems at the RMS conference on "High impact weather and climate" (Manchester, UK, 6-8 July 2016).
- Swiss Climate Summer School (Grindelwald, Switzerland, 28 August-3 September 2016).
- YOPP planning meeting (Reading, UK, 7-9 September 2016).
- NAWDEX field campaign (19 September – 16 October 2016).

Links with other working groups, projects, international initiatives

**PPP:** PDEF is engaged with preparations for YOPP (Year of Polar Prediction). Other concerns include: challenges of prediction at high latitudes; coupling issues for polar regions (especially stable BL); use of Thorpex Interactive Grand global Ensemble (TIGGE) & TIGGE-Limited Area Model (LAM) for case studies. Plan to include additional surface flux diagnostics in TIGGE for YOPP. Using the NAWDEX field campaign month to explore the value of additional radiosondes at high northern latitudes as a consideration for YOPP.

**S2S:** Important issues of common interest include: coupled modelling & assimilation challenge; ensemble initial conditions; stochastic physics; diabatic effects. PDEF has been actively seeking researchers willing to research advanced diagnostics for the S2S dataset such as diagnostics to link TC transitions with mid-latitude Rossby wave diagnostics.

**HIWeather:** Common areas of interest include: application of multi-model ensembles & calibration to improve forecast products; use of TIGGE & TIGGE-LAM for case studies. PDEF WG member Susanne Theis wrote summary guidelines on interpretation of probability forecasts from high-resolution ensembles to serve as advice for the HIWeather project.

**WGNE:** joint interest in systematic errors, stochastic physics.

**NAWDEX:** analysis of results to elucidate diabatic effects on model error and meso/synoptic scale dynamics.

**WCRP:** Grand Challenge on clouds, circulation & climate sensitivity – storm tracks & jet stream dynamics; mid-latitude blocking & persistent weather; diabatic effects.

**DAOS-WG:** ensemble initial conditions; coupled data assimilation; value of additional observations and design of data denial experiments.

**NMR-WG:** improved treatment of model uncertainties for convective-scale prediction.

**CBS:** PDEF brings academic expertise to bear on practical problems relevant to operational forecasting, including: application of multi-model ensembles & calibration to improve forecast
products; improvement of operational ensembles by improved initial conditions and better representation of model uncertainties.

**Future plans (2017-2018)**

- Follow on to the ECMWF model uncertainty workshop via the 2017 WGNE workshop on systematic errors and an effort to translate some of the findings from the 2016 workshop into a recommendation for new types of coarse graining experiments.
- John Methven will encourage use of the NAWDEX campaign period for model error studies.
- Munehiko Yamaguchi will be championing the PDEF ensemble forecasting focus following Yuejian Zhu’s retirement from the WG.
- Participation of some DAOS-WG members in the proposed joint ECMWF/PDEF workshop on model uncertainty. To help ensure that DAOS and PDEF work synergistically on these issues, it was agreed that a representative from PDEF should be invited to attend future meetings and workshops of the DAOS-WG and vice versa.

**8. Data Assimilation and Observing Systems Working Group (DAOS-WG)**

**Co-chairpersons:** Carla Cardinali – presented the report, Daryl Kleist

**Mission**
To provide guidance to the WWRP to optimize the use of the current WMO Global Observing System (GOS). The DAOS Working Group will facilitate the development of data assimilation and observing system methodologies from the convective scale to planetary scales and for forecasts with time ranges of hours to weeks.

**Key highlights in 2016**

- Joint Meeting of DAOS-WG and PDEF-WG (Exeter, UK, April 2016).
- WMO Observation Impact Workshops (Shanghai, China, 10-13 May 2016).
- Workshop on Coupled Data Assimilation (Toulouse France, October 2016).
- Reducing Noise in Ensemble Covariances and Hierarchical Bayesian Ensemble Kalman Filter update (Mikhail Tsyrunnikov).
- A new approach was presented for scale-dependent spatial localization of ensemble background-error and variational approach to a perturbed-observations Ensemble Kalman Filter (Mark Buehner).

**Links with other working groups, projects, international initiatives**

Liaisons were appointed for select working groups and projects: Mark Buehner for PPP, Daryl Kleist for S2S, Nadia Fourrie for HiWeather, Carla Cardinali for PPP and PDEF-WG. As needed, each liaison will follow up during the subsequent year, participating in teleconferences, and if possible attending meetings.

**WGNE:** Subsequent to the most recent Systematic Errors workshop: (a) Most operational centres tend to have a mid-latitude focus to their work. As a consequence, the quality of their tropical and polar analyses has been found to be lower than that in the mid-latitudes. This also applies to re-analyses. The workshop recommends additional efforts in the development of data assimilation systems in those regions. (b) The lack of and/or inaccessibility to some key
observations remains a major challenge. These include surface fluxes (especially over the oceans), and observations in polar and tropical regions. Additional efforts in these areas are required. Additional feedback from WGNE included: (a) Continued interest on potential recommendations regarding the use of analyses for forecast verification and for model error diagnostics. (b) Continued interest in any developments on treatment of model uncertainty (stochastic parameterizations) in ensemble DA, and (c) interest in developments in coupled Data Assimilation.

**S2S:** They continue to be interested in DAOS-WG promotion of coupled data assimilation (S2S member Arun Kumar was in the organizing committee of the Toulouse coupled Data Assimilation workshop. S2S is also interested in advice on optimally configuring future observing systems such that they help improve sub-seasonal forecasts. Answers to questions such as: What are the key observational needs? Will improved ocean observations lead to improved ocean state estimation and improved ocean forecasts?

**PDEF-WG:** Both PDEF and DAOS working groups have a common interest in the treatment of model uncertainties, as part of the DA cycling and in ensemble forecast models, respectively. Diagnostic techniques in the context of DA cycling could potentially be very helpful for informing us about how best to represent model uncertainties using stochastic physics methods. Participation of some DAOS members in the proposed joint ECMWF/PDEF workshop on model uncertainty will be very helpful. To help ensure that DAOS and PDEF work synergistically on these issues, it was agreed that a representative from PDEF should be invited to attend future meetings and workshops of the DAOS working group, and vice versa. Interaction with PDEF Co-chairpersons on possible steps DAOS may take with respect to the use of field campaign observations from the NAWDEX campaign.

**NAWDEX:** Main purpose: Assessment of model errors in Warm Conveyor Belts (WCBs) and their impact on downstream weather evolution.

**PPP:** In the area of coupled modelling, there was general agreement that the ocean-atmosphere coupling and land-atmosphere problem should receive the highest priority initially. Through interaction with the PPP, we also hope to address aspects of ice-ocean and ice-atmosphere coupling. Coupled modelling systems which realistically represent interactions of the atmosphere with land and ocean are important for extended-range prediction, which is particularly relevant to supporting the S2S project. Realistic representation of interactions with the cryosphere is also critical for prediction at high latitudes – the focus of PPP. Despite strong overlaps in the areas of ensemble forecasting and model error, PDEF-WG will have a much stronger focus on increasing understanding of the dynamics of the coupled system than DAOS-WG, while DAOS will pay more attention to improving observing networks for the coupled system and issues related to the realism of coupled uncertainty estimates in the short-range background forecasts. DAOS participated at the YOPP Planning Workshops (Reading, UK, September 2016)

**Future plans (2017-2018)**

- Data Assimilation Symposium (Florianopolis, Brazil 11-15 September 2017)
- Define selected research projects together with S2S (current focus of DAOS is days-to-weeks), PPP, HiW e.g. on coupled assimilation design from medium to seasonal scales, observing system design in polar areas, methods to initialize high-resolution models at local scale with a view on high-impact weather prediction.
• Establish link with PDEF to support ensemble system design, in particular for the formulation of model errors in ensembles using data assimilation methods.
• Establish link with Sand and Dust WG to coordinate how atmospheric composition data assimilation method and observing system evolution can be ingested by DAOS-WG.
• DAOS-WG will publish a short report (5 page statement and/or white paper on usefulness of Observing System Simulation Experiments (OSSE) to inform WMO projects and working groups, together with the broader community, on the various potential applications of OSSEs of relevance to WMO activities.
• DAOS-WG members attending a particular conference could be tasked with providing a 1-2 page report on progress, outstanding issues, and recommendations in specific areas. These could be compiled in a living WWRP document that is housed online and shared with the other WGs/projects. The DAOS-WG members attending the coupled Data Assimilation workshop in Toulouse could be tasked with providing a summary.

Issues if any needing SSC attention

Membership: The Co-chairpersons of the DAOS-WG had forwarded three names to the WWRP SSC for consideration: a new DAOS-WG Co-chairperson (Tom Auligne) and two new members (Ulrich Löhnert and Juan Ruiz).

9. Working Group on Nowcasting and Mesoscale Research (NMR-WG)
   Co-chairpersons: Rita Roberts, Peter Steinle – presented the report

Mission

To advance the knowledge of nowcasting and mesoscale processes and predictability; to promote, and aid the implementation of nowcasting systems within NMHSs and among their end-users, including the potential use of numerical modelling and assimilation of very high-resolution data.

Key highlights in 2016

• WMO Symposium on Nowcasting 2016 (Hong Kong, China, July 2016)
• First Meeting of NMR-WG (Hong Kong, China, 31 July 2016)

Links with other working groups, projects, international initiatives

ICE-POP2018: Yong Wang (INCA training and demonstration) and Peter Steinle on the Science Committee & Verification.

HIWeather: Peter Steinle, Paul Joe, Jianjie Wang, Jim Dudhia (MultiScale Forecasting Team).

AvRDP: Peter Li
SCOPE: Peter Steinle and Anthony Rea are discussing how to strengthen links.

PROFORCE: Yong Wang

ARISTOTLE: Yong Wang
EUMETNET: (various groups): Jeanette Onvlee

BNHCRC: Peter Steinle

TMR-WG: through SCMREX (JianJie Wang) and UPDRAFT (Yu Hui)

DAOS-WG/PDEF-WG: Peter Steinle attended joint meeting in Exeter

JWGFVR: Barb Brown attended WGNMR meeting in Hong Kong

SWFDP: with the departure of Estelle de Coning, will require member from Africa to provide link to South and East Africa SWFDP and links to other SWFDP to be strengthened

GURME: Assessing options for an Urban-scale modeller to join WGNMR and participate in the team for preparing the Guide for Urban Integrated Services

WGNE: Jeanette Onvlee used to attend WGNE meetings, Peter Steinle was to attend last meeting, but conflicted with HI Weather workshop. A presentation was provided by Deon Terblanche on behalf of WGNMR.

WCRP: To be discussed with incoming parametrization experts

Commission for Instruments and Methods of Observation (CIMO): To be discussed with incoming observation experts

SURF: JianJie Wang

Land-Atmosphere Feedback Experiment (LAFE): Volker Wulfmeyer, Jeanette Onvlee, Peter Steinle

RELAMPAGO: Rita Roberts, and new member from South America

Future plans (2017-2018)

- Finalize membership
- ICE-POP2018 Meeting (November 2016)
- Work with relevant groups on refining proposals and reviewing implementation plans and progress in contributing to WWRP Implementation Plan.
- Develop web page providing RDP/FDP contacts, implementation plans, data access policies, etc.
- Review and suggest revisions to RDP/FDP guidelines and to clarify the submission process, especially for cross-cutting projects.
- Prepare Nowcasting Guidelines
- Continue discussions with the Moroccan Weather Service on the next symposium regarding location, date, thematic content, local organizers, etc.
- Link to DAOS-WG regarding DA Symposium in 2017
- Begin planning GURME-NMR workshop for joint coordinated activities
- NMR-WG Meeting in 2017
10. **Weather Modification Expert Team (WM-ET)**

**Chairperson:** Roelof Bruintjes

**Mission**

The main purpose of Weather Modification is to promote scientific practices in weather modification research. This is done through the WMO Expert Team on Weather Modification and through organizing the quadrennial scientific conferences on weather modification.

**Key highlights in 2016**

- Increase in the number of countries active in weather modification research and operations from 47 in 2013 to 52 in 2016.
- In 2016, members of the WM-ET responded to requests from meteorological services of Canada, Saudi Arabia and other countries to assist in evaluation of weather modification activities in their respective countries.

**Future Plan/s (2017)**

- Major research programme in weather modification to enhance snowpack (Idaho, USA early 2017).
- WM-ET has been working with the CMA and their course on weather modification and has now been approached by the Department of Royal Rainmaking and Agricultural Aviation (DRRAA) to help with training and the design of a research programme with international participation.
- Review the mission of the Team and purpose of the of the WMO statement on Weather Modification.
- Continue to provide advice to member countries upon their request and participate in research programmes organized by individual countries.
- Continue to solicit funds for the trust fund and possibly from WMO solely for the meetings of the Expert Team.

11. **Aviation Research Project (ARP)**

**Objectives of the Project**

- To conduct research in nowcasting and mesoscale modelling at a number of international airports located in northern and southern hemisphere with a view to supporting the development of the next generation aviation initiative, namely, ASBU under the new Global Aviation Navigation Plan (GANP) endorsed by ICAO. Key concepts under ASBU are the development of seamless Trajectory-Based-Operation (TBO) and Meteorological Services to ATM (MSTA).
- To collaborate with the respective Air Traffic Management (ATM) to translate the Meteorological (MET) information into ATM Impact products so as to demonstrate the benefits of the MET information (nowcast and mesoscale modelling) in the aviation community;
- To transfer the knowledge gained in AvRDP to other WMO Members who need to enhance their aviation MET services so as to meet the ASBU initiative.
Future plans

- Aeromet Scientific Conference (Toulouse, France, 6-10 November 2016)
- 3rd AvRDP SSC Meeting (2017)
- 2nd AvRDP Training Workshop (2017)

12. Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

**SC Chairperson:** Enric Terradellas, Emilio Cuevas-Agullo – presented the report

**Objectives**

- To establish a coordinated global network of SDS research and forecasting centres
- To enhance operational SDS forecasts through technology transfer from research
- To improve observation technology
- To provide users access to forecasts and observations
- To promote research and applications related to the sand and dust storm process
- To build capacity of countries to utilize SDS products
- To build bridges with other relevant communities

**Key highlights in 2016**

- In February 2016, the article entitled "Airborne Dust: A Hazard to Human Health, Environment and Society" was published in WMO Bulletin Vol 64 (2), the Observational data sharing list was completed and the joint stations of IRIMHE (Mongolia) and RSE Kazhydromet (Kazakhstan) were established.
- 2016 New Mexico Dust Storm Workshop (Las Cruces, New Mexico, USA, 24 February 2016).
- The WMO SDS-WAS was presented at the First International Conference on Dust (Ahvaz, Iran, 2-4 March 2016).
- A paper on a model intercomparison was published (Huneeus et al., 2016; ACP).
- First Meeting of the Caribbean Aerosol-Health Network (CAHN) (San Juan, Puerto Rico, April 2016).
- The SDS-WAS RCNAMEE contributed to the Training course on the use of satellite products for agrometeorological applications (Tblisi, Georgia, 16-20 May 2016).
- Also, in May 2016, the SILAM model, daily run by the Finnish Meteorological Institute (FMI) was included in the SDS-WAS model intercomparison system; the side event "Achieving land degradation neutrality and combating sand and dust storms for healthy planet and healthy people" was held at the UN Environment Assembly (Nairobi, Kenya, 26 May), a resolution proposed by Iran and backed by Pakistan and Iraq that aims to enlist the aid of Middle East countries to tackle dust storms in the region was approved at the second UN Environment Assembly (Nairobi, Kenya, 23-27 May 2016) and the SDS-WAS participated in the 2016 WMO-GAW SAG-Aerosol meeting (Seoul, ROK).
- International Workshop on Asian dust and aerosol (Jeju, Republic of Korea (ROK) 21 September); Asia Node SDS-WAS Steering Group meeting (Jeju, ROK, 22-23 September) 2nd meeting of the WMO SDS-WAS Steering Committee (Jeju, ROK); 2016 Meeting of the Asian SDS-WAS Regional Node in connection with the Aerosol Asian Workshop (Jeju, ROK).
- In October 2016, the International Workshop on SDS was held in Istanbul, UNEP published the “Global Assessment of Sand and Dust Storms” a joint UNEP/WMO/UNCCD
report and WMO SDS-WAS presented our suggestions for UN consultations regarding the developing Sand and Dust Storms UN resolution being put forward by the G77 political group.

- I. R. of Iran Meteorological Organization (IRIMO), EUMETSAT and the WMO Barcelona Dust Forecast Center (BDFC) jointly organize the 5th Training Course on WMO SDS-WAS Products (Satellite and Ground Observation and Modelling of Atmospheric Dust) (Tehran, Iran, 5-9 November 2016).

Links with other working groups, projects, international initiatives

DAOS-WG: possible links with the SDS-WAS activities focused on better description of current and forecast conditions for dust using dust-related observations (satellites, lidars/ceilometers, etc) for data assimilation.

SERA-WG: possible links with SDS WAS in general (transfer of research results to user applications; an example of the SDS-WAS COST action initiative), and with the SDS-WAS on different dust sources characterization.

JWGFRV: possible links with SDS-WAS research on near real time and off-line dust evaluation using different satellite and ground based observation platforms and networks and using non-conventional verification methods such as pattern matching techniques.

HIWeather & NMR-WG: possible links with SDS-WAS research aimed to better understand generation and development of small-scale dust storms (such as density current storms, haboobs, etc.) by applying high resolution dust modelling systems.

PDEF-WG: possible links with a SDS WAS RC project focused on the study of large-scale meteorological processes that drive dust mobilization over the Sahara and dust transport out of Africa.

Future plans (2017-2018)

- Annual newsletter entitled "Airborne dust bulletin, which will be published by WMO The first issue is expected to be released in February 2017.
- Sixth Training Course on SDS-WAS Products (Turkey 2017).
- Routine dissemination of predicted ice nucleation.
- Phone App dust products dissemination.
- Global SDS-WAS Steering Committee meeting (Barbados).
- Asia Node SDS-WAS Steering Group meeting (Japan).
- Results and actions derived from proposals submitted to competitive calls
- Providing WMO SDS-WAS part (SDS observations, prediction, early warning and assessments) to the Technical Guide for SDS coordinated by UN Convention to Combat Desertification.
- Meetings of SDS-WAS Scientific Committee and Regional Steering Group (Tenerife, May 2018).
- Concerning research activities: Continue the current ongoing dust-related projects, Initiate activities in long-term dust reanalysis with links to dust WCRP.
Comments/answers to questions during discussions

In recent years, the sand and duststorm activity had been very active and the regional nodes did very valuable work in advancing the warning, advisory and assessment system by providing real time access to warnings and link to societal impact.

The Barcelona Computing Centre only has the primitive ensemble, information are from 11 models but the product of only one forecast.

Suggestions:

- Multi model ensemble (like in TIGGE and S2S) may help in assessing value of individual models.
- Skills acquired by advance nodes should be transferred/shared with other nodes.
- Work with WHO to learn more about the societal impact of sand and dust.
- Extend studies from dust and sand to other aerosols (e.g. mixed aerosols etc.).
- Utilize data from airports especially for the verification component.

WWRP IMPLEMENTATION PLAN (2016-2023) AND POTENTIAL LINKS TO INTERNATIONAL INITIATIVES

1. WWRP Implementation Plan and key needs for international coordination

In the presentation of the Chairperson of WWRP SSC, she emphasized that the new WWRP Implementation Plan will ensure the realization of a research strategy towards the seamless prediction of the Earth system from minutes to months. This research strategy is developed to face four scientific and societal challenges identified by CAS namely: High-Impact Weather, Water, Urbanization and Evolving Technologies. She also identified the four societal challenges: high impact weather, water, urbanization and new technologies, for the decade to come. For each of aforementioned challenges there are a set of action areas. Within each action areas, selected activities of WWRP’s working groups and core projects had been identified and if completed will help reach the overall programmatic goals of WWRP.

Sufficient international and regional mechanisms are already in place to save lives and property and enable individuals, institutions, society to manage weather and climate related risks. The WWRP’s goal is to advance society's ability to cope with high impact weather through research focused on improving the accuracy, lead time and utilization of weather prediction. There is general consensus that to share and access information a broad regional and international coordination is essential. Effective cooperation and collaboration therefore with the various partners, both within the WMO and with external organizations, of WWRP would significantly help the programme achieve its mission.

2. WWRP’s partners

Over the years, the symbiotic relationship between WWRP, field experiments, research projects and other WMO programmes has gradually led to advances in the science of weather and climate prediction and its service in meeting the challenges of the twenty-first century. It is envisioned that a higher platform of cooperation will be established between WWRP and its partners.
2.1 **Global Atmosphere Watch (GAW) Programme (Paolo Laj)**

Notable among the cross-cutting activities between WWRP and GAW is SDS-WAS. GAW’s expertise on atmospheric chemistry, aerosols, aerosol-cloud interaction and atmospheric deposition, its strong observational component, as well as other complementary approaches to several cross-thematic key issues makes the programme an ideal partner to WWRP. Another activity that calls for further collaboration is the GAW Urban Research Meteorology and Environment (GURME) initiative which contributes to the WMO cross-cutting urban focus and the concept of the integrated urban services. Joint collaborations and exchange on urban aspects will be further strengthened and even extended into public health, transport and the energy sectors.

2.2 **World Climate Research Programme (WCRP)/Global Energy and Water Exchanges (GEWEX)/WCRP Grand Challenge on Extremes (Sonia Seneviratne - remote)**

A close collaboration with WCRP, its experts and its Grand Challenge on Understanding and Predicting Weather and Climate Extremes is deemed crucial. Substantial potential for synergies includes issues such as representation of extreme events in models, building a seamless transition from weather to climate predictions, exploration of new data sources, field campaigns, high-impact weather events etc. WCRP’s GEWEX runs numerous projects that brings together observations and large-eddies to global model hierarchies for process understanding and parameterization development which both serve the weather and climate communities.

2.3 **Commission for Hydrology (CHy) (Jan Danhelka)**

Close collaboration with experts in WMO’s Commission for Hydrology is important for WWRP on topics such as improving modelling and prediction of the water cycle. There is an opportunity to focus joint efforts on the development of innovative observing techniques and improved use of remote sensing observations in data-sparse region. Improve coupled modelling of atmosphere/land/ocean/water and improved land surface models in coupled modelling systems to incorporate more hydrological processes, using ensemble QPE/QPF to drive ensemble hydrological predictions would serve both hydrological and weather communities.

2.4 **Global Data Processing and Forecasting System (GDPFS)(Alice Soares)**

Strong links between WWRP and GDPFS needs to be established as the latter moves into an enhanced integrated and seamless GDPFS. In the transition, GDPFS would need seamless blending of nowcasting, mesoscale and global numerical weather prediction, impact-based forecasting and risk-based warnings, extreme events, sub-seasonal to climate forecasting.

2.5 **Young Earth System Scientists (YESS) (Vera Schemann)**

In recent years, WWRP together with WCRP had made a concerted effort to support early career scientists particularly those in earth system science. The WCRP Joint Scientific Committee endorsed the ECS initiative at their 37th session (WCRP JSC-37, 2016. Support to ECS activities had been through assistance in interaction and outreach, and by certain level of financial support to organize events relevant to WMO research activities. The CAS Management Group (CAS-MG 11) during their meeting in 2016 agreed to promote this ECS initiative in their
own institutions and regions. EC-69 (2017) decided to support ECS to help develop a scientific workforce fit to face future research challenges and contribute to security and socio-economic development. In her presentation, Ms Schemann suggested ways for WWRP SSC could further support ECS/YESS:

- Consider ECS when recruiting members for working groups and committees
- Introduce ECS representative at SSC
- Offer travel support for YESS officer, working at the YESS Office in Argentina

2.6 Working Group on Numerical Experimentation (WGNE) (Ayrton Zadra – remote)

WGNE and WWRP has been working closely with the Joint Working Group on Forecast Verification Research which it jointly established in 2003. Closer working relationship with WGNE is called for as both are equally concerned with fostering the development of atmospheric circulation models for use in weather, climate, water and environmental prediction on all time scales and diagnosing and resolving shortcomings.

3. Break-out group sessions

Topic 1: How to be seamless across weather to climate, across weather to hydrology, across weather to environment?

As the delineation of boundaries between mesoscale, synoptic scale, seasonal and decadal predictions does not have a scientific basis and the simulation and prediction of mesoscale systems, synoptic scale disturbances, intra-seasonal, seasonal and inter-annual variations are intimately linked it has been proposed that future research on prediction of weather and climate be carried out in a unified framework. The use of a seamless prediction system would allow probabilistic projections of climate change to be constrained by validations on weather or seasonal forecast time scales.

What is necessary?

- To develop a next generation physics suite which should be scale and aerosol aware, and contain options for varying degrees of sophistication and physical realism.
- To build one channel for information (some linkages already exist). It is not necessary to have one model that serves all. Ideally we can combine information from those models that best fit for purpose into a seamless framework and make it accessible through one information channel. Data policy and data exchange also has to be considered (e.g. EU Copernicus).
- A common definition on risk and vulnerability across hazards.
- To change predictive range and need a scientific approach that is characterized for needs.
- To accept growth of the private sector (in 8-10 years there will be competitive private sector) and bind them into the research strategy.
- Understand evolution of climate extremes and impact on weather extremes.
Fundamental requirements for linking weather and hydrology:

- Map water cycle
- Full integration of hydrological component in meteorological model
- Atmospheric composition across all scales is important and will be part of the systems, not only air quality but chemistry in general
- Sufficient data especially from developing countries

Areas where we need to work more closely in the next 2 years:

- Atmospheric composition
- Atmospheric analysis
- Forecast uncertainty
- Land-surface hydrology coupling
- Data sources
- Incorporation of social sciences
- Extremes
- Urban issues

Where do we want to be in 8-10 years time?

- Moving towards an integrated earth system analysis and prediction capability with a weakly coupled system atmosphere ocean land ice, atmospheric composition can be fully integrated.
- Better representation of small water features, integrated hydrological information system for analysis of vulnerability, human impacts and decisionmaking, improved impact-based hydrological models and better integration of services.

What does seamless mean for developed and developing countries?

To both, seamless prediction refers to either bridging the gap between forecasting high-impact events at daily-to-seasonal timescales or defining the spatial-temporal continuum of the interactions between weather/climate and Earth system. It is not necessary that all forecast centres have their own model. What is necessary is to ensure that we address primary hazards in the country, recognizing that forecast centres vary in capability, location, and needs. The seamless framework would require the weather and climate communities to work as a single scientific enterprise.

How to deal with expertise on some lying outside the scope of NMHS?

There is a need to broaden the vision of services to include other expertise in optimizing the transfer of knowledge, improve interoperability and for centres to provide more usable comprehensive environmental information services. The goal is to serve a broader range of public and decision maker needs that extends beyond the current scope of the NMHS. Partnerships with academia, private sector, end-users, etc., needs to be developed and most importantly there is a need to fully understand the decision process and context from a user-perspective.
**Topic 2: How to improve research focus on operational needs?**

- It is necessary to start from operations, see what they need from the research community and understand how best to transfer this knowledge.
- Encourage interdisciplinary research programme through cooperation (get both sides involved from the start and break existing boundaries between operations and research).
- Understand the language nuances, different communities do have different terminologies.
- To establish a prize or a dedicated research focus but may require a critical level of funding.
- Research projects should call for concrete links between universities and National Meteorological Hydrological Services (NMHSs).
- Identify reliable partners in the academic community and build up a consistent relationship.

**On New Technologies:** Quality vs. data coverage has to be addressed, as well as usage of unconventional data.

**On Urban Services:** Stakeholders need information from NMHSs. FDPs can be used to demonstrate current capabilities. Pressing urban issues included air quality, flooding, heat, urban planning. There are scientific questions which have yet to be addressed in the Multi-Hazard Early Warning System (MHEWS). Reliable and timely forecasts could allow establishment of fines or rewards (e.g. fining pollution producers). This could also apply for renewable energies and tactical regulations. There is a need to conduct observation testbeds, develop framework/guidelines/structure on what users need and identify what research outcome is most socio-economically relevant.

**WWRP SSC CLOSED SESSION**

**WMO structure and retreat**

Work is ongoing toward the future evolution of CAS to be across weather, environment and climate, including discussions within WMO. Filling the gap between research and development (R&D) and operations requires a move from a current linear model of transferring research to operations to an interactive model, in which stakeholders assess and articulate their future needs, researchers work in dialogue with stakeholders to define and implement appropriate research programmes, the research results are transferred into operations at appropriate intervals and the stakeholder needs and research programmes are refined taking into account the knowledge and experience gained. This interactive path to value innovation requires:

- A close collaboration across the GAW Programme, the WWRP and WCRP.
- Commitment of the WMO operational community to exploit collaboration opportunities in the new implementation plans of GAW and WWRP, considering inputs from WCRP, and to develop joint activities.
- A continuous joint consultation of research and operations with the user community.
- Use of research inputs to design and develop new products and services.
- Continuous provision of feedback to drive new research activities.
Alan Thorpe is assisting in developing a framework for an integrated research and development approach.

Research was one of the discussion points during the 2016 WMO management retreat. WMO is a unique entity in the UN because of its research component. The needed restructuring/change is driven by outside forces that is rapidly evolving: the Earth system, society, and technology. The envisioned changes are expected to lead to new predictive skill:

- It is necessary to deal with research issues in an earth system context and find consensus on research topics.
- We need to plan jointly with CBS to limit duplication and attain a more complete perspective of the work especially those related to GFCS and GDPFS.
- Our success in finding additional funding is also an indicator for success.
- Partnership with academia, private sector and NMHSs is necessary.
- Engagement with early career scientists is desired.

Planned Structure of CAS Session

**Venue: Denpasar, Bali, Indonesia**

**The Science Summit (20-22 October 2017)**

The Technical Conference which is usually held in conjunction with the CAS Session has been renamed The Science Summit (20-22 October 2017). The Summit will provide an opportunity to shape the WMO research agenda building on the closer collaboration between weather, climate, water and environment research. An additional focus of the Summit is to close the gap between research and the derived societal benefits. Plans are to announce the Science Summit by December 2016 to have at least one year for preparatory work.

**CAS-17 (23-24 October 2017)**

Aside from securing the widest possible technical representation we also need to attract the participation of early career scientists, GAW scientific advisory group Chairpersons, WWRP working group Chairpersons and members of the WCRP modelling council to CAS-17.

**WWRP SSC-10 (25-26 October 2017)**

The 10th Session of WWRP’s SSC will be held in conjunction with the Science Summit and CAS-17.

**Overall review of implementation plan (2016-2023)**

The structure of the implementation plan is good, and it is an advantage to have a clear structure to work with. It is necessary though to discuss first how the reporting/evaluation will be conducted. Also, the IP needs to be converted to a work book before we can proceed to the next step which is a base-level refinement.

**CLOSURE OF THE MEETING**

The Chairperson announced the closure of the meeting at 5.30 p.m. on 27 October 2017.
ANNEX I

Ninth Session of the Scientific Steering Committee (SSC) for the
World Weather Research Programme (WWRP)

(Geneva, Switzerland, 24-27 October 2016)

List of Participants

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Mr Roelof Bruintjes (Chairperson, WM-ET)
Ms Carla Cardinali (Co-chairperson, DAOS-WG)
Mr Yihong Duan (Chairperson, TMR-WG)
Ms Jane Rovins (Co-chairperson, SERA-WG)
Mr Peter Steinle (Co-chairperson, NMR-WG)
Mr Lawrence Wilson (Co-chairperson, JWGFVR)
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Mr Peter Li, (Chairperson, AvRDP)
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Representative of WWRP Partners
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Ms Sonia Seneviratne (WCRP GEWEX) – remote
Mr Ayrton Zadra (WGNE) - remote

WMO Secretariat
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(Director, Research Department)
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Ms Estelle De Coning (SO, WWRD)
Ms Alice Soares (SO, DPFD)
Ms Julia Keller (JPO, WWRD)
Ms Nathalie Tournier (SS, WWRD)
### Ninth Session of the Scientific Steering Committee (SSC) for the World Weather Research Programme (WWRP)

*(Geneva, Switzerland, 24-27 October 2016)*

**Future and ongoing collaborative work between the working groups and projects**

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<td>Verification of seeding activities</td>
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**S2S**
- Coupled DA Configuring future observing systems
- S2S book: chapter on verification

**DAOS-WG**
- Attended Exeter meeting
- Ensemble initial condition, coupled DA

**JWGFVR**
- B Brown attended HK meeting
- NRT & offline dust evaluation

**NMR-WG**
- Interpretation of probability forecasts

**PDE-F-WG**
- Small-scale duststorms

**SDS-WAS**
- HIWeather Task Teams

**SERA-WG**
- Enhancing snowpack

**HIWeather**
- Verifying & products sub-project

**WM-ET**
- Verification of seeding activities

**PPP**
- Verification in polar regions

**S2S**
- Database for YOPP & YTMIT

**S2S**
- Nowcasting & mesoscale modelling

**HIWeather**
- HIWeather Task Teams

**PPP**
- Enhancing snowpack

**JWGFVR**
- Verification in polar regions
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<th>Lake Victoria Project</th>
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<td>SCMREX</td>
<td>Dust/aerosols and tropical cyclones/monsoon</td>
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<td>SCMRex UPDRAFT SCMREX TLFDP</td>
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<td>Multi-scale forecasting of weather-related hazards</td>
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<td>Targeted cloud &amp; precipitation processes</td>
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<td>Arctic &amp; Antarctic sea ice &amp; the Indian monsoon</td>
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World Weather Research Programme (WWRP) Report Series

Sixth WMO International Workshop on Tropical Cyclones (IWTC-VI), San Jose, Costa Rica, 21-30 November 2006 (WMO TD No. 1383) (WWRP 2007-1).


WMO International Training Workshop on Tropical Cyclone Disaster Reduction (Guangzhou, China, 26 - 31 March 2007) (WMO TD No. 1392) (WWRP 2007-3).


Expert Meeting to Evaluate Skill of Tropical Cyclone Seasonal Forecasts (Boulder, Colorado, USA, 24-25 April 2008) (WMO TD No. 1455) (WWRP 2008-4).

Recommendations for the Verification and Intercomparison of QPFS and PQPFS from Operational NWP Models – Revision 2 - October 2008 (WMO TD No. 1485) (WWRP 2009-1).


4th WMO International Verification Methods Workshop, Helsinki, Finland, 8-10 June 2009 (WMO TD No. 1540) (WWRP 2010-1).

1st WMO International Conference on Indian Ocean Tropical Cyclones and Climate Change, Muscat, Sultanate of Oman, 8-11 March 2009 (WMO TD No. 1541) (WWRP 2010-2).

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2nd WMO International Workshop on Tropical Cyclone Landfall Processes (IWTCLP-II), Shanghai, China, 19-23 October 2009 (WMO TD No. 1548) (WWRP 2010-4).

5th WMO Symposium on Data Assimilation, Melbourne, Australia, 5-9 October 2009 (WMO TD No. 1549) (WWRP 2010-5).
7th International Workshop on Tropical Cyclones (IWTC-VII), Saint-Gilles-Les-Bains, La Réunion, France, 15-20 November 2010 (WMO TD No. 1561) (WWRP 2011-1).


Recommended Methods for Evaluating Cloud and Related Parameters (WWRP 2012-1).


Fifth Session of the Joint Scientific Committee (JSC) for the World Weather Research Programme (WWRP), Geneva, Switzerland, 11-13 April 2012 (WWRP 2012-3).

Second WMO/WWRP Monsoon Heavy Rainfall Workshop, Petaling Jaya, Malaysia, 10-12 December 2012 (WWRP 2013-1).

International Workshop on Unusual Behaviour of Tropical Cyclones, Haikou, Hainan, China, 5-9 November 2012 (WWRP 2013-2).

Abstracts of Papers for the Fifth WMO International Workshop on Monsoons (IWM-V), Macao, China, 28-31 October 2013, Hong Kong, China, 1 November 2013 (WWRP 2013-3).

Second International Conference on Indian Ocean Tropical Cyclones and Climate Change (IOTCCC-II), New Delhi, India, 14-17 February 2012 (WWRP 2013-4).

WMO/WWRP International Workshop on Rapid Changes in Tropical Cyclone Intensity and Track, Xiamen, China, 18-20 October 2011 (WWRP 2013-5).

5th International Verification Methods Workshop, Melbourne, Australia, 5-7 December 2011 (WWRP 2013-6).

Verification Methods for Tropical Cyclone Forecasts (WWRP 2013-7).


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Workshop on Communicating Risk and Uncertainty, Melbourne, Australia, 26-27 July 2012 (WWRP 2014-3).


6th International Verification Methods Workshop, New Delhi, India, 13-19 March 2014 (WWRP 2014-6).

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3rd International Workshop on Monsoon Heavy Rainfall (MHR-3), New Delhi, 22-24 September 2015 (WWRP 2015-6).


Verification of Environmental Prediction in Polar Regions: Recommendations for the Year of Polar Prediction, (WWRP 2017-1).