WGNE-30

23-26 March 2015

NOAA Center For Weather and Climate Prediction (NCWCP)

College Park, Maryland, USA

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Fig 1. Attendees of the WGNE30 session

We are very grateful to NCEP/EMC for hosting the session and to The American Meteorological Society for its generous support to the meeting.

1. Introduction

1.1 Welcome, adoption of the Agenda and local arrangements

Co-chairs welcomed all attendees and thanked the NCEP/EMC for hosting the meeting. They quickly reviewed the main objectives of the session aimed at reviewing progress since WGNE29 held at the Bureau of Meteorology, Melbourne, Australia on 10-13 March 2014. The agenda was adopted without noteworthy changes. Jean-Noël Thépaut noted that the current WGNE Terms of Reference are quite similar to what they were initially, and that the organization of workshops remains an important WGNE core activity. He encouraged and invited all attendees to contribute actively to this session.

Michael Ek provided some details on local arrangement and thanked The American Meteorological Society for their generous sponsorship to the meeting.

1.2 Welcome addresses

Dr Louis Uccellini, National Weather Service (NWS) Director, welcomed all participants and highlighted the NWS priority to build a weather-ready nation aiming at building community resiliency in the face of increasing vulnerability to extreme weather, which will require a seamless suite of forecasts increasingly based on multi-model ensembles. He reviewed the current status of High Performance Computing and stressed the challenge of measuring success beyond traditional forecast metrics to assess socio-economic impacts and human factors. He highlighted THORPEX, which has been a major driver for research leading to significant progress in multi-model ensemble forecasting.

He further encouraged WGNE to develop Earth System Modelling, coupling, and multi-model ensembles, recognizing that the main building blocks exist, the challenge being to interconnect them.

Bill Lapenta, Director NCEP, welcomed all participants and noted that the NWS consists of a number of specialized centers, the National Centers for Environmental Predictions (NCEP). He highlighted that modeling is a cornerstone activity of NCEP.

Hendrik Tolman, Director of the NCEP Environmental Modeling Center (EMC/NCEP) welcomed all participants and highlighted the growing multi-disciplinary nature of Environmental Predictions.

1.3 WGNE: history, achievements and lessons learnt

Lawrence (Larry) Gates kindly provided a history of WGNE. He served as a member (1974-1988) and chair (1989-1990) of WGNE then as a chair of the WCRP Joint Scientific Committee. Larry joined Lawrence Livermore National

Laboratory (LLNL) in 1989 to establish the Program for Climate Model Diagnosis and Intercomparison (PCMDI) under the sponsorship of the DOE. He highlighted the founding work of Charney, Fjortoft and von Neumann (1950) and Philips (1956), the emergence of GARP (Global Atmospheric Research Programme), established by WMO (World Meteorological Organization) in 1967 and subsequent establishment of WCRP (1980), TOGA (1985), IBGP (1986), IPCC (1988), GEWEX (1988), AMIP (1990), WOCE (1990), SGGCM (1990), SPARC (1992), UNFCCC (1992), PILPS (1992), ACSYS (1993), CLIVAR (1995), WGCM (1996), CMIP (1996), WWRP (1997), CliC (2002), THORPEX (2994), GAW (2008), GFCS (2009). WGNE eventually emerged from GARP and held its first formal session in 1985. He concluded with a personal viewgraph synthesizing nicely the evolution, breadth and depth of GARP and WGNE activities over the 1960-2015 period.

Ayrton Zadra pointed to the growing complexity to be addressed by WGNE, which seems overwhelming, and Paolo Ruti stressed the need for centers to integrate new expertise as scope expands, to which Larry Gates responded that WGNE should continue to play its international coordination role, keeping a strong focus on numerical modeling issues. Hendrik Tolman remarked that WGNE can leverage NWS long-term expertise in operational forecasting.

1.4 Review of WGNE29 Actions

1. CLOSED
2. CLOSED (discussed herein)
3. CLOSED (discussed herein)
4. CLOSED (discussed herein)
5. CLOSED
6. CLOSED
7. CLOSED (discussed herein)
8. CLOSED
9. CLOSED (discussed herein)
10. CLOSED (discussed herein)
11. CLOSED
12. CLOSED (discussed herein)
13. CLOSED
14. CLOSED
15. CLOSED (discussed herein)
16. ON-GOING: Keith Williams agreed to follow-up on exploring ways to archive and preserve historic GASS data sets
17. CLOSED (discussed herein)
18. CLOSED (discussed herein)
19. ON-GOING
20. CLOSED (discussed herein)
21. CLOSED (discussed herein)
22. CLOSED (discussed herein)
23. CLOSED (discussed herein)

24. CLOSED (discussed herein)

2. Sponsors

2.1 WCRP matters

Michel Rixen highlighted the increasing convergence of visions between weather, climate and environmental communities towards seamless research. Strategically, WCRP, WWRP and GAW are facing a number of new challenges requiring enhanced collaboration between these programmes:

- a critical mass of multi-disciplinary research is required to make further progress in model development and harvest additional prediction skill
- the seamless prediction value chain goes beyond numerical modelling and needs to encompass observations, metrics, verification, research and services
- current governance structures are currently still largely fragmented
- resources for fundamental research are shrinking and will require breaking organizational and cultural barriers

He highlighted the new WCRP/WWRP International Prize for Model Development and the Summer School on Model development organized at MPI, 15-26 June 2015 both managed by the WCRP Modeling Advisory Council, which is meeting on 9 April to discuss some emerging topics such as urban complexes and megacities, systematic errors and a possible new Transpose-CMIP activity and the assessment of initial shocks and drifts in climate predictions.

He also stressed the importance of the Earth System Grid Federation and its associated observational (obs4MIPs) and reanalysis (ana4MIPs) components, as the recommended archiving and dissemination platform within WCRP and the need to interface such infrastructure with WMO protocols and standards.

Craig Bishop suggested using climate models in assimilation mode instead of initializing models with reanalyses and mentioned the following useful reference: "Klocke, D. and Rodwell M. J., A comparison of two numerical weather prediction methods for diagnosing fast-physics errors in climate models (2014), Q. J. R. Meteorol. Soc. 140: 517 – 524, DOI:10.1002/qj.2172".

2.2 CAS matters

Paolo Ruti provided a summary of the 10-year vision of the Commission for Atmospheric Sciences on behalf of Øystein Hov:

- High Impact Weather and its socio-economic effects in the context of global change
- Water: Modelling and predicting the water cycle for improved DRR and resource management

- Integrated GHG Information System: Serving society and supporting policy
- Aerosols: Impacts on air quality, weather and climate
- Urbanization: Research and services for megacities and large urban complexes
- Evolving Technologies: Their impact on science and its use

Ayrton Zadra enquired about the match between the 10-year vision and the WGNE30 agenda items, and whether new, especially observing, technologies can be sustained over the long term. Craig Bishop stressed the emergence of new cell phone applications sending extreme event warnings. Paolo Ruti highlighted the S2S data base protocols being almost the same as TIGGE.

2.3 WWRP matters

Paolo Ruti noted that the World Weather Research Programme (WWRP) advances society's resilience to high impact weather through research focused on improving the accuracy, lead time and utilization of weather prediction, and through engaging users & stakeholders to define research priorities and facilitate transition to applications. WWRP develops cooperative international & interdisciplinary research in the operational and academic communities and supports the development of early career scientists. WWRP aims at Seamless Prediction of the Earth System from minutes to months using coupled systems – thus applying expertise in weather science to promote convergence between weather, climate and environmental communities.
Weather prediction has achieved immense progress, driven by research and increasingly sophisticated telecommunication, information technology and observational infrastructure. Predictive skill now extends in some cases beyond 10 days, with an increasing capability to give early warning of severe weather events many days ahead. Ensemble methods now routinely provide essential information on the probability of specific events, a key input in numerous decision-making systems.
Partly because of these advances, the needs of the users of weather services have simultaneously diversified to encompass “environmental” prediction products such as air quality or hydrological predictions. But as the science advances, critical questions are arising concerning, for example, the possible sources of predictability on weekly, monthly and longer time-scales; seamless prediction; optimal use of local and global observing capabilities; and the effective use of massively-parallel supercomputers.

WWRP, working in partnership with other international initiatives, will ensure the implementation of a research strategy towards the seamless prediction of the Earth system from minutes to months.

He highlighted the achievements of THORPEX on:
- Adaptive observations
- Ensemble-based Data Assimilation
- Multi-center ensemble forecasting

- TIGGE
- Field campaigns

and the three legacy projects: High Impact Weather (HIWeather), Polar Prediction Project (PPP) and Subseasonal to Seasonal Project (S2S) which will form the pillars of the WWRP strategy for the next 10 years.

The short discussion focused on the level of maturity of hydrological models and the possible role of WGNE, noting some on-going discussions with the WMO Commission for Hydrology.

2.4 GAW matters

Greg Carmichael detailed the Global Atmospheric Watch mission that will support 1) the Systematic Global Monitoring of the Chemical Composition of the Atmosphere 2) the analysis and Assessment in Support of International Conventions and 3) the development of Air Pollution and Climate Predictive Capability. He highlighted the new Strategic Implementation Plan (2016-2023) focusing on "Science for service" covering Disaster Risk Reduction, Global Integrated Polar Prediction Systems, Megacities, the Global Framework for Climate Services (GFCS), and the WMO Integrated Global Observing System (WIGOS) and WMO Information System (WIS) in the context of the CAS-16 identified priorities.

Jean-Noël Thépaut and Saulo Freitas suggested a possible involvement of GAW in the WGNE aerosol projet and a possible joint workshop on the Beijing case study.

3. Outcomes from recent workshops

3.1 WWRP Open Science Conference (WWOSC)

Paolo Ruti provided a report on the World Weather Open Science Conference (WWOSC) held in Montreal from 16 to 21 August, 2014 and attended by more than 1,000 meteorologists, forecasters, social scientists and application developers from 57 countries, which has laid the foundations to face future challenges. Open Science Conferences happen infrequently and are designed to draw the whole research community together to review the frontiers of knowledge and to act as an international stimulus for the science and its future. The WWOSC did consider the state-of-the-art and the future evolution of weather science and also the related environmental services and how these need to be supported by research. These discussions were informed by research presentations and input by both providers and users of weather and environmental prediction services. The merits of key components of modern operational systems have been discussed in depth, as well as the major scientific challenges still facing the community. The event also provided an important space for the students and early career scientists. The conference was co-sponsored by major scientific and operational bodies such as

Environment Canada, National Council Research Canada, World Meteorological Organization (WMO) and the International Council for Science (ICSU). The highly successful conference did achieve its grand goal to chart the future course of scientific research and its potential for generating new and improved weather services.
The overarching theme of the conference was “Seamless Prediction of the Earth System: from minutes to months”. The conference highlighted recent advances in weather science and in the science and practice of weather prediction. The Conference also considered areas where a predictive capability is emerging, including a range of aspects of the natural environment, to provide predictions of importance in a range of different socio-economic sectors.

3.2 PPP workshop in Barcelona

Francois Bouyssel briefed WGNE on the outcomes of the “International workshop on “Polar-lower latitude linkages and their role in weather and climate prediction” (10-12 December 2014, hosted by the Institut Català de Ciències del Clima (IC3) in Barcelona, Spain.”

The workshop was motivated by the fact that the polar regions are anticipated to undergo rapid changes with global warming. These changes may have teleconnections (atmospheric and oceanic) for the weather and climate, which are not yet sufficiently well understood. 80 participants including early career scientists, from 20 different countries and from atmospheric, oceanic, prediction and services communities attended the workshop. A preliminary workshop report and presentations (slides and audio) are available on: http://www.polarprediction.net/linkages/webinar.html

The workshop addressed a wide range of time scales: from medium range, S2S to climate. The assessment of the potential for recent Arctic changes to influence broader hemispheric weather now and in the future is a difficult and controversial topic, because of major uncertainties due to the short observational record since major Arctic changes began and a large chaotic component to weather systems relative to potential Arctic forcing.

There is a need to improve our understanding of the key processes in atmosphere, snow, sea ice and ocean responsible for linking the polar regions with the lower latitudes and to verify that these key processes are well represented in coupled models (atmospheric, ocean, sea-ice) used for weather and climate predictions. The development of coupled data assimilation systems is highly desirable. Others key recommendations include: i) executing coordinated model experiments to assess possible remote impacts of polar climate change, ii) exploring the limits of predictability of polar weather and climate and their impacts on mid-latitude forecasting, iii) determining the impacts of enhanced predictive capacity in the polar regions for mid-latitude forecasting by carrying out coordinated forecasting experiments (e.g. data denial and relaxation experiments), iv) development of

the polar observing systems taking into account prediction and model assessment (opportunity of YOPP).

How WGNE could help in terms of numerical experimentation was not discussed in much detail. It was suggested to discuss this further (PPP session on Thursday afternoon). One question would certainly be how sensitive the lower-latitude response is to model formulation and what are the potential relevant factors influencing lower latitudes to be studies in more detail. WGNE has some activities in terms of intercomparing performances and analyses over the poles. Activities are planned with S2S on teleconnections, which may be relevant for this.

3.3 Scalability workshop at ECMWF

Francois Engelbrecht provided a short summary of the Scalability Workshop held at ECMWF, Reading, on 14-15 April 2014.

The challenges of highly parallel computing in areas such as observational data processing, data assimilation, the formulation of the model dynamical core and model output management have led to the formulation of a Scalability Project at ECMWF. The project will coordinate resources defining the future forecasting system across all scales. This will be in preparation for future high-performance computing architectures aiming at accurate, efficient and scalable algorithms and code structures.

The Scalability Project will rely heavily on external partnerships with numerical weather prediction centres, high performance computing centres, academia and hardware providers. The workshop included presentations covering weather and climate science applications at exa-scale, as well as numerical algorithm and hardware aspects towards exa-scale high-performance computing.

The full workshop report and presentations given during the workshop are available at
http://old.ecmwf.int/newsevents/meetings/workshops/2014/Scalability/.

The discussion highlighted the potential role of WGNE to run regular reviews on main scalability developments within centers, including I/O 500 Top ranking. Error tolerance was not discussed at the workshop.

3.4 WGRC Expert Meeting on Climate Information Distillation

Francois Engelbrecht provided a short verbal report on the outcomes of the meeting held in Santander, Spain on 29-31 October 2014, highlighting the leading complication for users of climate information for policy and adaptation in dealing with the spread of messages arising from data of historical change, GCM projections, downscaled projections from RCMs and statistical downscaling, and from other related spatial disaggregation methods. The confusing mix of contrasting data sets offer widely differing (and often times

fundamentally contradictory) indications of the magnitude and direction of past and future regional climate change. More details can be found at http://www.wcrp-climate.org/index.php/distillation-about.

3.5 CCMM workshop

Saulo Freitas presented the key outcomes of the Symposium on Coupled Chemistry-Meteorology/Climate Modeling (CCMM) held at WMO on 23-25 Feb 2015. The main focus was on aerosols and their feedbacks/forcing addressing coupled modeling, key processes of chemistry-meteorology interactions, aerosol effects and NWP, air quality and atmospheric composition, model evaluation and validation and data requirements and assimilation. Online modelling approach may benefit applications on all time scales of NWP, air quality and climate models, noting that a single 'one fits all' integrated approach/system may not fulfill all requirements from the community. More details can be found at http://eumetchem.info/index.php?option=com_content&view=article&id=85%3Asymposium-on-coupled-chemistry-meteorology&catid=11%3Anews&lang=en.

Jean-Noël stressed the complexity of the challenge and the potential role of WGNE. Saulo Freitas and Michel Rixen noted the ending COST action and a possible follow-up activity expanding into the climate research territory.

4. WGNE activity reports

4.1 MJO-Task Force

Jon Gottschalck provided an update on the MJO Task Force activities, for which the mandate was renewed in 2013 for a new term of 3 years under WGNE. The work is organized into 5 sub-projects:

- Process-oriented diagnostics/metrics for MJO simulation
- Evaluation of realtime forecasts of tropical intraseasonal variability
- Assessment of CMIP5 model capability to simulate realistic intraseasonal variability
- MJO TF + GASS Multi-Model Diabatic Processes Experiment
- Develop, coordinate, and promote analyses of MJO air-sea interaction

Members acknowledged the strong contribution of the Task Force and the quality of related outcomes. Keith Williams cited the MJO as a good example of tackling specific systematic errors and successful data dissemination effort through the Earth System Grid Federation (ESGF).

4.2 Aerosol project

Saulo Freitas presented the 3rd report on the aerosol project now involving 8 participating centers running 4 global and 4 regional models. The 2 first case studies (dust and urban pollution) were revisited. Preliminary results from the 3rd case (smoke in South America) were presented. Quantitative evaluation of skill of the 2-m temperature forecast showed improvements for all models applying prognostic aerosols.
The proposed next steps are to:

- convert the data set sent by the centers into the standardized NetCDF format
- consider OpenDAP/GDS to supply simulation data and as meta-information to the public
- perform data evaluation using observational data from CPTEC/INPE, CMA, ECMWF and NASA Goddard
- write a report
- initiate discussions about possibilities of the Project be continued and merged with others initiative.

Michel Rixen highlighted the benefit of such experiment as a good example of WGNE activity benefiting modeling centers through intercomparison exercises, and recommended migrating the data set into the Earth System Grid Federation to facilitate model intercomparison and validation against observations. Paolo Ruti suggesting considering GAW observations, as currently only AERONET and MODIS data are being used so far. Wider participation in the drag project was encouraged and UKMO and Environment Canada offered potential commitment pending available resources. Brian Golding (via email) highlighted the interest of HIWeather in this activity, in particular at urban scale and noted on-going discussions with Xudong Liang about whether the Beijing SURF project could be a HIWeather RDP, addressing the air quality component. The project team has been encouraged to commit to making the surface and emissions data available to potential partners so that an intercomparison can be carried out.

4.3 Drag project

Ayrton Zadra and Julio Bacmeister noted that some of the project participants took advantage of recent meetings (e.g. 21st Symposium on Boundary Layer and Turbulence in Leeds, UK; World Weather Open Science Conference in Montreal, Canada) to meet and discuss current challenges and future steps. The list of suggestions include an exchange/comparison of ancillary files; use of high-resolution simulations to examine the partitioning of momentum processes; design of an idealized single-column model protocol to compare parameterizations; identification of a set of super-site observations to evaluate model forecasts. A successful validation exercise was also completed, through collaboration between A. Zadra (CMC) and Irina Sandu (ECMWF). The upcoming Workshop on Angular Momentum Budget (April 2015, Univ. of

Reading, UK) should provide an opportunity to publicize the initial results from the Drag Project and engage a larger community.

Connections with the SPARC GW activity were described. These include the momentum diagnostics MIP proposed as part of CMIP6. In addition, we were informed that surface drag quantities identified by the WGNE Drag project have been included as part of the data request for HighResMIP. WGNE member Bacmeister attended the QBO intercomparison workshop held March 16-18 in Victoria Canada. Recommendations for experiments to diagnose QBO dynamics were described, including initialized seasonal forecast experiments that could be of interest to WGNE members.

An important obstacle to understanding and then correctly simulating the QBO in models is the lack of any observational constraints on small scale wave activity in the tropics. Instrumented super-pressure balloons deployed by Albert Hertzog of the Laboratoire de Météorologie Dynamique (LMD) during two field campaigns to the Antarctic have proven to be invaluable sources of data about momentum fluxes from gravity waves of several km to 100's km wavelength. These platforms are unique in their ability to directly measure momentum fluxes as well as wave intrinsic frequencies. A tropical campaign using super-pressure balloons *(STRATEOLE-2)* is under consideration. We believe these measurements could transform current understanding of QBO dynamics and troposphere/stratosphere coupling in general. This new understanding would almost certainly have immediate consequences on modeling of the tropical upper-troposphere/stratosphere system.

The discussion considered the possibility for WCRP to write a supporting letter to STRATEOLE-2. Whilst attendees recognized the importance of such initiative it was felt that the scope was not broad enough to justify such supporting letter.

It was further suggested that the upcoming workshop in April could explore various ways forward on the drag project, such as the discrepancies between tendencies profiles.

4.4 Systematic errors

Keith Williams highlighted the main conclusion of the WGNE Systematic Errors Workshop held at the Met Office (15-19 April 2013) was that "more emphasis [should be placed] on seamless approaches to model evaluation and improvement across the existing programmes of WMO…. The WGNE should play a major role in facilitating this approach". A set of more specific conclusions were also listed in the workshop report (http://www.metoffice.gov.uk/media/pdf/h/9/WGNE_Workshop_Summary_v1p0.pdf) which were (paraphrased):

- The lack of and/or inaccessibility to some key observations (especially near surface data over oceans, tropics and polar regions) remains a major challenge

- A range of diagnostic techniques should be employed to investigate systematic errors. These need to be supported by well organised data available in common formats across timescales
- Links between communities divided by timescale need to be strengthened (workshop?)
- More diagnostic methods linking dynamical and physical processes are required
- The quality of (re-)analyses in tropical and polar regions is relatively poor. WGNE should lead an effort to assess the systems and propose future activities
- An impediment to progress is that different model configurations are often submitted to different MIPs.

Many systematic errors exist (e.g. lack of propagating MJO, precipitation biases over S. Asia/Maritime Continent/Warm Pool, poor simulation of sub-tropical stratocumulus, mid-latitude PV biases in ridges at the dynamical tropopause, Southern Ocean surface flux biases, and many more). A considerable amount of work is being undertaken to investigate these. In some cases (e.g. MJO), this is well coordinated internationally. In other cases, some additional coordination may be required and future field campaigns may offer a focus. The benefits of looking across timescales are clear and a number of studies have been doing this with one model, however multi-model studies across timescale are more limited due to the differing file formats, model configurations and diagnostic lists which exist between the different databases.

Keith Williams further commented that on the diagnostic side, the main limitation is mainly the lack of integration of tools which could be unified, with some interface between Grib and NetCDF. Jean-Noël Thépaut noted that ECMWF will add some NetCDF capability in their MARS system. Hendrik Tolman mentioned that OPeNDAP/THREDDS server already facilitate access to both formats in a seamless way. Fred Brandski noted the importance of meeting users needs. Both formats are recognized by WMO and mechanisms should be developed to make the two-way conversion possible. He expressed concerns about the plethora of databases and encouraged distributed architectures and improved access through portals. Peter Gleckler emphasized the need to agree on standards, such as the NetCDF 'CF' convention, which serves as a role model for NWPs, also used for observations (obs4MIPs). Keith Williams and Jean-Noël Thépaut noted the planned field campaigns (YMC, YOPP) which could help federate possible numerical experiments. Jon Petch note the lack of straightforward conclusions from MJO metrics on AMIP runs. Several suggestions were made for the next Systematic Error Workshop planned for 2017: a focus on teleconnections, an agenda designed across time scales, a NWP host with a topical focus on shorter time scales, etc. Brian Golding (via email) noted that there were some presentations at the Ningbo Workshop early 2015 suggesting that systematic errors in precipitation are quite important, particularly in tropical cyclone forecasting, an area of high interest for HIWeather.

5. Other activity reports

5.1 Subseasonal to Seasonal (S2S) Project

Frederic Vitard presented on the Sub-seasonal to Seasonal Prediction Project (S2S), the joint research project between the World Weather Research Programme (WWRP) in World Meteorological Organization (WMO) and the World Climate Research Programme (WCRP). S2S is one of the legacy projects of THORPEX, THe Observational system Research and Predictability EXperiment. The main goal of the S2S project is to improve forecast skill and understanding on the sub-seasonal to seasonal timescale, and promote its uptake by operational centres and exploitation by the applications community. Specific attention will be paid to the risk of extreme weather, including tropical cyclones, droughts, floods, heat waves and the waxing and waning monsoon precipitation. The implementation plan is available at http://s2sprediction.net. The research topics of S2S are being organized around a set of six sub-projects: Africa, Monsoon, Extreme weather, MJO, Verification and Interactions and teleconnections between midlatitudes and tropics. A main deliverable of the S2S project is the establishment of a database containing sub-seasonal (up to 60 days) forecasts from 11 operational centres. The database is hosted at ECMWF and CMA and the data portal will open soon (April 2015). Preliminary results from the forecasts already available in the database suggest that all models have issues representing MJO teleconnections over the Northern hemisphere, particularly over the Euro-Atlantic sector, which is an issue likely to reduce the sub-seasonal predictive skill. MJO teleconnections (and more generally topical-extratropical interaction) have been identified as a possible topic for collaboration between WGNE and S2S, and could be included in the 2016 WGNE workshop on systematic errors.

Paolo Ruti and Jean-Noël Thépaut suggested strengthening the collaboration with WGNE on seamless verification, via the JWGFVR and the WGCM/WGNE Metrics Panel. Laurie Wilson is member of both groups and could liaise accordingly.

5.2 Polar Prediction Project (PPP)

Thomas Jung (via Webex) reported that the WWRP Polar Prediction Project (PPP) aims at promoting cooperative international research enabling development of improved weather and environmental prediction services for the polar regions on time scales from hours to seasonal. The Polar Prediction Project (http://polarprediction.net) is organizing the Year of Polar Prediction (YOPP) which will cover an extended period of coordinated intensive observational and modelling activities in order to improve polar prediction capabilities on a wide range of time scales in both polar regions, and involving key stakeholders. A summit has been planned to take place in Geneva, 13-15 July.
In the last year key relevant topics have been addressed through a series of workshops: the presence of atmospheric and oceanic teleconnections linking

the polar regions with the lower latitudes what is expected to have implications for mid-latitude prediction across a wide range of time scales; the growth in resource development, transportation, tourism, other industries and research activities in polar regions meaning that more people, economic activity, and infrastructure are becoming exposed to conditions that affect safety, health, mobility, and productivity; and how changes in the climate system have in some situations compromised the reliability of traditional and experiential knowledge used by members of Indigenous societies and polar communities to deal with weather-related hazards.

Tom Hamill offered a potential support from DAOS towards the design of observing strategies for YOPP and recalled that the analysis of uncertainties in polar regions was discussed during WGNE29. Jean-Noël Thépaut suggested investigating the impact of observations by looking at the analysis maps. Keith Williams wondered about the motivation for a Transpose-CMIP effort, as coupled models do not have their own analysis. Tom responded that using one own analysis is a safer approach to interpret tendencies. A lot could be learnt from Transpose-AMIP and coupled systems in data assimilation mode. Francois Engelbrecht encouraged science efforts to explore links with lower latitudes, and the great opportunities engaging with SPARC to that effect.

5.3 High Impact Weather (HIWeather)

Paolo Ruti presented the High Impact Weather (HIWeather) project aiming at promoting cooperative international research to achieve a dramatic increase in resilience to high impact weather worldwide by improving forecasts for timescales of minutes to two weeks and enhancing their communication and utility in social, economic and environmental applications. The scope of the project is defined by the needs of users for better forecast and warning information to enhance the resilience of communities and countries in responding to a carefully selected set of hazards, with particular emphasis to urban areas: urban floods, wildfire, localized extreme winds, disruptive winter weather, and urban heat waves and air pollution. HIWeather has finalized his scientific plan last year (https://www.wmo.int/pages/prog/arep/wwrp/new/high_impact_weather_project.html).

The discussion addressed the links between HIWeather and Urban science. Air quality and coupling with atmospheric chemistry is an integral part of this effort which also aims at closing a gap with applications and end-users. There were some concerns about the proliferation of databases and members advised to leverage existing efforts to avoid possible duplication, a strategy also consistent with the WMO Cg-17 relevant documents developed to that effect.

5.4 PDEF

Craig Bishop updated WGNE on the Working group on Predictability, Dynamics and Ensemble Forecasting (PDEF), a merger of THORPEX TIGGE (The International Grand Global Ensemble) and PDP (Predictability and Dynamical Processes) working groups. PDEF initial foci include:

- Stochastic representation of the effect of sub-grid-scale uncertainty in numerical models
- Construction of ensemble initial conditions
- Interactions of diabatic processes with meso/synoptic scale dynamics
- Assessment of multi-model ensembles and calibration techniques
- Coupled modelling & assimilation

He advocated strongly for stochastic modeling, as numerical models only have a finite number of variables and at best, can represent only some sort of averaged or filtered version of reality and an unambiguous definition of sub-grid scale to obtain the filtered state that the model's numerical scheme is designed to evolve eventually leading to new 'Grey-zone' type projects. He welcome WGNE's input on this issue.

Jean-Noël Thépaut cited the ECMWF NWP model example which has effective resolution of 6-8 Delta_X. Tom Hamill highlighted the importance of having the right ensemble to capture uncertainties. It was noted that a handful 6-7 centers are using stochastic parameterization. Michael Baldauf remarked that there is no perfect solution, maybe a way forward is to use dynamics and physics on different - fine and coarse – grids. It was suggested to organize a PDEF-DAOS workshop on stochastic parameterization and subgrid scales.

5.5 SPARC

Quentin Errera from Stratosphere-troposphere Processes and their Role in Climate (SPARC) presented the status of four SPARC activities that are relevant for the WGNE community.
Meteorological reanalysis are more and more used by the SPARC community and there is a need to evaluate and intercompare these products. The SPARC-Reanalysis Intercomparison Project (S-RIP), setup in 2013, aims to do this evaluation with a focus on the stratosphere-troposphere system. WGNE could help S-RIP by getting its various members to participate in S-RIP and/or to make available their internal knowledge/reports (grey literature) about reanalysis products.
The second activity presented is the Stratospheric Network for the Assessment of Predictability (SNAP). It is a network of researchers that would like to address the role of the dynamical stratosphere for the tropospheric predictability. This is done by analysing ensemble forecast for two case studies: (1) the Stratospheric Sudden Warming (SSW) that occured in January 2013 in the northern hemisphere and (2) the final warming of the southern hemisphere that occurred in October 2012.

The Gravity Wave (GW) activity has in recent years focused on gravity wave effects on the atmospheric momentum budget. This group described a method for comparing gravity wave momentum fluxes between observations, high resolution GCMs and low resolution GCMs with parameterizations. In coordination with WGNE, an extension of this comparison has been proposed within the HighResMIP project. The GW group also proposes to coordinate with WGNE on the extension of their "drag project" applied to climate models to examine surface drag relationships to orographic waves and cloud responses, including high altitude cirrus.
The Quasi-Biennial Oscillation intercomparison project (QBOi) is also a SPARC emerging activity (see also the contribution of J. Bacmeister in the drag project). The QBO is the longest predictable atmospheric phenomenon with statistically distinct teleconnections. Nevertheless the QBO is not robustly captured across global climate models. Those models which do capture a QBO, exhibit a too narrow latitude width, do not descend deep enough in the lowermost stratosphere and do not appear to exhibit a consistent entrainment with the (semi-)annual cycle. The goal of QBOi is to identify model biases by endorsing a set of QBO metrics and conducting targeted numerical experiments across different global climate models. The WGNE community could help by improving parameterisations for convection and gravity waves, and dynamical core formulation to better resolve wave-types and their evolution. All of these are essential for capturing a good QBO and QBO-related impacts.

Julio Bacmeister and Jean-Noël Thépaut remarked that having a nice continuous QBO, is not always a sufficient indicator of model skill, e.g. for seasonal forecasts, as it usually breaks after a few months. Francois Bouyssel noted that Météo-France has increased vertical resolution and improved the parameterization of gravity wave drag to address this issue. Ayrton Zadra mentioned the workshop in Reading organized by Ted Shepherd which will discuss the drag project and how to connect this effort to SPARC. He also suggested adding this as a topic for a future systematic error workshop.

5.6 GASS

Jon Petch reported that GASS provides leadership for the scientific community involved in improving the representation of atmosphere processes in weather and climate models. It addresses this goal primarily through the coordination of scientific projects that bring together experts in process-modelling, observations, and the development of atmospheric model parameterizations. GASS intercomparison projects are typically based around observational field campaigns, or more idealised studies. These intercomparisons makes extensive use of initial value global forecasts with weather and climate models (so called Transpose AMIP), regional convective scale modelling, single column modelling, cloud-resolving or large-eddy simulations and a range of in-situ and remote sensing observations.

Currently GASS has 10 active projects overall with 4 projects in the later stages. In the past year, a further 4 projects have finished, or are finished except for the publication of project results. The representation of moist

convection and turbulence in atmospheric models with Grey Zone resolution (1-10 km) is being studied using a cold-air outbreak case. 50 scientists attended a Grey Zone project workshop that was held in December 2014 at the Max-Planck Institute for Meteorology and results from several models are being compared. The representation of atmospheric boundary layer processes and their interaction with the land-surface is the focus of the joint GASS/GLASS DICE project. Over fifteen different models are involved in the project and a workshop was held at the UK Met Office in October 2013. Additionally, due to significant scientific overlap, scientists working on GABLS4 will meet with those working DICE at an upcoming workshop in May 2015 at MeteoFrance. The coupling of large-scale dynamics with tropical moist convection is being studied using the so-called "Weak-Temperature" Gradient methodology. Several models have contributed to this project which aims to learn which are the most robust and valuable methodologies to study the convection-dynamics coupling with both cloud-resolving and single-column models. At the pan-GEWEX meeting in July 2014, the GASS Scientific Steering Committee (SSC) met to discuss its project and status. This was the first in-person meeting of the SSC in nearly 2 years and was helpful to discuss the status of GASS's projects and identify future directions.

Preliminary discussions have occurred regarding a 2nd Pan-GASS science conference. An initial discussion with Joe Santanello suggests that this could be conducted jointly with a GLASS, as was done at the last pan-GASS conference in Boulder in September 2012. It is envisioned that this would occur somewhere in Europe probably in the late summer or early fall of 2016.

The discussion pointed to the treatment of land in coarse resolution models, which are ran from the global forecast analysis and to GASS progress in understanding boundary layers and micro-physics well beyond convection.

5.7 GASS Grey Zone Project

Jon Petch reported that the Grey Zone Project has been established to provide a systematic evaluation of atmospheric models operating in the so called Grey Zone Resolution range of 1~10km and the project committee has performed a survey and came with the conclusion that especially from the mesoscale model community there was a strong preference to select a cold air outbreak as a first intercomparison study for the Grey Zone Project.

The Case leaders have worked over the last 12 months to set up a cases for a full hierarchy of models (global, LAM and LES) based on observations from the CONSTRAIN experiment during which a classic cold air outbreak over the North Sea north of Great Britain was observed. Realistic high resolution simulations with the correct classic spatial mesoscale features with 2 independent LES models have been produced.

The case has been released in 2013 and many modellers have submitted model results. In total we received results from 6 LES codes, 7 mesoscale models and 7 global models. December 1-3 2014, around fifty scientists

visited the first Workshop on the Grey Zone Project organized by Lorenzo Tomassini at the Max Planck Institute for Meteorology in Hamburg, Germany. They came together to present and discuss i) the model results of the intercomparison study based on the CONSTRAIN cold air outbreak ii) novel ways of representing physical processes (clouds, convection and turbulence) in models that operate in the Grey Zone with respect to these processes and iii) to discuss any further coordinated actions.

The following activities are planned for the next 1-2 years:

- April 2015: Submission deadline of the 2nd round of the cold air outbreak
- May-Sept 2015: Analysis Results
- Late 2015: Drafts ready for submission of 4 papers (2 on the mesoscale/global model results, 1 on the LES results and 1 general BAMS-like paper)
- 2016: There is interest to have a follow-up case on deep convection along the same lines (i.e. exploring the resolution-dependency of convection-representation)

5.8 GLASS

Michael Ek reviewed the different projects under the Global Energy and Water Exchanges Project (GEWEX) Global Land Atmosphere System Study (GLASS), with focus on those GLASS projects of particular interest to WGNE, i.e. increasing our process-level understanding and land data assimilation as part of model development. Specifically, the land model benchmarking project, "PALS-PLUMBER", provides an assessment of land models in terms of a "minimal level of performance", where the initial 20-site flux data sets will be extended to provide a broader coverage of surface types (vegetation and soils) for different climate regimes over the globe; currently the land models pass "simple" model benchmarks, but not "regression" benchmarks, especially for sensible heat flux. The Project for the Intercomparison of Land Data Assimilation Systems (PILDAS) is likely underway in 2015, and will enable better communication among LDAS developers, with a common framework of sensitivity studies and data sets for LDAS comparison and evaluation, ultimately, producing enhanced global data sets of land surface fields. Land-atmosphere interaction (L-AI) is examined in an effort to understand the nature of these systems in a coupled setting via a number of efforts, i.e. (1) the Local Coupled Land-Atmospheric Modelling (LoCo) project currently has a planned summer 2015 Southern Great Plains testbed field program to assess land-atmosphere coupling diagnostics, (2) the Diurnal land/atmosphere coupling experiment (DICE) used data from the 1999 Cooperative Atmospheric Surface Exchange Study (CASES-99) field program to assess the impact of land-atmosphere feedbacks in land and single-column atmosphere models separately, constrained by observations, then identifying changes due to coupling, where currently surface fluxes dominate the signal of land-atmosphere interaction, and (3) the proposed GEWEX Atmospheric Boundary Layer Study (GABLS) project for Antarctica, GABLS4 (or “DICE-over-ICE”), to examine interaction of a boundary layer with strong stability and

a snow/ice surface using observations at the Antarctic Plateau at Dome C. LoCo is GLASS-led, and DICE and GABLS4 are in partnership with the GEWEX Global Atmospheric System Studies (GASS) panel. Broad overviews were given for other GLASS projects, i.e. "ALMIP2" (land processes and L-AI in the west Africa monsoon region), "GSWP3" (20C land retrospective runs, with links to iLEAPS/carbon community), "LUCID" (how land coupling affects climate sensitivity to land cover change), and "GLACE-CMIP5" (quantification of soil moisture feedback processes in a global modeling framework).

Peter Gleckler noted the potential benefit of PALS for climate models, as climate model output fluxes can be extracted at particular points and this approach also holds in NWP mode. Stan Benjamin highlighted the complexity of the land surface problem involving the whole vertical column. Jon Petch noted the need to isolate some tractable pieces of the land problem. SMOS and SMAP were cited as potential game changer. Michael Ek pointed to on-going collaboration with NESDIS and NASA on SMAP data, also used in an operational context.

5.9 WGSIP activities

Keith Williams presented WGSIP on behalf of Adam Scaife. He noted the growing number of seasonal hindcasts in the CHFP database and revisited coordinated experiments and strong links to operational climate predictions in CMIP. Promising results are emerging on mid-latitude winter predictability and a role for the stratosphere. Three new science projects have been initiated in WGSIP:

- tropical/extratropical interactions
- drift/shock
- snow cover

Decadal prediction efforts for CMIP6 are being coordinated jointly with WGCM and CLIVAR. Real time decadal predictions are being exchanged as part of the Decadal Forecast Exchange exercise coordinated by the UKMO (http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-multimodel). WGIP is strongly engaged with the WCRP Grand Challenges and THORPEX legacy projects such as S2S.

Frederic Vitard remarked that the teleconnection topic in S2S is focused on MJO whilst the WGSIP teleconnection focus is broader. Michel Rixen noted the on-going work to migrate the CHFP data base into the Earth System Grid Federation (ESGF).

6. Centre Reports

6.1 Australia - BOM

Oscar Alves provided an update on the NWP and seasonal forecasting at the Bureau of Meteorology, which includes a N512-L70 UM8.2 trial system running for over a year expected for operational transition mid-2015, an ensemble prediction system based on UKMO MOGREPS and ETKF running daily at 60km, with 70 level which will be handed over to operations later in 2015. He also presented the new multi-week/seasonal prediction strategy and the projected NWP roadmap with the new HPC systems planned for 2016-2021.

The discussion confirmed that seasonal hindcasts are covering a 30 year period and that the UKMO dynamic land surface model will be used by 2016, bringing BoM and UKMO models closely together.

6.2 Brazil - CPTEC

Saulo Freitas highlighted the progress on NWP capabilities on several scales. At the regional scale, a locally adaptive emergency system is now running with the BRAMS model on 1 km resolution to provide guidance on severe weather occurrences. Also a new product using BRAMS on 5 km resolution covering all of South America is running and is under evaluation. Rainfall forecasts show good improvement. At the global scale, preliminary results using a new set of physical parameterizations indicate better scores. The GSI 3d-VAR data assimilation approach has been adopted by CPTEC and this system was implemented with the AGCM. The ensemble forecast system has been improved with new methodology for the application of random perturbations developed at CPTEC.

6.3 Canada - CMC

Ayrton Zadra noted that in 2014, the most significant development was the implementation of the 4D-EnVar, which replaced the 4D-Var as the assimilation system of the CMC deterministic systems. This event was a major step towards the increasing role of the ensembles in the Canadian forecasting systems.
In the near future, the CMC global systems will move to Yin-Yang grids and will benefit from various recent improvements in the model dynamical core, some of which were shown to lead to surprisingly large (and positive) impact on the forecasts. A high-resolution 250m environmental prediction system with hydrology was designed and will be tested during the Pan American Games, taking place in Toronto in the summer of 2015. A supercomputer upgrade is expected to happen in 2015-2016 as well.

He noted the expected benefit of replacing the static covariances by the covariance from the Ensemble Kalman Filter. He highlighted the fact that precipitation verification can be quite sensitive to interpolation methods and resolution.

6.4 China

The current status of the production NWP systems was introduced by Jian Sun. Some of them were upgraded in 2014, including the global ensemble and typhoon prediction system, the limited-area meso-scale model and the cloud-resolving model. GRAPES-GFS will be put into operation in June 2015 and its performance is comparable to the current global spectral model in CMA. The FY-3C MWTS assimilation system was highlighted. Some research activities in NWPC/CMA include:
1) The GRAPES global 4D-Var is mostly finished and its performance is very similar to GRAPES 3D-Var when only GTS data is assimilated. Some linear physics will be implemented and satellite data will be assimilated in GRAPES 4D-Var in 2015.
2) GRAPES Yin-Yang grid dynamics, which is built in the framework of the lat-lon grid GRAPES, is almost finished. Several idealized tests are conducted with GRAEPS Yin-Yang grid dynamics and the reasonable results are shown. The plan for GRAPES Yin-Yang grid dynamics is the physics package implementation.
3) A new dynamics scheme based on multi-moment constrained finite volume (MCV) method was described. Several idealized tests show some advantage of the new dynamics.

Francois Engelbrecht commented that most centers are still using semi-implicit lagrangian schemes, which poses an issue of scalability.

6.5 ECMWF

Jean-Noël Thépaut noted that wwo main model cycles have been or are about to be introduced since the last WGNE meeting. The first one only included technical changes required for the migration to the Cray in 2014. The second one (CY41R1), to be implemented in April 2015, includes an upgrade to the micro-physics package, a revised detrainment in the convection scheme, the introduction of a lake model (Flake), an increased resolution for the inner loop of 4D-Var (255L-255L-255L grid) as well as an EDA improved noise filtering, an upgrade of the ENS re-forecasts from 5-member once to 11-member twice weekly, the active use of wave modified stress in coupled mode, the introduction of new surface climate fields (land-sea mask, sub-grid orography, etc.), some improvements to the semi-lagrangian trajectory calculations (addressing stratospheric noise issues), and last but not least, a comprehensive upgrade in the way satellite data are assimilated in all-sky conditions. The impact of this new cycle is overall quite positive for the upper air scores.
Another comprehensive change to the operational system will be introduced towards the end of 2015, followed by an horizontal resolution increase of the whole suite (high resolution run, ensemble of data assimilation, ensemble forecasts, …) quite soon after. The exact timing and content of these two packages is still under scrutiny at ECMWF.
The MACC and ERA activities were presented, and Jean-Noël Thépaut introduced the Copernicus programme (ECMWF will operate the Copernicus Atmosphere Monitoring Service as well as the Copernicus Climate Change

Service, on behalf of the European Commission) and the Scalability programme, which aims at ensuring a long-term efficiency plan for the ECMWF forecasting systems (including data assimilation, observations, dynamical core, etc.) on future HPC architecture.

Jean-Noël further confirmed that uncertainties will be provided in ERA5 through the EN 4DVAR system. He clarified that the Copernicus Climate Services are run by ECMWF on behalf of the European Commission and are developed separately from ECMWF, which is also a provider of the services (e.g. reanalyses, seasonal forecast, infrastructure database). He commended that the target scalability is 10 to 100 compared to now, i.e. 10e6 cores).

6.6 France – Météo-France

François Bouyssel presented on recent developments at Météo-France. A major upgrade of operational NWP systems enabled by the new computer system has been prepared since the last WGNE meeting (operational implementation foreseen in April).

The spatial resolution of the global deterministic system ARPEGE is improved, from 60 to 36 km over Southern Pacific and from 10 to 7.5 km over Western Europe. The analysis increment resolution is refined from 62 to 50 km in the second 4D-Var minimization. The vertical resolution is also finer: 105 levels instead of 70 with a lowest model level at 10m. A new version of the ARPEGE ensemble assimilation has been developed, based on 25 members, a temporal average reduced to one day and a half (instead of 4 days), and an update of correlations every 6 hours (instead of 24 hours). The number of observations grows significantly, with a doubling of the density of satellite observations in the analysis and the assimilation of new observations (SAPHIR, SSMI/S 183 GHz channels, additional CrIS tropospheric channels, clear sky radiances of Meteosat-7 and Mtsat-2, radiosoundings in BUFR, etc.). This new version of ARPEGE improves synoptic scores, as well as precipitation scores over France to a lesser extent.

A new version of the global ensemble prediction system (PEARP) has been developed with the same horizontal resolution as current operational ARPEGE deterministic system (10 km over Western Europe, 60km over Southern Pacific) and an enhanced vertical resolution (from 65 to 90 levels). It is based on 35 members. Its initialization is taking benefit from 17 EDA members (instead of 6) and a new set of 10 physical packages is been used, 3 of them including a new prognostic convection scheme (PCMT). The statistical resolution of this new EPS version is improved on all parameters.

The spatial resolution of the convective scale model AROME has significantly increased, from 2.5 to 1.3km in the horizontal and from 60 to 90 vertical levels with a lowest level at 5 m. The semi-Lagrangian advection scheme has been modified to take into account deformation, this limits the over-estimation of density currents below convective cells. Wights take winds into account. The temporal frequency of 3D-Var assimilation cycle has been increased from 3h

to 1h, allowing the use of more observations of radar, ground GPS, SYNOP, SEVERI, etc. This configuration of the AROME-France system improves precipitation forecasts, including a reduction of the positive bias, which was particularly pronounced between 12 and 18 TU (occurrence of the maximum of convective precipitation).

New NWP systems based on AROME convective scale model have been developed for nowcasting and ensemble prediction that should be operational in 2015/2016. AROME configurations at 2.5km are being developed on overseas domains including a 1D ocean mixing layer scheme.

A new version (version 5) of seasonal prediction system is being developed for Eurosip with increased resolution (T255, 91 vertical levels), the sea-ice model GELATO, improvements in the surface and the stratosphere, stochastic perturbations in the dynamics equations and new ocean analysis by Mercator-Ocean (NEMO 1°).

Paolo Ruti enquired about the way Météo-France approaches seamless prediction. Francois Bouyssel mentioned that there is now some use of AROME HARMONIE for climate simulations. Jean-Noël remarked that the Global ARPEGE model runs at 7.5 km, that is, within the grey zone. Francois Engelbrecht further noted that the non-hydrostatic mode can be activated everywhere, which is more costly tough.

6.7 Germany - DWD

Michael Baldauf noted that DWD currently runs operationally the global, non-hydrostatic model ICON (since 20 Jan 2015) with about 13 km horizontal resolution, and the non-hydrostatic model COSMO in the two setups COSMO-EU (7 km) and the convection-permitting setup COSMO-DE (2.8 km). The latter is run as an ensemble with 20 members.
By the end of 2015 it is planned to replace COSMO-EU by the zooming option of ICON with 6.5 km resolution. COSMO-DE will be slightly enhanced in the domain size, resolution (2.2 km) and number of vertical levels (up to 65).
Larger developments at DWD concern the hybrid 3DVarEnKF data assimilation for ICON (planned for end 2015) and the LETKF for COSMO-DE (planned for 2016). Even now, both methods show larger improvements compared to the pure 3DVar and the nudging, respectively.
The COSMO-DE ensemble will be enhanced to 40 members. The use of the LETKF members as initial conditions is superior compared to the downscaling of the perturbations from the driving models. For both the LETKF and the COSMO-DE forecast ensemble a new stochastic physics scheme is under development which shall replace the current fixed parameter perturbations.
Some work is invested into the improvement of the forecast for renewable energy (wind power and photovoltaic energy production). One aspect is the assimilation of these distributed data into COSMO by the LETKF scheme.

Michael Baldauf clarified that wind speed improvements benefit from the better representation of the boundary layer and that drizzle skill improvement

refer to 3 hour time windows. The global ensemble data assimilation will be implemented by the end of 2015.

6.8 Japan - JMA

Junichi Ishida (Japan Meteorological Agency) presented the current status and recent upgrade of JMA's operational system. JMA operates one global model (grid spacing of about 20km), two regional models (that of 5km and 2km), two global ensemble prediction systems (that of about 40km) and climate ensemble prediction systems.
JMA upgraded its global deterministic model in March 2014. The number of vertical layers was enhanced from 60 to 100, many physical processes were upgraded and some satellite data assimilation started. This upgrade successfully achieved higher forecast skill.
JMA has introduced the new dynamical core "ASUCA" which has higher accuracy and computational efficiency than the old one, "Physics Library" which is designed to be easily plugged into any models, and a new variational data assimilation system "ASUCA 3D-VAR" into its 2km regional NWP system. The new dynamical core reproduces Karman vortex streets better than the old one. The new system employs a parameterization of convective initiation, which improves too-strong grid scale convection and the diurnal cycle of precipitation for the free convection. The scheme is regarded as one of solution to the grey-zone problem for convection.
In WGNE-29 meeting, JMA was recommended to conduct systematic comparisons of analysis. The progress of a study on analysis field discrepancies was reported. In the survey, spread of analyses by CMC, ECMWF, JMA, NCEP and Met Office are calculated. That of height at 500 hPa is decreasing over recent years especially over southern polar regions, while that of temperature at 850 hPa seems to be almost unchanged.

6.9 Republic of Korea - KMA

In his presentation, Dong-Joon Kim noted that KMA is introducing a new HPC (Cray XC40-LC). The initial stage system (peak performance: 447TFlops) was installed in November 2014, and the final stage system (peak performance: 5.8PFlops) will be installed by the end of 2015. The operational NWP System upgrade involved a revision of background error covariance for the regional (East Asia domain) NWP system, which resulted in reduction of continental warm bias in the analysis field. A new global NWP system development (2011~2019) funded by KMA is in progress under KIAPS (Korea Institute of Atmospheric Prediction Systems), a separate entity from KMA. A new global NWP system development (2011~2019) funded by KMA is in progress under KIAPS (Korea Institute of Atmospheric Prediction Systems), a separate entity from KMA. A prototype version of new global NWP model – a hydrostatic version model on a cubed sphere grid - and a 3DVAR data assimilation system were developed. KIAPS development plan for 2015 includes building a non-hydrostatic version of the model as well as 3DVAR-EnKF hybrid DA system.

On-going research and development activities include 1) a convective-scale lo cal EPS with 3km horizontal resolution planned to be in operation in Q4 2015 2) the development of a local NWP system expanding the outer domain of the model to mitigate negative impact of lateral BC from global model as well as d evelopment of atmosphere-wave coupling and 3) a 17km resolution global N WP system (Unified Model) to be tested in real-time in 2015, with an operation al implementation in 2016.

6.10 Russia - RHMC

Elena Astakhova presented the current status of forecasting systems at the Hydrometcenter of Russia (RHMC) and their recent development. The RHMC data assimilation system is 3D-Var; its inner-loop resolution has been increased to 55km. The development of a new hybrid EnVar system has started. The main achievements in global modeling are the pre-operational implementation of a new version of the global SLAV model with a horizontal resolution of 20-25 km and improved physics (on trials now), the operational implementation of T339L31 RHMC spectral model, and the operational implementation of the global EPS. As a step to seamless prediction, a unified version of the SLAV model applicable both for NWP and climate simulations has been developed. Mesoscale forecasts at RHMC are issued using COSMO-Ru systems with resolutions of 13, 7, 2.2, and 1.1 km. The most important progress in LAM was the development and testing of 1.1 km model as well as a new method to work with snow characteristics (to initialize input and postprocess output). At the end of presentation, the information about the status of WWRP FDP/RDP FROST2014 project devoted to Sochi Olympics was briefly presented: its field campaign was mostly over and the focus switched to analysis and verification of results.

It was noted that the spread decrease at lower elevation with the stochastic perturbation of physics tendencies (SPPT). Arktika satellites will sit on molnyia orbits. A question was raised as whether the associated data would be accessible to the community.

6.11 USA - GFDL

Ming Zhao noted that since GFDL finished its development of CM2 (CMIP3/AR4), new model development has evolved in numerous directions including 1) Earth system models (ESM2M and ESM2G) for closing carbon cycle; 2) CM2.5, CM2.6 for higher resolutions without physics change; 3) coupled data assimilation for seasonal to decadal predictions; 4) CM3 for studies of atmospheric chemistry, stratosphere, and aerosol-cloud interactions; 5) HIRAM, high resolution atmospheric models for studies of tropical cyclones. In 2011, GFDL strategic science plan endorsed a goal of high resolution Earth system model combining strengths of GFDL's diverse modeling streams. In the past couple of years, GFDL has been in a consolidation phase, bringing together what we have learned from different streams of model development and applications.

In 2013, GFDL formed a new model development team (MDT) for designing and developing next generation GFDL climate model (CM4) and Earth system model (ESM4), which will be suitable for 1) projection of climate change up to several hundred years into the future; 2) attribution of climate change over the past century; 3) prediction on seasonal to decadal time scales. New development will also need to keep in mind the needs for improved regional climate information and assessments of diverse climate impacts. Based on the above and GFDL's computational resource, CM4 has been designed to have 50km resolution atmosphere (AM4) and 1/4 degree ocean (MOM6) and is capable of running from emissions in regard to both the carbon cycle and aerosols. A new prototype AM4 was first created by merging AM3 and HIRAM. The new model contains 1) Finite Volume dynamic core on cubed-sphere; 2) on-line transport of aerosols driven by emission; 2) simplified chemistry for aerosol sources and sinks only; 3) aerosol cloud interactions; 4) two different configurations of convection (AM3-like and HiRAM-like); 5) large-scale cloud scheme based on Tiedtke 1993 with prognostic liquid drop number; 6: microphysics based on Rotstayn, (1997, 2000); 7) PBL scheme based on Lock et. al (2000) 8) GFDL radiation package. For new development, we also need to consider a balance between innovation and incremental bias reduction with a goalto increase both physics realism and simulation fidelity.

We find that the two initial AM4 prototype models (AM3-like and HIRAM-like) perform well in simulations of mean climate in AMIP (forced by observed SSTs) mode but suffer from major biases in coupled simulations. These biases motivated further development of the convection scheme. In the past couple of years, we have developed a new double-plume convection (DPC) scheme which incorporated recent findings on key processes of modeling convection and MJO. It is based on the single bulk plume model used in HIRAM (Bretherton et. al 2004) with the following modifications: 1) include an additional plume with entrainment dependent on ambient RH for representing deep/organized convection 2) include cold-pool driven convective gustiness and precipitation re-evaporation 3) enhance shallow cumulus moistening ahead of deep/organized convection 4) calibrate convective microphysics and cloud radiative effect (CRE) using observed response of LW and SW CRE to ENSO and MJO 5) quasi-equilibrium cloud work function for deep convection closure. We find that AM4 using the new DPC 1) significantly reduces the equatorial Pacific cold and dry bias 2) improves simulation of precipitation and cloud response to ENSO; 3) dramatically improves model simulations of MJO; 4) still maintain a competitive simulation of global TC statistics. Finally, the DPC scheme has also been tested in multi-year hindcast experiments, and is demonstrated to have substantial skill in MJO and TC prediction.

In the past couple of years, there are also several ongoing developments in GFDL aiming to unify the large-scale cloud and PBL turbulence scheme using the CLUBB (cloud layer unified by bi-nominal) in combination with the Morrison and Gettelman microphysics.

He commented that GFDL uses a standard diagnostics package. Results were comparable to the previous models in the monsoon regions. Stan Benjamin suggested by-passing CLUBB to check the benefit from the new Unified large-scale cloud turbulence scheme.

6.12 USA - NCAR

Julio Bacmeister discussed plans for new physics in CESM. Convection (deep+shallow), cloud, and PBL schemes may be changed in the near future – possibly before CMIP6. Two configurations are being evaluated by an external committee composed of 5 University and Research Center scientists. A preliminary report in February pointed out problems with ENSO variability in both configurations. A re-evaluation will take place in June 2015. Developments that are already slated to become part of CESM for CMIP6 include a complete Earth system-wide water isotope scheme and new cloud microphysics with prognostic precipitation.

Second, activities in high-resolution atmosphere-only simulation were described. As of WGNE-30 CAM5 had amassed over 300 years of simulations conducted at 25 km horizontal resolution. A sensitivity of tropical cyclone activity to choice of dynamical core was noted. It was re-emphasized that higher resolution simulation does not automatically imply better quality.

Julio Bacmeister confirmed that Taylor diagrams are computed on 30 years series of annual averages and that he model was tuned at 100km. Jon Petch recommended developing a model at the highest resolution and then adjust the tuning for lower resolution. Michael Ek wondered about the cause for ENSO concerns and commented that whilst the boundary layer might improve, the interaction with the upper ocean may be an issue.

6.13 USA - NCEP

Bill Lapenta reviewed the different systems in the NOAA Operational Numerical Guidance Suite, providing updates of those systems. The NCEP global data assimilation (DA) plans include observational changes, and changes to the Hybrid 4D EnVar (i.e. Cloudy Microwave Radiances, CRTM2.2, and additional aircraft and AMV data), and the Near Sea Surface Temperatures (NSST) Analysis. The Global Forecast System will have convective, land and surface-layer physics upgrades in 2016, with an increase in vertical resolution and additional enhancements to physics, and aerosol prediction in 2017. The global (GEFS) and regional (SREF) ensemble systems will increase in resolution, with the introduction of other stochastic schemes and an extension to 35 days as a coupled GEFS, and convection-allowing-scales for the SREF. The mesoscale (NAM) model will increase to 3km for the continental US and Alaska nests, with improved shallow convection and other physics changes, 4-d EnKF, and a rapidly updated hourly assimilation system (NAMRR). A unified global coupled hybrid data assimilation and forecasting system is being explored, with atmosphere,

land/hydrology, ocean, sea-ice, wave, chemistry/aerosols, and ionosphere components. The hurricane (HWRF) system has seen significant improvements in the past 5 years, with future upgrades planned in resolution, DA, and physics (including land), with a global coverage. Upgrades have been made, with additional planned for the land-hydrology, ocean, and sea-ice models at NCEP, as well as for the "simple framework" NOAA Environmental Modeling System (NEMS). With an expanding scope of evaluation tools, the NCEP/EMC Model Evaluation Group (MEG) is a forum for interaction with the NWS forecast offices and others that provide useful feedback on model performance, that aids NCEP/EMC in making model improvements.

Hendrik Tolman highlighted the collaborations between ESRL and EMC. Michael Ek commented on the planned integration of prognostic aerosols (GOCART) into NEMS GFS and the involvement of CPC in NMME and EUROSIP.

6.14 USA- NRL

Carol Reynolds noted that the spring 2015 upgrades to the Navy Global Environmental Model, NAVGEM 1.3, include increased resolution (T425L60) and improved numerical stability through a perturbation virtual potential temperature formulation. Upgrades to the physical parameterization suite including non-orographic gravity wave drag (improves upper-atmosphere temperature biases) and Xu-Randall cloud fractions. NAVGEM has been coupled to the HYCOM ocean model and CICE sea ice model under the Earth System Prediction Capability effort. Testing of ensemble-based background error covariances in the NAVDAS-AR 4DVAR global data assimilation system are very promising and are scheduled for transition to operations next year. The Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), coupled to the NCOM ocean model and SWAN and WWIII wave models, has undergone several system upgrades including microphysics and boundary layer parameterizations and the land surface model. COAMPS-Tropical Cyclone (COAMPS-TC) initialization and physics improvements have resulted in substantial track and intensity improvements. A COAMPS-TC ensemble system has been developed and is part of the NOAA Hurricane Forecast Improvement Project multi-model ensemble. The global Navy Aerosol Analysis and Prediction System (NAAPS) now includes MODIS aerosol optical depth assimilation and the FLAMBE smoke source model. COAMPS Aerosol forecasts of dust storms have improve through an updated NRL dust source data base. Development continues on the Navy Environmental Prediction System Utilizing the NUMA Core (NEPTUNE) with a flexible cubed sphere or icosahedral grid and spectral element discretization. NEPTUNE is part of the NOAA dynamical core inter-comparison effort.

Carol Reynolds clarified that the large impact of unmanned aerial system observations decrease with increasing forecast time, and that radiances were not assimilated in this example. Craig Bishop remarked that the error

reduction statistics depend on the region on which they are computed. NEPTUNE can be run as both a global and limited area model..

6.15 UK - MetOffice

Keith Williams presented the three operational upgrades at the UKMO this year:

- PS33 (4th Feb 2014): Technical change to use ROSE (https://github.com/metomi/rose/) for managing suites.
- PS34 (15th July 2014): Major upgrade of global systems: introduced GA6 science configuration (ENDGame revision to dynamical core plus numerous physics changes); increase in resolution of deterministic to 17km; MOGREPS-G extended to 7 days (now forms our TIGGE submission)
- PS35 (3rd Feb 2015): Science upgrade to UKV including introduction of ENDGame revision to dynamical core, and blended BL scheme.

The introduction of GA6 (Global Atmosphere 6), whilst being overall neutral on CBS scores, significantly improves variability in the model. This includes maintaining the intensity of mid-latitude depressions (which previously weakened with lead time) and a considerable improvement in the track and intensity of tropical cyclones. Climate change simulations have been performed with GC2 (Global Coupled 2), which uses GA6, and this has a slightly lower climate sensitivity than HadGEM2, now below 4. It is suspected that the large amount of sub-visual cirrus in GA6 is responsible for this.
The blended boundary layer scheme introduced to the UKV provides a scale-aware blending between the 1D non-local boundary layer scheme and Smagorinsky turbulence schemes as more of the turbulence becomes resolved. This suppresses near-grid scale circulations which can lead to the spurious break-up of stratocumulus. The UKV is also being used on climate change timescales as a downscaler, with some notable differences in results compared with simulations with parameterized convection (esp. over orography and summertime convection).
Operational upgrades planned for the coming year are:

- PS36 (July 2015): Science neutral migration to new supercomputer
- PS37 (October 2015): Routine science changes to UKV plus routine DA, data changes.
- PS38 (Spring 2016): Increases in resolution/number of ensemble members/fc range of various systems. Upgrade science in global systems to GA7/GC3 which will be the physical model underpinning UKEMS1 (our CMIP6 submission).

Keith Williams further clarified that MOGREPS is uncoupled and that the decision to increase the lead time and domain of UKV has not been made yet.

7. Recent developments

7.1 Data assimilation and Observing Systems (DAOS)

Tom Hamill reported on the mission of DAOS to provide guidance to the WWRP on international efforts to optimize the use of the current WMO Global Observing System (GOS). He highlighted the WMO DAOS meeting (Montreal, Aug 2014), in particular the emerging topic of "Forecast Sensitivity to Observations" (FSO) and the current limitations of OSSE in providing only upper bounds on expected impacts.

He then reviewed recent developments at several operational centres (in particular 4D-En-Var comparisons), a few highlights from the recent data assimilation literature such as the benefit of optimizing the error statistics for AMSU-A, the issue of scatterometers and GPS-RO satellite constellations and emerging new missions (ADM-Eolus, etc), the JAMSTEC-AORI global 870m simulation, feature calibration and alignment to reduce the amount of non-Gaussianity in data assimilation. He invited WGNE to discuss the coordination of activities on reanalyses, common observational data bases, and coupled data assimilation.

He also suggested developing best practices for weather-climate prediction system development as a potentially new WGNE activity, at some more or less formal level, to benefit a number of areas including standardized diagnostics and benchmarks, documentation, sharing of software tools.

7.2 Ensemble Prediction

Carolyn Reynolds and Junichi Ishida noted that most operational centers now provide ensemble forecasts, with improvements continuing in both the global and regional systems. Most centers are already including methods to account for model uncertainty and are testing upgrades to this capability. Several centers (ECMWF, Met Office, NCEP, NRL, JMA, Météo-France) are either running coupled systems or including lower boundary perturbations of some kind. Resolution is regularly increased, with most of the regional EPS systems running at or below 5km resolution. Several centers are achieving ensemble forecast improvements through improvements to the initial conditions, often through more unified approaches to ensemble forecasting and data assimilation.
Research interest in ensemble prediction, data assimilation, model uncertainty, and calibration and post-processing remains high, as the number of publications in all these areas continues trending upward. Centers continue to explore methods to account for model uncertainty in ensemble design through, e.g., stochastic methods, parameter variations, multi-model ensembles. Discussions continue on integrating parameterization and ensemble development efforts in this line of research. Efforts in post-processing are moving beyond bias correction to include, e.g., "neighborhood" methods to improve quantitative precipitation forecasting. Multi-model ensembles are proliferating for many different applications (sub-seasonal to

seasonal forecasting, global weather forecasting including aerosol forecasting, high-resolution forecasting, including tropical cyclone forecasting), and issues concerning multi-model ensembles (such as calibration-reforecasting and data transfer and latency issues) are mentioned. Many centers are testing coupling to (or incorporating uncertainty from) other components of the earth system, requiring collaborative efforts to ensure that coupled systems outperform uncoupled systems.

Some attendees suggested promoting best practices regarding model development, maybe starting with a survey of each center to identify common issues that WGNE can address. Annarita Mariotti highlighted the recent NOAA open call on process-based diagnostics. Ayrton Zadra wondered about uncertainty differences near the surface between coupled and uncoupled systems. Jean-Noël Thépaut noted the paradigm shift moving away from deterministic metrics such as anomaly correlation. He further explained that AMSU error statistics were calibrated through a sensitivity experiment (Forecast Sensitivity to Observations - FSO). Future reanalyses will include input data archives both before and after bias correction. Craig Bishop suggested developing an observations database including metadata on observations errors and remarked that 30 members should be enough to decrease forecast RMS. Keith Williams highlighted UKMO plans to further develop stochastic parameterization. Michel Rixen noted the WDAC plans to establish a reanalysis effort, known as CREATE-IP.

7.3 Numerical Methods

In this report, M. Baldauf presented material from the “PDEs on the sphere” workshop, 07-11 April 2014, Boulder, organized by Peter Lauritzen (NCAR).
The survey was subdivided into the following topics:
- Vertical grids and choice of vector components for well-balancing. The ideas to improve well-balancing over steep terrain comprises the use of covariant velocity components in the standard terrain-following grid, or a fully 3D-orthogonal grid, or the use of cut-cells.
- Horizontal grids: apart from the relatively new icosahedral-based hexagon or triangular grid cells, the cubed sphere approach is still widely used by global models. Here, better equi-angular or conformal-cubic grids are now used. ECMWF has has positive experiences with the so-called octahedral cubic Gaussian grid: the grid imprint is strongly reduced against the standard version.
- Time integration: apart from the two ‘standard’ integrator schemes of dynamical cores (semi-implicit and horizontally explicit –vertically implicit (HE-VI)), some new ideas came up: the exponential integrators use the exact solution of the linear parts of the PDE-system; Parallel-in-time methods even better use massively parallel computers (but these methods are certainly not yet mature).
- Alternative discretization schemes: during the last years, finite-element like schemes as continuous Galerkin (or spectral element) and discontinuous Galerkin schemes gained a lot of attraction. Examples are the CAM-SE (NCAR) model and the NUMA dynamical core of the NEPTUNE modelling

system (US Navy): grid imprints are strongly reduced at higher convergence order. An alternative to achieve higher order are the ADER schemes; at the 'PDEs', especially the ADER-differential transform scheme has been described.
- Adaptive mesh refinement (AMR) in general attracts a lot of attention in academia. Nevertheless, one can say that only applications with a well-defined singular structure gain from this approach: tropical cyclone simulations in meteorology and tsunami simulations in oceanography. Apart from the technically quite complicated codes, the lack of good refinement criteria still dampens the enthusiasm for trying out AMR at NWP centers.
- Derivation and use of approximated/filtered equation sets: advanced techniques (e.g. by variational principles) to derive such equation systems are explored. However, experience has found that fully compressible, non-hydrostatic solvers can even be faster than approximated equation solvers under certain circumstances.
- The last item mentioned in the review has been the 'dynamical core intercomparison project (DCMIP). This initiative by Christiane Jablonowsky (Univ. of Michigan) and her colleagues from several institutions has been carried through in 2008 and 2012. A new intercomparison could take place in 2016; ideas for new model tests and the general organization for this intercomparison are still being collected. Remark: WGNE should discuss to again foster DCMIP 2016, if it takes place as planned.

It was noted that DCMIP has tested 3D advection and tracer transport. Craig Bishop enquired about the time step of adaptive meshes and whether this varies with local resolution. It was unclear whether this had already been implemented. Prospects remain unclear around the idea of separation of mean and perturbed flow in dynamical cores which in some way relate to the idea of slow manifold.

7.4 Mesoscale NWP and new research development projects

Paul Joe noted that CAS-16 recommended that the Nowcasting and Mesoscale Weather Forecasting working groups of the World Weather Research Program merge on 1 Jan 2015 with the purpose of focusing on accelerating nowcasting improvements in the 1-6 or 1-12 h time scale. The new group name is Nowcasting Mesoscale Research (NMR) working group. NMR is leading several projects that are quite extensive and require the collaboration with WGNE in the fullness of time.

The Aviation RDP originated from a request from CAEM to CAS for support the vision on the ICAO-CAEM General Aviation Navigation Plan (2013-2028). The envisioned Air Traffic Management system has a strong reliance and dependence on meteorological information for efficiency and safety at all time and space scales. The GANP is divided into 5 year blocks (ASBU) and the initial block will focus on nowcasting and the terminal area. The plan envisions high impact and seamless predictions that include uncertainty and will be verified on a user metric. In future ASBU's, the focus will be on enRoute predictions and will require contributions from global and regional NWP in a seamless fashion.

The WWRP-Lake Victoria Project is a WMO Executive Council directed project for understanding the dynamics of thunderstorms producing high winds and waves on Lake Victoria. The core for the understanding of the dynamics is a field project that will focus on the convective initiation. Lake measurements are planned and aircraft campaigns are being proposed to better understand the microphysics for both weather and climate modeling. In discussions with the East African Community, related projects in East Africa have been combined into the Lake Victoia Basin Hydroclimate to Nowcasting Early Warning Systems consortium where warning systems are envisioned at time scales from climate to nowcasting and will include establishing a supporting observation network. A nowcasting system is planned to be developed and demonstrated within the context of the Severe Weather Forecast Demonstration Project's cascading process (products flowing from Global, to Regional, to National, to local centres) and will include high resolution satellite, lightning and NWP (4km) with radar as an optional data source. Underpinning climate science, capacity building and long term monitoring plans will supplement the field program which will also be used to validate the nowcasting system. Due to the strong impact of local influences, NWP is expected to work well for locally driven convection and be a critical part of the nowcasting system but this needs to be demonstrated. The lake is shallow and lake-atmophere coupled models are needed to capture the location and initiation of the thunderstorms. Contributions and collaborations with WGNE would be welcomed.

GURME focuses on urban scale prediction - with an air composition and human health perspective. High resolution NWP is an envisioned component of such a prediction system. The Canadian Pan Am 2015 project (centred on Toronto) has an extensive atmospheric, air quality high resolution observation program. GURME will propose a WWRP RDP related to the Pan Am 2015 project by broadly releasing the data. The intention is to use this as a starting point for a future joint GURME-WWRP summer Olympic games RDP or FDP (perhaps Tokyo 2020) related to urban, high impact, air quality and health project related to GURME and HIWeather objectives. The Tokyo Metropolitan Area Convection Study (TOMACS) is a current WWRP RDP focussing on the use of high density measurement and urban nowcasting and synergies will be explored with GURME-WWRP.

NMR is and will continue to be an active participant in the Grey Zone project.

No immediate action items were proposed. Active collaborations between WGNE and NMR are expected in the future.

7.5 High-resolution NWP

To begin, M. Baldauf gave an overview on the center plans for 2015 by the “WGNE-table about the centre...”. Some of the centers (UK MetOffice, MeteoFrance, KMA) will be able to cover their whole domain with a convection-permitting (c-p) model setup with resolutions around 1.5 km. Other

countries are so large, that they can perform such high resolutions only on subdomains (HMC Russia, NCEP, BOM Australia). Some centers will run c-p models with slightly coarser resolutions of 2-3 km over their whole domain (DWD, CMC, JMA). C-p EPS systems with resolutions below 3 km will be run in 2015 at UK MetOffice, DWD, and KMA. Apparently, the mostly used data assimilation systems for c-p models is a 3DVar system. NCEP and CMA will have a hybrid EnKF-Var. assimilation system.

Some highlights from the different centers:
- CMA plans to introduce a 3 km 'on-demand' model running over parts of China (mainly during the rain seasons).
- The US Navy is currently testing a 6-class (graupel)-microphysics scheme for their future c-p model (probably not before 2016). The graupel class is important for c-p models since it has higher sedimentation velocities and a reduced ability for water vapor deposition in comparison to snow particles.
- A special task for CMC is the development of a numerical environmental prediction system for the Pan Am Games 2015. For this purpose, model setups with 1km and 250m will be used. This allows the use of an urban parameterization to better simulate heat island effects and tracer dispersion. The 250m model has proven to realistically simulate daytime convection. A lake prediction system (NEMO) coupled to the atmospheric model allows the forecast of wind driven coastal inundations.
- The winter Olympic games in Sochi have proven the additional benefit of the HMC 1.1km model compared to a 2.2 km model in mountainous and steep terrain for the forecast of wind (speed, gusts, ...).
- The improved dynamical core ('ENDGame') for the UKV models greatly improves the forecast of lee waves in the 1.5 km setup. Further work has been done on the development of blended schemes to better describe the transition from a pure statistical turbulence scheme to the LES regime. For the MOGREPS 2.2 km EPS system an improved initialisation method has been developed and the use of randomly chosen parameters for the stochastic physics will be used.
- MeteoFrance regularly runs a 500m model over selected subdomains (airport and Alpine regions). This proves the high numerical stability of the Aladin model. Stability problems due to steep terrain only occur below 250m resolutions.
- DWD plans only a moderate increase in horizontal and vertical resolution. Nevertheless, benefits could be demonstrated for a high-damaging squall line case compared to the current setup.

Jean-Noël Thépaut highlighted the issue of scalability when running high resolution models.

7.6 Physical Parameterizations

The presentation, given by Ayrton Zadra and Francois Bouyssel, was based on material kindly provided by various WGNE members/centres. The reported developments related to physical parameterizations fall into three main categories: (1) adjustments/improvements to existing schemes; (2) addition of

new processes/schemes; (3) and infra-structure changes (e.g. changes to resolution, time-stepping, dynamics-physics interface, etc.).

In terms of the processes usually parameterized in numerical models, the majority of reports were related to convection and microphysics (including at the km scale); followed by reports on clouds & radiation; boundary layer; surface models; orographic processes; and non-orographic gravity wave drag, in that order. Some of the recent developments are related to (possibly inspired by) activities supported by WGNE, such as the Grey Zone project and the Drag Project

Jean-Noël Thépaut noted that stochastic physics is becoming an integral part of NWPs. He further highlighted that WGNE's 'Recent development' briefs also provide a platform to report failures, lessons learnt and challenges. Jon Petch suggested increased collaborative work on convection, boundary layers and microphysics which require a cultural shift. Michael Ek noted the existing connections between GASS/GLASS and NWP. Jon Petch remarked that the success of Grey Zone project and the overshoot issue which now requires a fix.

8. Host country presentations

8.1 Office of Naval Research (ONR)

Daniel Eleuterio noted that in the face of increased public and Federal awareness and concern over high-impact weather events globally and the changing climate environment, a number of calls have appeared seeking revolutionary collaboration among research sponsor and operational environmental prediction agencies, and between the weather and climate communities, to significantly advance our prediction capability to benefit mitigation, response and policy. The National Earth System Prediction Capability (ESPC) represents part of the U.S. response to this need for improved coordination of research towards more skillful and extended range operational environmental prediction. Synoptic/sub-seasonal to seasonal global earth system models are under development at several U.S. centers consisting of high-resolution atmosphere, ocean, sea ice, land, and near space components with the goal of seamless prediction at lead times from a few hours to months or years in operations by 2025. The National ESPC will address the scientific, technical, computational, and organizational challenges to meet this ambitious goal.
Navy sponsored and Naval research in global coupled environmental numerical prediction model development and extended range predictability and prediction were described. The Naval Research Laboratory is developing a global fully coupled system including NAVGEM (atmosphere), HYCOM (ocean), CICE (sea ice), wave (WW 3) and land model (LIS) utilizing the Earth System Modeling Framework (ESMF). The near-term focus of the Navy ESPC demonstration and validation work includes high impact weather, S2S, and polar prediction efforts that are in line with the WWRP/THORPEX-WCRP

HIWeather, S2S, and PPP goals. Recent simulation results from the prototype forecast system are compared to recent field project observations such as the 2011 Dynamics of the MJO (DYNAMO) period.

The discussion clarified ONR's science objectives in the Arctic, focusing on the marginal ice zone, a.o the role of wave and associated ocean-atmospheric fluxes.

8.2 Science presentation about EMC

Hendrik Tolman provided a strategic view of EMC modeling directions, challenged by emerging requirements (Weather Ready Nations, high impact events, weather to climate seamlessness, growing range of products). The tendency is towards unified modeling and fewer numerical prediction systems. Guiding factors include growing community modeling, new resource opportunities (Sandy supplemental, R20 funding, etc) and science and technology advances in observing systems, HPC, data dissemination, modeling, data assimilation, ensembles and predictability. Whilst priorities for deterministic developments are clear (dynamical cores, model physics, resolution, etc), there is a growing focus on probabilistic approaches.

Jean-Noël Thépaut highlighted the ambition of the strategic undertaking tackling multiple fronts (ensembles, reanalysis and reforecasts), which are indeed not time critical and can be performed elsewhere. EMC is involved in DC-MIP which focuses on the intercomparison of dynamical cores. The outlined strategy takes due consideration of THORPEX legacy projects S2S, PPP and HIWeather.

8.3 GODAE Ocean View (GOV)

Hal Ritchie provided an update on GODAE Ocean View (GOV), which continues the legacy of the Global Ocean Data Assimilation Experiment (GODAE) in providing leadership in consolidating and improving R&D for global and regional analysis and forecasting systems. GOV is represented by the GOV Science Team (GOVST) consisting of representatives from national, international and intergovernmental organizations with expertise in operational ocean monitoring and forecasting. GOV aims to coordinate the development of new capabilities through a number of Task Teams (TTs) which focus on specific topics of particular interest to GOV. The current task teams are: Coastal Ocean and Shelf Seas (COSS-TT), Coupled Prediction (CP-TT), Intercomparison and Validation (IV-TT), Marine Ecosystem Analysis and Prediction (MEAP-TT), Observing System Evaluation (OSEval-TT), and Data Assimilation (DA-TT).

At the most recent GOVST meeting in Beijing last October the CP-TT was renamed from the former Short-to-Medium-Range Coupled Prediction TT and Hal Ritchie (Environment Canada) and Chris Harris (Met Office UK) were appointed as new co-chairs. The mission goal of the CP-TT is to draw together the international scientific and technical expertise in ocean, sea-ice

and wave prediction and to seek collaboration with equivalent expert groups in atmospheric - land surface – hydrology prediction to accelerate the scientific and technical development of fully coupled systems for short- to medium-range prediction. The focus areas for activities and projects are: coupled prediction in and Earth System Modeling context but with a focus on the role of and impact on oceans (e.g., ocean-ice-wave interaction), and coupled data assimilation in coordination with the DA-TT. The main priorities for activities and projects are: facilitate exchange of national and international programs of scientific research, collate quantified impact of earth system coupling for ocean-wave-sea ice-atmosphere and interfacial flux phenomena, and foster targeted research on related topics of particular interest to GOV members (e.g. sea surface temperature / diurnal cycle, sea ice impacts on boundary layer fluxes, wave coupling).

One particular CP-TT objective is to continue links with the Working Group on Numerical Experimentation (WGNE) related to coupled prediction as a follow up to our joint GOV-WGNE workshop in March 2013. This presentation will give an overview of GOV, the CP-TT and recent results provided by members, and foster further links between WGNE and the CP-TT.

It was suggested to invite GOV to the YOPP summit and to consider a GOV-WGNE workshop on modeling and data assimilation in 2017.

9. Forecast verification and metrics

9.1 Verification scores

Jean-Noël Thépaut presented scores inter comparisons between all major NWP centres, covering both the traditional “deterministic” models, but also the ensemble systems. He also paid a particular focus on the Polar Regions. Overall, ECMWF has the lead for most parameters and most areas when the deterministic models are compared to analyses, but model skills are getting closer together when verified against observations. The progress of Meteo-France and NCEP was noticed, and they seem to be in the lead for some scores against observations.
The forecast skill gap between ensemble systems remains quite large, with the ECMWF ensemble system outperforming the other global ensemble systems.
One interesting feature is that although polar analyses are getting closer across the centres in terms of RMS, significant mean state differences persist. There is also a large discrepancy among the different models in terms of activity, the MetOffice having been the most under active and CMC being the most overactive. However, the recent changes at the MetOffice with the implementation of the new dynamical core start to be noticeable (scores are yearly averaged).

Jean-Noël Thépaut asked for further feedback and suggestions to improve the website that ECMWF hosts as WMO lead Centre for Model Verifications.

Keith Williams suggested improving the complementarities of verification presentations. Tom Hamill noted the comment made by Tim Palmer at the WWOSC that scores on deterministic forecasts could be misleading. Keith Williams asked about the confidence level on scores because of the disclaimer. Jon Petch noted that HIWeather and impact studies suggest the use of probabilistic scores whilst improving physics suggests the use of deterministic scores. Jean-Noël Thépaut noted the complementarities between both approaches. One attendee noted the need for dedicated and specific approaches in the polar context, including during YOPP.

9.2 Joint Working Group on Forecast Verification (JWGFVR)

Following a brief review of membership and aims of the verification working group, Lawrence Wilson presentation some highlights of the activities of the JWGFVR for the last year. The major training activity was the Sixth International Verification methods workshop, held in New Delhi, India, March 2014. Primary research activities include the organization and launch of the Mesoscale Verification in Complex Terrain (mesoVICT) project, which gives the proponents of spatial verification methods the opportunity to test their methods in complex terrain, and to evaluate performance of the methods for wind as well as precipitation. MesoVICT also includes an opportunity to verify ensembles with spatial methods. Reruns of regional models are possible, but it was emphasized that the main focus of the project is on verification methods.

Preliminary results were shown for the Sochi Olympics period. This work demonstrates the proper design of a user-oriented verification technique. The results are still preliminary, pending final quality control of the special observations collected for the 2 month Olympic period.

Other ongoing research focuses on ensemble applications of spatial methods and the extension of object-oriented methods to the time dimension. Three-dimensional time-space objects are characterized by specific spatially defined parameters, then forecast and observation are compared in terms of those parameters.

The verification working group seeks to ensure best practices in verification by issuing WMO documents containing recommendations of the most suitable verification methodology for different weather elements. So far, documents have been issued for precipitation (2008), cloudiness (2012) and tropical cyclones (2013). At the request of WGNE 28, guidelines on the verification of precipitation with respect to high resolution observational datasets were prepared and sent in November 2013. Progress on the application of these suggested methods by WGNE members was reported in a later presentation at the meeting.

The working group is already heavily involved in the three THORPEX legacy projects, and this involvement is expected to continue. A verification question connected with the PPP project led to a discussion of the issue of grid box verification vs. point verification. It was noted that grid-box averaging of observations, whether by means of the analysis or by upscaling, leads to verification results that are not useful for most users, and that verification at points is not only more appropriate for user focused verification, but also leads

to better opportunities for rigorous intercomparison of verification results among different models. When grid-box averaged observations are considered important, for example, to eliminate those scales not resolved by the model, then it is suggested that analysis-based verification could be done if it is restricted to those grid boxes which are supported by point observations. This minimizes, but does not eliminate the model-tainting that is a problem when a model is verified against its own analysis.

Michel Rixen noted that the work of JWGFVR is mainly focused on NWP and suggested stronger coordination with the WGCM/WGNE metrics panel. Beth Ebert is member of both groups and could help coordinating this. Caio Coelho is also a member of the JWGFVR and the S2S Steering Group and could bridge some gaps.

9.3 Tropical cyclone verification

Junichi Ishida (JMA) made a report about TC verification for 2013. Ten NWP centres (BoM, CMA, CMC, DWD, ECMWF, JMA, Météo-France, NCEP, NRL and Met Office) participated in the project this year.
Overall ECMWF achieves the best forecast on average followed by NCEP and Met Office in almost all basins. There is a significant slow bias after recurvature for JMA, Met Office, DWD and NRL in WNP basin. In WNP basin, Met Office, CMC, BoM and CMA predict relatively shallow TCs compared to the best track, though it should be noted that the result depend on not only the resolution of NWP model but that of gridded data. Relatively large missing rates in all NWP centres were shown in NAT basin this year. Most TCs were weak and current NWP system had difficulty representing them. NRL and Met Office performed well in terms of the detection rate in ENP and AUR basin, respectively.
The verification of regional models was also introduced. The forecast of each regional model of JMA, Meteo France and NCEP were compared to their global models that provide lateral boundary conditions. The position error of regional model is almost the same as that of global model, while some regional models improve TC intensity forecast compared to the global models.
The differences of wind fields in the analyses are investigated. Large discrepancies in the analyses exist over the Eastern Pacific region. Several models have forecast bias over the Eastern Pacific and Western Pacific, which seems partly due to the difficulty in maintaining the convective activity over the Maritime Continent.
As an additional verification, the survey of selective ensemble mean for TC track forecast was introduced. It shows that selective ensemble mean approach is better than simple ensemble mean approach especially for the cases where the spread at short lead time (e.g. T+6) is very large. In general, a simple ensemble mean by ECMWF and NCEP achieves the best performance. These results planned to be submitted to an international journal.

Ayrton Zadra recommended providing statistics on false alarm rates as was done at WGNE29.

9.4 Precipitation Verification

Francois Bouyssel presented on material kindly provided by various WGNE members/centres (CMA, DWD, ECMWF, JMA, MF, NCEP, RHMC, UKMO). The aim of the presentation was to give an update of WGNE QPF intercomparison based on high resolution limited area precipitation observations with a specific focus on the use of new verification techniques proposed by JWGFVR in November 2013. The move towards the suggested scores (ETS, EDI, FSS for deterministic forecasts and BSS, ROC area and CRPSS pour probabilistic ones) is being implemented in most centers at a pace depending on available resources for verification techniques. The verification of deterministic systems has received more attention than the verification of ensembles. The use of confidence intervals on aggregate verification is not yet done systematically. The SEEPS score, which requires a long-term climatology, is also used at ECMWF and UKMO. The spatial and temporal resolutions of global model forecasts available for WGNE QPF intercomparison is rather coarse (generally 24 accumulation with 0.5°x0.5° or 1°x1° horizontal resolution) to motivate the use neighbourhood methods such as Fraction Skill Score (FSS).

It was recommended to increase the forecast data resolution in time (at least 6h) and space. Jean-Noël Thépaut highlighted the emerging benefits from the work carried out in the JWGFVR from which recommendations are now being used in these reports. Lawrence Wilson noted that SEEPS was not adopted by WMO for a number of reasons and that FSS was developed in the UK. The question arose as to the need to build a common climatology for SEPS. Keith Williams remarked on its use in the UKMO model development cycle.
Brian Golding (via email) noted the relevance of precipitation verification and a framework for seamless metrics for HIWeather. I think we would view the priority to be a seamless verification framework. HIWeather stresses the need for verification to be informed by user needs – particularly moving towards verifying hazards and their impacts. This is likely to mean that the most relevant metrics are in some way determined by the nature of the hazard, its space and time scales, posing hence a challenge to the overall concept of seamless metrics.

9.5 WGCM/WGNE climate metrics panel

Peter Gleckler provided an update on the WGNE/WGCM climate metrics (and diagnostic) panel, in particular within the CMIP context gradually evolving from AMIP experiments. He highlighted the benefits of the CF data conventions from CMIP3 onward and the implementation of the Earth System Grid Federation, the distributed data infrastructure used to support CMIP5 and many related model intercomparisons. He remarked the recent surge in research topics related to model metrics including model intercomparisons, model dependence, multi-model combinations, but also some challenges regarding the limited opportunities to verify climate model simulations, the lack of observations for many processes believed to be important, and the expectations for widely applicable metrics. CMIP6 will include an entry card

for modeling groups and MIPs experiments a.k.a the Diagnostic, Evaluation and Characterization of Klima (DECK) experiments. The ToRs of the WGNE/WGNE metrics panel are being updated to help coordinate community based capabilities that are being developed in support of the CMIP DECK. Some examples of the diagnostics and evaluation packages available to the community were discussed.

It was suggested to circulate the proposed revised ToRs for the Metrics Panel to WGNE and WGCM members for comments and approval. The discussion highlighted the HighResMIP effort which includes AMIP runs, a component of CMIP6 contributing IPCC AR6 for which the final schedule is still unknown.

9.6 obs4MIPs/ana4MIPs and CREATE-IP

Peter Gleckler presented the common goals of obs4MIPs and ana4MIPs which include making observational data and reanalysis more accessible for the evaluation of CMIP class simulations. Data made available from these projects match fields included in the CMIP5 standard model outputs, are technically aligned with CMIP data conventions (e.g., they are CF compliant netCDF), arevailable through ESGF along with the CMIP data Technical notes describe these datasets and their relevance for model evaluation. Around 40 data sets have already been published in obs4MIPs. An obs4MIPs-CMIP6 planning meeting was held at NASA HQ in April 2014 and a full report is available at hpps://www.earthsystemcog.org/projects/obs4mips/planning201405. A recently published meeting summary in BAMS highlights the expansion of obs4MIPs with new data sets, higher spatio-temporal resolution, support of off-line simulators, and possibly sparse in-situ data sets. Improved error characterization is recognized to be crucial for many aspects of model evaluation. A sister initiative focused on reanalyses and known as ana4MIPs follows the same principles as obs4MIPs. It already includes MERRA, ERA-Interim, CFSR; JRA25, JRA55 and 20CR for a limited set of fields.

Mike Bosolovich summarized a new project called CREATE-IP which aims at expanding the scope of ana4MIPs with regular updates, higher spatio-temporal frequency, all available levels, and increments and observations. A Task Team will be established within WDAC to help guide CREATE-IP and its coordination with obs4MIPs and ana4MIPs.

The associated web sites for each of these projects are hosted on the CoG, directly connected to the ESGF.

Keith Williams supported the publication of sub-daily data within obs4MIPs so they can be used for S2S and NWP work. Jean-Noël Thépaut noted that obs4MIPs data are typically level 3 data for the time being and ana4MIPs anomaly data are real observations, pointing to the need to train the community on using these resources in an informed context. It was suggested to circulate the CREATE-IP white paper and to ask for feedback by 1 June 2015.

9.7 HIGHRESMIP

Julio Bacmeister reemphasized the need/desirability of *minimal retuning* of high res model configurations. Consideration of more ensembles using shorter time-slice runs (2x 25 years) vs longer 1950-2050 was suggested. Possible advantages of time slices include better sampling of internal variability, easier generation of forcing data sets, potential to capture stronger climate change signal. Issue of aerosol forcing was addressed. Presenter suggested that keeping aerosol forcing consistent between STD and HI configurations is both easier and more consistent with principle of minimal retuning. In addition, results were shown that suggest a large impact from aerosols on N. Atlantic TC activity, whilst noticing no change in mean precipitation. Implication of this finding for HighResMIP design is ambiguous. Finally, it was suggested that HighResMIP consider accepting high resolution atmosphere/low resolution ocean coupled configurations.

Keith Williams suggested offering both prescribed and prognostic options and the possibility for NWPs to run only AMIP runs at high and low resolution. Ayrton Zadra suggested regional models to circumvent some of these limitations. Carolyn Reynolds asked about relaxing the 100-year constraint with eventually more ensembles. Peter Gleckler encouraged more involvement of NWP centers, to which Météo-France and EMC responded positively. Jean-Noël Thépaut highlighted the importance to verify models against observational records.

9.8 Transpose-AMIP

Keith Williams presented an overview of Transpose-AMIP, which is running climate models in "weather forecast mode". The Transpose-AMIP II set of experiments was conducted alongside CMIP5 and involved running a prescribed set of hindcasts from ECMWF analyses (www.transpose-amip.info).
He highlighted some successes. More centres submitted data to T-AMIP II than to T-AMIP I / CAPT. Consequently more centres now have the ability to easily run this type of expt in the future. A comprehensive set of diagnostics has been saved (e.g. satellite simulators) and the data are much more accessible thanks to being on the ESG (alongside CMIP5, Obs4MIPs, etc.). The methodology is widely supported and strongly encouraged at key workshops (e.g. *WGNE systematic errors workshop*, *Pan-GASS meeting*) as necessary to fix model biases.

The methodology is now being used by other MIP's (e.g. YOTC MJO-TF/GASS diabatic processes project), with a very strong take up (more models submitted to this MJO project than T-AMIP II).
He noted that the data have been under-utilized with only a handful of analysis projects being conducted and that it was hard to cover everyone's needs with set hindcast lists (e.g. those studying MJO likely to want different cases than those studying mid-lat depressions).

He concluded with some remarks for future work. The steering committee shares the view that any new T-AMIP expts are best formed around a particular science question (e.g. continental warm bias; cloud biases; MJO; mid-latitude dynamics). T-AMIP should stop as a project (i.e. NOT be a separate MIP in CMIP6), but WGNE/WGCM/GASS/etc. should strongly encourage the methodology be used within other MIPs (e.g. CFMIP, MJO-DP, NORDEX, GEWEX-PROES). A Transpose-CMIP (raised at the WGNE workshop) – would require exploratory work; no one has volunteered to take this on. Issues (and solutions) may fall out as NWP centres move to coupled modelling.

10. WGNE Business

10.1 AOB

Co-chairs thanked Elena Astakova for taking the lead on the WGNE Blue Book, which contribution deadline is extended until 15 April. Some attendee commented on the proliferation of data and lack of associated exploitation and publications. Fred Branski mentioned the WMO Solid Precipitation Intercomparison Experiment (SPICE), which could be of use for WGNE Verification exercises.

Brian Golding (via email) noted that HIWeather is very interested in both proposed workshops on stochastic parameterization and on modelling/data assimilation and encourages WGNE to include some focus on the distinctive aspects of these issues for convection-permitting models, which are important not just as the leading edge source of forecasts of surface weather today, but also as the basis for the global models of a decade ahead. HIWeather has a specific proposed activity to review stochastic parameterization for convective-scale models, which could be addressed accordingly. HIWeather also has a workshop penciled in for 2016 or 2017 for data assimilation in convective-scale models.

10.2 Next session

Francois Engelbrecht offered to host WGNE31 at CSIR in South-Africa around March and will consult internally for date and venue options. Participants welcomed this proposal.

10.3 Memberships

WGNE co-chairs reviewed current WGNE membership. Michael Baldauf and Saulo Freitas will rotate off end of 2016. Saulo Freitas proposed to consider a continued CPTEC representation. Jean-Noël Thépaut will rotate off end of 2015 because of his new commitment on the Copernicus Climate Change Services and sought offers for his replacement. Michel Rixen noted the challenge to address geographical and gender balance on top of a suitable

weather/NWP and climate membership representation whilst keeping the overall group to a manageable size.

10.4 Decisions and Actions

Actions were reviewed and are summarized in ANNEX B. Participants agreed to have their presentation being published in pdf format at http://polar.ncep.noaa.gov/conferences/WGNE-30/ and on the WMO WGNE web page.

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ANNEX B - WGNE30 ACTION LIST

ONGOING/OPEN ACTIONS FROM PREVIOUS MEETING

WGNE29 ACTION ITEM 1: WGNE members and their modelling centres to consider offering to host the modelling summer schools and to make available lecturers for these events. (all)

WGN29 ACTION ITEM 15: Operational modelling centres to move quicker to adopt new verification techniques for precipitation and to extend to regional models. (all)

WGNE29 ACTION ITEM 16: Andy Brown, Peter Glecker and Jon Petch to discuss ways to archive and preserve precious historic GASS data sets. (Keith Williams replacing Andy Brown in this item?)

WGNE29 ACTION ITEM 18: Xue Shun to investigate the availability of additional data from China related to the Beijing aerosol case study. (Jian Sun replacing Xueshun in this action?)

WGNE29 ACTION ITEM 19: Jean-Noël Thépaut, Tom Hamill and PDP co-chairs to discuss and propose ways forward for verification against analyses.

AEROSOL PROJECT

ACTION ITEM 1: Saulo Freitas and Greg Carmichael to liaise and explore enhanced GAW (incl. GURME)-WGNE collaboration (e.g. 2016 workshop on WGNE aerosol case studies - Beijing pollution case, promote possible COST action EUMETCHEM Phase II); update contact points; develop a publication; centers to submit latest data (Oct 2015).

DRAG PROJECT

ACTION ITEM 2: Ayrton Zadra to promote WGNE surface drag project at forthcoming Workshop on Momentum Budget and its Role in Weather and Climate, at University of Reading April 2015; and explore with SPARC expansion of the project to assess momentum budgets; report back to WGNE (May 2015).

ACTION ITEM 3: Julio Bacmeister to contact WGNE with QBOi experimental protocols (May 2015).

PPP - YOPP

ACTION ITEM 4: WGNE, SPARC/GEWEX, DAOS, GOV representatives to attend YOPP Summit (WGNE Co-chairs & Paolo Ruti, 15 April 2015).

ACTION ITEM 5: WGNE to provide inputs/slides to and seek feedback from PPP, and together with DAOS to further the characterization of analysis uncertainties in Polar Regions (Junichi Ishida and Tom Hamill, 15 May 2015).

RECOMM ITEM 1: DAOS to provide advice on YOPP observational strategies for model development and to consider data denial experiments during YOPP (Michel Rixen to forward WGNE30 report, June 2015).

RECOMM ITEM 2: GOV to provide advice on ocean/atmosphere/sea-ice coupling case studies (Michel Rixen to forward WGNE30 report, June 2015).

SYSTEMATIC ERROR

ACTION ITEM 6: Explore options for Systematic Error Workshop in 2017 in collaboration with S2S (maybe joined with WGNE32?, Canada?, Jeju?, France? Jointly with pan-GASS?); consider a potential teleconnection session (WGNE Co-chairs and members, Oct 2015)

ACTION ITEM 7: Centers to consider exploiting T-AMIP/YOTC-MJO data sets (all).

ACTION ITEM 8: Develop a concept-document on TRANSPOSE-CMIP (Keith Williams, GOV-Hal Ritchie, NCAR-Julio Bacmeister, NRL-Carolyn Reynolds, NCEP-Mike, GFDL-Ming Zhao, BoM-Oscar Alves, PPP-Thomas Jung, Dec 2015).

DATA, VERIFICATION AND METRICS

ACTION ITEM ITEM 9: Report also on TC false alarm ratio (Junichi Ishida, WGNE31).

RECOMM ITEM 3: JMA to consider preparing a publication on the results from the TC verification.

ACTION ITEM 10: Organize a survey to review current precipitation verification practices and check NWP centers' willingness to exchange high resolution precipitation model and observational data sets for WGNE research activities (and possibly for other verifications) and report to next session (Francois Bouyssel, WGNE31).

ACTION ITEM 11: Invite members to contribute to Polar verification (WGNE Co-chairs, Oct 2015).

ACTION ITEM 12: JWGFVR to engage with METRICS panels and S2S to collaborate towards a strategy for seamless metrics and verification – maybe through a joint activity in 2017 – e.g. systematic error workshop (report at WGNE31, co-chairs JWGFVR/METRICS/S2S panels).

ACTION ITEM 13: Circulate CREATE-IP white paper to WGNE for comments (Michel Rixen, 1 June 2015).

HIGHRESMIP

ACTION ITEM 14: NWP centers are strongly encouraged to participate in HighResMIP (all members, ex-officios) and explore ways to relax the 100-year constraints with HighResMIP leads. Julio to prepare a letter to be sent to WGNE (Julio Bacmeister, 15 April 2015)

WMO

ACTION ITEM 15: WGNE to start dialogue among WCRP, CAS, CBS on seamless data archives and dissemination (e.g. grib-netcdf interfacing) (Michel Rixen, Paolo Ruti, June 2015).

WORKSHOPS

ACTION ITEM 16: Explore possible joint workshop among WGNE, DAOS, PDEF on stochastic parameterization (see also upcoming ECMWF workshop, possible presence of WGNE reps) (Jean-Noel Thépaut, April 2015)

ACTION ITEM 17: GOV–WGNE workshop on modeling and data assimilation in 2017 (Michel Rixen to follow-up with GOV-Hal, Dec 2015).

BUSINESS

ACTION ITEM 18: WGNE to consider new agenda structure encouraging center overview to focus on lessons learned and for themed overviews (e.g. “recent advances in physics”) to focus on specific topics (e.g., “convection” or “radiation”). (Co-chairs and members inputs, WGNE31).

ACTION ITEM 19: Next WGNE conference call (Rixen, fall 2015).

ACTION ITEM 20: Next session, similar time frame, South-Africa (Francois Engelbrecht as host) – Doodle (Michel Rixen, June 2015).