29TH SESSION
OF THE WORKING GROUP
ON NUMERICAL EXPERIMENTATION (WGNE-29)

Melbourne, Australia, 10-13 March 2014

Prepared by

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Supported by
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WGNE is a Joint Working Group of the Commission for Atmospheric Sciences
and the
World Climate Research Programme

1. INTRODUCTION

The meeting was opened at 09:00 on 10 March 2014 at the Travel Lodge, Docklands, Melbourne, Australia by Andy Brown on behalf of the Co-chairs of WGNE (Andy Brown and Jean-Noël Thépaut). They welcomed the members of WGNE to the 29th session and thanked all for attending and contributing. He also acknowledged the support from CAS and WCRP as well as the Bureau of Meteorology (BoM) for hosting the event. He also thanked the invited experts for their attendance. This was followed by the participants briefly introducing themselves and providing a short background to their fields of expertise.

Gary Dietachmayer, representing the local host provided information on local arrangements, specifically as the first day of the meeting (10 March) was a public holiday in Australia and therefore not being able to meet at BoM on the first day. However, he indicated that the rest of the meeting will be hosted at BoM offices.

2. WELCOME BY CAWCR DEPUTY DIRECTOR

Peter May welcomed the members of WGNE back to Australia on behalf of BoM and indicated that the previous meeting of WGNE in Australia occurred 13 year ago. He mentioned that WGNE is regarded as one of the key WMO Working Groups addressing issues of prime importance to Members through its focus on modelling and the actionable information derived from these systems. Peter referred to the significant progress that has been made in NWP and that predictions based on these models have now become an integral part of planning day to day activities. He highlighted that the development in NWP over the past 50 years is one of the prime examples of scientific progress, based on complex data collection exchange and the sophisticated use of computing systems. He mentioned that challenges remain, including QPF, biases in coupled models used for seasonal predictions, Indian Ocean predictability and issues related to MJO prediction. These challenges provide new opportunities to WGNE. He wished the participants a successful meeting.

3. MEETING GOALS AND ACTIONS FROM LAST MEETING

The Co-chairs stated that the goal of WGNE-29 was to review progress (e.g. through centre reports) and to discuss current and future specific initiatives (e.g. Polar Prediction, Sub-seasonal to Seasonal Prediction Projects; sessions on aerosols and surface drag in NWP and Climate models).

The importance of WGNE was highlighted in its role of bridging the weather and climate modelling and research communities and to continuously promote model development as a fundamental building block to improved understanding and prediction of both weather and climate.

Jean-Noël gave reviewed all action items, indicating that all were acted upon since the previous meeting.

Andy introduced the agenda for the remainder of the four days with special mention of how best to accommodate participants that will join the meeting via telephone or video conferencing. The agenda was adopted.

4. CAS, WWRP and WCRP MATTERS

4.1 WWRP matters and implications for WGNE

Gilbert Brunet presented on the World Weather Research Programme (WWRP), its research focus areas and how it structure will evolve in light of the conclusion of THORPEX at the end of 2014. WWRP will essentially consist of a number of working groups representing the expertise required to advance weather science and projects focusing on specific high priority issues that can best be advanced by a coordinated global research effort.

Special attention is being given to ensure a smooth post-THORPEX transition when this 10-year experiment is concluded. The three working groups under THORPEX will be reorganized in the form of two new working groups under the WWRP, i.e. one on Data Assimilation and Observing Systems (DAOS), and the other on Predictability, Dynamics and Ensemble Forecasting (PDEF). These two broad areas of research are considered to be fundamental in improving forecasting systems and services and require a coordinated global effort.

WWRP also realized that future advances in nowcasting (two hours ahead) and very short-range forecasting (12 hours ahead) will involve high resolution regional models that would use a growing amount of unconventional data. For this reason a merger between the Nowcasting Research Working Group and the Mesoscale Weather Forecasting Research Working Group will be phased in to accelerate the global knowledge in this emerging field.

Gilbert highlighted the good progress that has been made against the goals set out in the first Strategic Plan for the Implementation of WMO World Weather Research Programme (WWRP): 2009 – 2017 (WMO/TD-No. 1505). He also highlighted the contribution of WGNE in this regard.

He gave an overview of the new High Impact Weather project (HIWeather) which “Promotes cooperative international research to achieve a dramatic increase in resilience to high impact weather, worldwide, through improving forecasts for timescales of minutes to two weeks and enhancing their communication and utility in social, economic and environmental applications”. He further highlighted a new WWRP focus on water related to the modelling and predicting the water cycle for improved Disaster Risk Reduction (DRR) and resource management. He also stressed that improving the accuracy of short-range forecasts for security of people and properties, health, transport, defense and the energy market and developing climate services, i.e. improving sub-seasonal and seasonal predictions, and assessing decadal prediction should remain major objectives of the weather and climate research communities. In this regard he highlighted trends in NWP and highlighted commonalities between weather science challenges and WCRP Grand Challenges that WGNE should keep in mind.

Gilbert concluded with an overview of the World Weather Open Science Conference (WWOSC) that will take place from 16 to 21 August 2014 in Montreal, Canada (http://wwosc2014.org/). To date over 1200 abstracts have been submitted. The overarching theme of WWOSC is “Seamless Prediction of the Earth System: from minutes to months”. The conference is structured around two programmes:

- The science programme will cover basic weather research that extends knowledge of processes and systems as well as the applied research needed to put prediction systems together and assess the impacts of weather and climate events.

- The user, application and social science programme will consider the goods and services economy and the role of government in disaster risk reduction and management and the communication of weather information.

The scientific program will be organized around five science themes:

- Data Assimilation and Observations;
- Predictability and Dynamical/Physical/Chemical Processes;
- Interactions between sub-systems;
- Prediction of the Earth system: putting it all together;
- Impacts of weather and climate events.

A particular focus will be given also to major cross cutting themes, such as ensemble prediction. WGNE members were encouraged to activity participate and support the WWOSC.

4.2 Feedback on CAS-16 and its technical conference

Deon Terblanche reported on the 16th Session of the Commission of Atmospheric Sciences (CAS-16) that was held from 20-26 November 2013 in Antalya, Turkey. CAS-16 was preceded on 18 and 19 November by the Technical Conference (TECO): "Responding to the Environmental Stressors of the 21st Century" which focused on six broad thematic areas which will most likely hold significant challenges and opportunities to Members over the next decade and beyond:

- High impact weather and its socio-economic effects;
- Water: improved disaster risk reduction and resource management;
- Integrated Greenhouse Gas Information System;
- Aerosols: Impacts on air quality, weather and climate;
- Urbanization: Research and services for megacities;
- Evolving Technologies: Their impact on science and its use.

He made special mention of the value gained from the relationship between CAS and WCRP as spearheaded through the Working Group on Numerical Experimentation (WGNE), and the relatively new joint activities on sub-seasonal to seasonal prediction and polar weather prediction and climate predictability. These research initiatives make direct contributions to the Global Framework for Climate Services.

Deon reported that Oystein Hov (Norway) has been elected as President of CAS, and Jae-Cheol Nam (Republic of Korea) as the Vice President of the commission. The CAS Management Group was also established and they will meet from 23-25 April 2014 in Geneva to decide how best to take the decisions and recommendation of CAS-16 forward.

4.3 WCRP matters and implications for WGNE

Christian Jakob provided an update on WCRP matters, on behalf of Michel Rixen. The new WCRP structure now includes a WCRP Data Advisory Council (WDAC), and a WCRP Modeling Advisory Council (WMAC) on which WGNE is represented. The MJO Task Force now reports directly to WGNE, consistently with its expected research contribution at the weather-climate interface.

The WCRP community has identified 6 Grand Challenges (GC) representing the major science foci of the program for the 3-5 years ahead. In particular the effort on “Cloud, circulation and climate sensitivity” recognizes major gaps in understanding cloud feedback processes and their implications for changing patterns. A kick-off workshop was being held in Rottach-Egern, Germany, 23-28 March 2014. This GC aims at leveraging past climate

records and will be supported by model development initiatives. A summer school on model development is being planned for June 2015 at MPI in Hamburg to that effect.

The Research, Modeling and Prediction pillar of the Global Framework for Climate Services (GFCS) represents another important initiative for WGNE, especially regarding the gaps between science and services, the seamless suite of climate products, the unknown predictability and skill of current systems, and the lack of a comprehensive approach to uncertainties.

The Future Earth call for proposals on Fast Track Initiatives and Cluster Activities with deadline 4 April 2014 was highlighted.

The new CMIP structure includes a strong focus on analyzing systematic biases in climate models, addressing short-term hindcasts, ocean/sea ice coupling, clouds and circulation, and chemistry and aerosols. A new Transpose-CMIP effort is also currently under discussion.

WMAC2 and the JSC34 endorsed the Earth System Grid Federation (ESGF) as the future pan-WCRP model-data dissemination mechanism within the program. Initially adopted by the CMIP community, this archiving system is now being also used by CORDEX. WGSIP is planning to migrate to this infrastructure soon. The sister initiative on observations aka obs4MIPs brings satellite data to the same archive and aims at expanding to many observational products. A kick-off meeting was being planned on 29 April – 1 May 2014 at NASA HQ, Washington, USA with data providers to explore possible contributions.

Some important upcoming meetings were briefly reviewed, such as the 7th GEWEX conference (http://gewex.org/2014conf/home.html) in The Hague, Netherlands, 14-17 July 2014 and the pan-GEWEX and pan-CLIVAR meetings at the same venue 17-18 July, as well as the Climate Symposium in Darmstadt, Germany, 13-17 October 2014.

Christian Jakob also provided an update on the WCRP Modelling Advisory Council matters, noting that most WCRP Grand Challenges and CMIP6 activities require major model improvements, but that an overall strategy to achieve this is still lacking, and raising concerns about the fragmentation of the modelling community. The coordination of these activities will be discussed during the WMAC3 session in Heidelberg in conjunction with the 35th session of the WCRP Joint Scientific Committee 30 June to 4 July. A small WMAC task team will promote model development by establishing several prizes to recognize significant contributions in the field with a focus on early career scientists, and by organizing summer schools every 2 years focusing on parameterization, the first one being held in June 2015 at MPI in Hamburg. The schools will include general lectures on parameterization, specific lectures on the host model and SCM-based tutorials and exercises.

Consideration should also be given to possible future WGNE-sponsored workshops (bi-annually, perhaps joint with another WWRP, WCRP acticities) where student and early-career scientists may learn about/work on model (physics) parameterization development. These could be supported by the various institutes represented on WGNE.

5. OUTCOMES FROM RECENT WORKSHOPS RELEVANT TO WGNE

5.1 Joint GODAE Oceanview (GOV)/WGNE Workshop

Michael Ek presented on the Joint GODAE Oceanview (GOV)/WGNE Workshop which was held from 19-21 March 2013 in Washington DC, USA. The workshop focused on the status, needs and challenges of short- to medium-range coupled prediction for the atmosphere-wave-sea-ice-ocean. The workshop attracted members of the atmospheric, ocean, wave and sea-ice community with an interest in developing coupled forecasting systems targeting

short- to medium-range prediction to review the status of research and to debate the potential benefits, gaps and priorities for making advances. The workshop was endorsed by the GODAE OceanView Science Team (GOVST) and the Working Group for Numerical Experimentation (WGNE).

The workshop concluded that evidence is now compelling for coupled modelling (short- to medium-range) and that a coupled framework will put a spotlight on the problem of air-sea interaction. Coupled modeling introduces additional requirements on observation systems, both for air-sea parameterization and systematic bias and dialogue to specify these requirements is needed.

5.2 Systematic Error Workshop

Andy Brown reported on the 4th Systematic Errors workshop held at the Met Office in Exeter in April 2013. This was a lively and extremely well attended meeting and given its success and the desirability of encouraging work looking to understand and alleviate model errors, it was suggested that it should definitely be held again within 4 years, and ideally sooner. One encouraging aspect was the degree to which different presentations showed evidence of work genuinely looking across timescales (weather to seasonal to climate) in order to understand errors, suggesting that this seamless approach is beginning to gain real traction. One idea for further consideration is to try to build on this by trying to design some sort of transpose-CMIP initiative looking at the growth of errors in coupled models. Other issues raised and worthy of further consideration by WGNE include uncertainties in the quality of analyses in the tropics and Polar Regions, and the need to bring together physics and dynamics communities to make the most progress is disentangling the causes of model errors. The desirability of consolidating standard diagnostic codes and packages was also highlighted.

6. WWRP AND WCRP POLAR PROJECTS

The chair of the WWRP Polar Prediction Project (PPP), Thomas Jung, gave an update on PPP and the related WCRP Polar Climate Predictability Initiative (PCPI). He pointed out that PPP will focus on the following flagship activities: sea ice prediction, linkages between polar and lower latitudes and their implication for prediction, improved availability of observations from Polar Regions, and the Year of Polar Prediction (YOPP) - an intensive observation and modelling effort to advance polar environmental prediction capabilities.

PCPI is led by Ted Shepherd and Cecilia Bitz. It is still in its development phase. Substantial progress is expected from the upcoming pan-PCPI meeting, which will be held from 3-4 April 2014 in Boulder, USA. Six different initiatives have been identified: Improve knowledge and understanding of past polar climate variations (up to 100 years), assess performance of CMIP5 models in polar regions, improve understanding of how jets and non-zonal circulation couple to the rest of the system in the Southern Hemisphere, assess reanalyzes in polar regions, improve understanding of polar climate predictability on seasonal to decadal time scales, and model error. The last three initiatives will be done jointly with PPP.

Thomas Jung continued his presentation by outlining how WGNE could contribute to PPP: Attendance of a WGNE representative at the next steering group meeting in Montreal (22-23 August 2014) and at the upcoming workshop on polar-lower latitude linkages in Barcelona (10-12 December 2014) was suggested; he asked for the draft YOPP Implementation Plan to be reviewed by WGNE; and asked for advice on how to best develop an observing campaign that provides the data necessary to advance models. He also suggested to have a Transpose-CMIP experiment and to align it with YOPP (mid-2017 to mid-2019) in order to exploit the extra data that will be available, and to provide a special YOPP data set

similar to the one available for YOTC. He finished by proposing to have a joint activity on sea ice modelling/prediction once coupled atmosphere-ocean-sea ice models become available at forecasting centres (around 2017-18).

7. REPORT OF THE JOINT WORKING GROUP ON FORECAST VERIFICATION RESEARCH

Beth Ebert reported on recent development on forecast verification.

The WWRP/WGNE Joint Working Group on Forecast Verification Research (JWGFVR) has continued to promote methods for verifying deterministic and ensemble NWP forecasts including from high resolution models. A second phase of the Spatial Verification Methods Intercomparison Project has commenced to test the utility of diagnostic spatial methods for verifying precipitation and wind forecasts in complex terrain. It will reuse several cases from the MAP D-PHASE experiment in central Europe. Deterministic and ensemble NWP forecasts will be verified against point observations as well as ensembles of gridded analyses representing observational uncertainty.

A new publication, *Verification methods for tropical cyclone forecasts* (http://www.wmo.int/pages/prog/arep/wwrp/new/documents/WWRP_2013_7_TC_verification_15_Nov_en.pdf), describes the current state of the art in objective verification of TC track, intensity, strike probability, and associated hazards from heavy rainfall, strong winds, storm surge, and waves. The document pays special attention to verification of ensemble forecasts, seasonal forecasts, and TC genesis. At the other extreme, JWGFVR assisted in the verification of winter weather forecasts in the FROST-14 (Sochi Winter Olympics) FDP/RDP, which had participation from a large number of modelling centres. JWGFVR conducted the 6th International Verification Methods Workshop at NCMRWF and IMD in Delhi, India, in March 2014, as well as a one-day training workshop on ensemble verification at the European Meteorological Society meeting in Reading, UK, in September 2013.

8. CENTRE REPORTS

8.1 CPTEC, Brazil

Saolo Freitas presented recent developments at CPTEC in Brazil:

1. Completed 1 year of a NWP product using the Brazilian regional model BRAMS on 5 km resolution covering the entire South America. Rainfall and several meteorological fields forecast presented large improvements. BRAMS also has been also integrated with JULES surface scheme and now includes the carbon cycle.
2. On the global scale, preliminary results using a new set of physical parameterizations at the CPTEC AGCM indicated better scores. More robust evaluation is going on.
3. The GSI 3d-VAR data assimilation approach has been operationally adopt by CPTEC and this system was applied to the AGCM. The new analysis presents large improvement in comparison with the former data assimilation system. It is planned for this year to implement the same methodology for the regional weather forecasting with BRAMS.
4. The global scale ensemble forecast has been improved with new methodology for the application of random perturbations developed at CPTEC and it is operational since 2013.
5. The Brazilian Earth System Model is also under development showing improvements in precipitation simulations over the Amazon Basin.
6. Developments on the regional scale with a new time-steeping scheme and an aerosol/scale aware deep convection scheme are being made for the BRAMS model.

8.2 Environment Canada, Canada

Ayrton Zadra presented recent developments at Environment Canada.

Recent changes in operational systems are as follow:

- Global deterministic system (GDPS): significant improvements due to changes in physics (orographic blocking and boundary layer schemes), increased resolution (33 to 25 km), new vertical coordinate and discretization, increased resolution of analysis increments and other enhancements in 4D-Var.
- Global (GEPS) and regional (REPS) ensemble systems: significant improvements due to higher resolution, reduced thinning of satellite observations, evolving SST, improved dynamics and physics.

Experimental systems:
New Regional Ice Prediction System (RIPS), Global Ice Ocean Prediction System (GIOPS), and Pan-Canadian High Resolution Prediction System (HRDPS)
Ongoing work and plans:

- Data assimilation: replacement of 4D-Var by EnVar in GDPS; reorganization of NWP suites with increasing role of ensembles; development of regional EnKF and EnVar; new data assimilation (land surface and upper-air) for convective-scale model
- Dynamics: global Yin-Yang grid to become operational in 2015; enhancements in calculation of displacements in semi-lagrangian scheme.

8.3 Japan Meteorological Administration, Japan

Chiashi Muroi(JMA) made a report about current status and recent upgrade of JMA's operational NWP system. JMA has a plan to enhance vertical resolution deterministic global model, GSM, from TL639L60 to TL639L100 and upgrade physical processes in Mar. 2014. JMA also upgraded its One-week Ensemble Prediction System and Typhoon Ensemble Prediction System from TL319L60 to TL479 and changed the configuration, in Feb. and Mar. respectively. Improvements of these upgrades, improvements ratio of the standard score, TC forecast and some impact were shown.

8.4 Centre for Australian Weather and Climate Research (CAWCR), Australia

Gary Dietachmayer presented on recent developments at CAWCR.

This presentation provided a review of some of the major modelling activities at CAWCR, covering the period from WGNE-28 (Nov 2012) to the current meeting.

POAMA (Predictive Ocean Atmosphere Model for Australia), the CAWCR seasonal forecast system, was upgraded from version P24 to M24. This new version focused on improving the forecasts at shorter (multi-week, intraseasonal) timescales, as part of the ongoing development of a genuine seamless prediction capability. The introduction of atmospheric perturbations as part of the ensemble system produced more reliable precipitation forecasts for fortnights one and two, together with improved accuracy in simulating the MJO.

In the NWP space, as part of an ongoing rationalization strategy, the previous two regional systems were replaced by a single system with both a large domain and (relatively) high resolution (12km). The new system included assimilation of two additional data types (GPS-RO and IASI), together with greater volumes of ATOVS data. The new system generally outperformed those it replaced, though in rainfall there was a tendency towards too-large areas of light-rain.

The higher-resolution “city” models received a modest improvement in resolution (five to four kilometers). The development of these models provided useful insights into the importance of land-surface conditions on forecast accuracy, and the value-uncertainty associated with LS fields such as urban-fraction and tree-heights.

The early stages of the development of two new climate models were also described. ACCESS “ESM1” is the first ACCESS model to include a full carbon-cycle, and ACCESS “CM2” is a prototype for a potential CAWCR AOGCM contribution to CMIP6.

8.5 NCEP, USA

Michael Ek provided a report on recent modelling activities at the National Center for Environmental Prediction (NCEP). He briefly reviewed the NOAA mission for weather and climate and associated NOAA Operational Numerical Guidance Systems, and provided an overview of the NOAA Operational Computing System and the current status of the NCEP "Production Suite" that has an increased computational capacity (2x over our previous production machine). NCEP global data assimilation (DA) plans include a T574 analysis (~35km at equator), code optimization, a number of enhancements and EnKF modifications. Plans for the Global Forecast System (GFS) include Semi-Lagrangian T1534 (~13km at the equator), use of high resolution daily SST and sea ice analysis, high resolution forecasts until 10 days, and a number of physics changes; additional future plans are described. We also report on NCEP’s contribution to the WGNE aerosol-NWP experiment.

The NCEP Global Ensemble Forecast System (GEFS) plans include use of the GFS Semi-Lagrangian model, increased resolution, with other enhancements and more frequent output; the "Superstorm" Sandy case is reviewed. Similarly, increased resolution is planned for the Short-Range Ensemble Forecast (SREF) system. Test results for the new package for the (mesoscale) NAM model show improvement in precipitation scores and other metrics via physics and DA upgrades. Other topics include: the NOAA Environmental Modeling System (NEMS), drought monitoring, the NCEP/EMC Model Evaluation Group (MEG) and the framework for a model parameterization development testbed, NOAA Climate Program Office (CPO) activities where CPO provides support for the North American Multi-Model Ensemble (NMME) project for seasonal-to-interannual prediction, and reviews of the 2013 GOV/WGNE workshop and the 2014 WMO WWRP/THORPEX-WCRP conference on sub-seasonal-to-seasonal prediction.

8.6 Meteo France, France

Francois Boussel presented on recent developments at MeteoFrance.

In July 2013, there were modifications in the global NWP system Arpege, including a wavelet approach for a flow dependent B matrix from an ensemble data assimilation ensemble, the use of satellite observations from new instruments (Suomi-NPP/ATMS + CriS radiances, Oceansat-2/OSCAT winds, METOP-B instruments IASI, AMSU-A, MHS, GRAS, ASCAT), the increased usage of existing instruments : METOP-A/GRAS, METOP-A/IASI WV channels, Aqua/AIRS (over land and additional upper tropospheric channels), GNSS-RO (reduced vertical thinning), SSMI/S sounding channels, METOP-A/MHS, CSR from GOES-13 and GOES-14), and few changes in the physics (shallow convection scheme, improved description of surface properties over ice caps).

Same additional observations are assimilated in the mesoscale system Arome, but along with a denser thinning of AMSU-A (80km) and SSMI/S (139km), Doppler winds from one X-band radar (Mont-Maurel) and more SEVIRI radiances over land, using climatological maps of surface emissivity and retrieval of surface temperature.

The migration of the operational NWP suite on the new super-computer (Bull) has been completed mid-January 2014. Resolution upgrades are being prepared for operational NWP systems (global, meso-scale, global ensemble data assimilation and prediction system). The increase of horizontal resolution has been evaluated as more beneficial than the vertical resolution both on the convective scale and in the global models. Two new NWP systems are being developed for ensemble prediction and nowcasting based on the convective scale model Arome.

8.7 China Meteorological Administration, China

Xueshen Shen presented on recent developments at the China Meteorological Administration.

In 2013, CMA is running both the spectral model system and the self-developed GRAPES system, while the spectral system provides the 10-day global deterministic (T639), ensemble (T213) and typhoon (T213) forecast products; and GRAPES system has been operated for 10-day global deterministic (50km), meso-scale (15km) with 3-hourly RUC and regional typhoon intensity (15km) forecasts. The only change of the operational systems in 2013 is that the 5km-resolution meso-scale forecast started the product services during the rainy season over 6 regions of mainland China whenever severe weather occurred. Since July of 2013, the CMA HPC has been upgraded to IBM Flex P460 with 508 TFlops and 17920 cores as sub-system 1, while sub-system 2 will be ready by the end of June of 2014. Due to the increased computer power, CMA will upgrade the ensemble and global typhoon forecast model from T213 to T639 in May 2014. And, 15km GRAPES_Meso model will be upgraded to 10km version nested by 1 full time 3-km window as well as 5 seasonal 3-km windows which cover the Huai River basin and other regions where severe weather frequently occurs, respectively. By the end of September 2014, 50km GRAPES_GFS will be upgraded with the help of improvement in global GRAPES_3DVAR and minor revisions to the model. The 25km version of GRAPES_GFS, currently being tested, shows better forecast skill than those of the 50km version and T639 for the ACC and RMSE of almost forecast variables globally. The 25km GRAPES_GFS will be put into operation officially in 2015.

To consider the future development of CMA NWP models as well as the accuracy and scalability problem of current GRAPES, CMA has finished fundamental research on the new dynamical core based on a multi-moment constrained FV algorithm. The 2-dimensional slice non-hydrostatic dynamics and shallow water model on various quasi-uniform spherical grids have been carefully evaluated by using idealized experiments. Also, the 1st operational Chinese polar-orbit satellite FY-3C has been introduced, which was launched in September of 2013. It is recommended that operational centers should start to assimilate or monitor FY-3C radiance data.

8.8 Hydrometcenter, Russian Federation

Elena Astakhova presented recent developments in data assimilation as well as in global and regional NWP at the Hydrometcenter of Russia (RHMC). The main results in global NWP are the development of the 3D-Var data assimilation system and its successful trials; a new version of the global SLAV model with a horizontal resolution of 20-25 km and improved physics, prepared for operational trials (starting in April 2014); and a T339L31 version of the RHMC spectral model. Success in meteorological support of the Sochi 2014 Olympics can be considered as a main achievement in LAM. Operational products of COSMO-Ru deterministic systems with resolutions 7, 2.2, and 1.1 km and COSMO-Ru2-EPS with a resolution of 2.2 km and boundary and initial conditions provided by ARPA-SIMC (Italy) were of essential help for Sochi forecasters. High-resolution (2.2 and 1.1km) COSMO-Ru models

were prepared especially for Sochi 2014 and use nudging to assimilate AMS/HMS data in the region. Preliminary results of WWRP FDP/RDP FROST2014 project devoted to Sochi Olympics were presented. Also, the progress in numerical climate modeling at the Institute of Numerical Mathematics/Russian Academy of Sciences was reviewed.

8.9 ECMWF

Jean-Noël Thépaut presented on recent development at ECMWF.

Two main model cycles have been introduced since the last WGNE meeting. The main ingredient of the first cycle implemented (CY38R2) was the change of number of vertical levels increased from 91 to 137 in high-resolution forecast model (HRES), the ensemble of data assimilations (EDA) and main assimilation (4DVAR). Other important changes include revised background error variances and revised EDA calibration and filtering for 137 levels, modifications of the surface drag, boundary layer and shallow convection, and an adjustment of the non orographic gravity wave drag. With this new cycle, tropospheric upper-air scores were overall slightly improved in northern hemisphere and mainly neutral for Europe and southern hemisphere. Tropics were mixed with some negative results compared to observations but neutral against analyses. In the extra-tropics the main negative impacts are for the upper-tropospheric relative humidity (300hPa). The main positive impacts are for geopotential in the lower stratosphere, and to a lesser extent also in the troposphere. Another comprehensive change to the operational system was introduced in November 2013 (CY40R1). This cycle included three major modifications to the ensemble forecasts: the vertical resolution (going from 62 to 91 levels and raising the top from 5 to .01 hPa), the coupling of atmosphere and ocean from initial time of the forecast using a new version of the NEMO ocean model, and the introduction of perturbation of land surface initial conditions in the ensemble system and perturbation of land surface temperature and moisture observations in EDA. Other changes include:

- A major upgrade of the physics: Modifications to convection to address the diurnal cycle of precipitation, changes introduced to stable boundary layer diffusion, turbulent orographic drag, orographic gravity wave drag and surface-atmosphere coupling over forests, which improves boundary layer winds (e.g. at wind turbine hub height) and improves northern hemisphere winter scores.
- A dynamic estimation of background error covariances for 4DVAR with enhanced 25-member EDA.
- The activation of SSMIS 183 GHz channels in all-sky microwave radiance assimilation enhanced use of AMSU-A, AMSU-B and MHS data over sea ice, situation-dependent observation errors and revised quality-control for AMVs.

It was noted by WGNE that the improvement of the diurnal cycle constitutes a major breakthrough fixing a long-standing issue in NWP and climate models. Future research areas were also presented, with a special focus on the "scalability project" that is being kicked off and the associated workshop that will bring the community together and define a roadmap for future collaborations across NWP Centres on this particular issue.

8.10 Naval Research Laboratory (NRL), USA

Carolyn Reynolds reported that the global atmospheric forecast modeling system has recently been upgraded to the Navy Global Environmental Model (NAVGEM) from the previous Navy Operational Global Atmospheric Prediction system (NOGAPS). The new system has semi-Lagrangian/semi-implicit dynamics and upgrades to the physical parameterizations including prognostic clouds and adaption of the eddy-diffusivity mass flux boundary layer parameterization. NAVGEM is also currently being coupled to the HYCOM

ocean model and the CICE sea-ice model. Improvements to the NAVDAS-AR 4DVAR global data assimilation system include variational bias correction, CRTM v2 for NPP, and assimilation of additional sensors. A prototype hybrid 4DVAR data assimilation system is under development. The Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), coupled to the NCOM ocean model and SWAN and WWIII wave models, has capabilities including coupled atmosphere ocean ensembles, aerosol/cloud/radiation interaction, and adjoint-based sensitivity and observation impact. COAMPS-TC (specifically designed for tropical cyclone applications and producing skillful intensity forecasts) has been transitioned to operations in June 2013. The global Navy Aerosol Analysis and Prediction System (NAAPS) has been upgraded from 1 degree to 1/3 degree resolution and includes MODIS aerosol optical depth assimilation and the FLAMBE smoke source model. The Navy Environmental Prediction System Utilizing the NUMA Core (NEPTUNE) is under development as a potential candidate for the next generation global-regional prediction system based on a spectral element core.

8.11 NCAR, USA

Julio Bacmeister reported that the community land model (CLM) the land-model component of the community earth system model (CESM) had significant updates, including improved plant physiology, representation of flooding, improved crop and urban models. This led to better simulation of latent heat fluxes and land carbon storage in CESM. The community atmosphere model (CAM) officially adopted the spectral element dynamical core (SE) as an option. Results of 100km and 25km CAM AMIP run comparison were reported. Impact of higher resolution in CAM is mixed with some improvement, e.g., summer precipitation in sub-Saharan Africa, and some degradation, e.g., Pacific ITCZs. Improvements in sub-Saharan were associated with increased large scale (vs parameterized convective) precipitation. Coupled simulations with SE are still a work in progress, with initial SST cooling in coarse resolution runs and warming in high-resolution. Results of increased vertical resolution were also reported. A spontaneous quasi-biennial oscillation is obtained in CAM with 500m vertical grid spacing and non-orographic gravity waves.

8.12 KMA, Republic of Korea

Hoon Park presented on the current status and update strategy of the KMA NWP system. He also highlighted research activities related to NWP at the Administration. He gave an overview of the KMA computing resources focusing on the HaeOn and HaeDam computing systems (combined 758 TF total peak performance and 120 TB main memory) for operational runs, and backup and research respectively. Hoon gave an overview of the global deterministic and ensemble system, the Asian region model and the high-resolution (1.5 km) local model over the Korean Peninsula. He then gave an overview of the plans up to 2017 and highlighted research in a number of fields including that related to data assimilation, aerosols, land surface processes, and the local ensemble prediction system.

Hoon concluded his presentation on ocean data assimilation and forecasting and the ongoing work of implementing NEMO / NEMOVAR at KMA.

8.13 United Kingdom Met Office, UK

Gilbert Brunet reported that the Met Office has completed important advances in basic convective-scale UK forecasting capability in the last decade. The Met Office UKV regional deterministic Numerical Weather Prediction (NWP) system outperforms significantly over the UK territory the global NWP system that provides its boundary conditions. The added value of UK NWP relative to the global NWP system in the last five years was presented (the

comparison is based on the Met Office UK Index that focuses on the predictive skill for surface weather - temperature, wind, visibility, total cloud, cloud base height and precipitation.

The UKV has been more skilful than the Global deterministic system by at least 8% in the last year. The Global NWP system improvements included in the baseline above is approximately 1-2% each year. An added value of 8% for UKV represents 4-8 years lead over Global NWP system, hence justifying greatly the continued Met Office investment in convective scale NWP, or even accelerating it. This unprecedented added value in predictive skill is believed to be due in great part to UKV significant higher space-time resolution, improved physics and data assimilation advances.

The Met Office NWP long-term strategy is to improve the socio-economic value and increase the lead time of the UK forecasts and to widen their scope to new environmental applications. This will be achieved by:

- Improved data assimilation, ensemble forecasting techniques and modelling at convective scale;
- Improved global and regional observation processing;
- Coupling the next generation convective scale forecasting system with coastal ocean, terrestrial hydrology & atmospheric composition;
- Improved global model boundary conditions beyond a few days ahead from better treatment of the physics, data assimilation techniques (including hybrid variational and ensemble approaches), integration of global observations, coupled ocean-atmosphere, and tropics/mid-latitudes interaction.

This NWP strategy will support directly Met Office capabilities in predicting weather impacts for UK, which are essential for Met Office operational services and support of increasingly collaborative advice, for example through the Natural Hazard Partnership. It will contribute also significantly to the Met Office national and international commercial growth strategy.

Met Office Science in 2012-14 has pulled through significant R&D innovations in data assimilation, dynamical and physical modelling. It has implemented operationally two Met Office Global and Regional Ensemble Prediction Systems (MOGREPS): the high resolution global (33km) MOGREPS-G and the convective-scale 2.2km MOGREPS-UK. The implementation of the MOGREPS-UK, and the development of products based on it, could be declared as operational in July 2013 when it was implemented into the site-specific Best Data blending. There is a wide range of products available now on the internal website, including also First-Guess Severe Weather Warnings. The new neighbourhood verification scheme results demonstrate also the benefit of MOGREPS-UK ensemble over the deterministic UKV. Met Office has successfully demonstrated a NWP-nowcasting system (with four-dimensional variational data assimilation) that was showcased at the London 2012 Olympics. This Nowcasting Demonstration Project (NDP) prepares the way for a UK-wide implementation in the next few years.

In the next 2-3 years the Met Office is planning a series of innovations that will be implemented with a sequence of NWP Parallel Suites (PSs). They are:

- PS33: This is a technical release named Rose. Rose is a group of utilities and specifications which aim to provide a common way to manage the development and running of scientific application suites in both research and production environments;

- PS34: A global ENDGame NWP system with increased resolution (17km) and retuned physics. ENDGame is the next Met Office finite-difference model discretised on a latitude-longitude grid and is based on the fully compressible, nonhydrostatic Euler equations. Other potential advances include extending MOGREPS-G forecast

range (currently 3 days), higher-resolution global 4D-Var resolution (~60km to ~40km), additional satellite data and numerous model, data assimilation and observations to the operational UKV;

- PS35: UKV and MOGREPS-UK will be based on ENDGame. The UKV will provide inputs to the CEH-developed Surface Water Flood inundation model;

- Other innovations that are planned for 2014-15:

    - UKV/MOGREPS-UK with increased vertical resolution;
    - Increased ensemble size for MOGREPS-UK;
    - Expanded UK domain;
    - Ensemble Prediction System downscaled over Europe at 4km and possibly with 7-day leadtime;
    - UKV/MOGREPS-UK coupled to ocean and/or improved land surface models;
    - MOGREPS-UK will use high resolution and hourly analysis for the UK;
    - Post-processing: improvements in site-specific techniques (visibility, adaptive neighbourhood, gridded Kalman-Filter for sites without observations), calibration of ensemble spread, migration to Rose and use of JULES land-surface model.

8.14 DWD, Germany

DWD currently runs operationally the global, hydrostatic model GME with about 20 km 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.

The plans are to replace GME by ICON at the end of 2014 with about 13 km resolution. Mid 2015 COSMO-EU will be completely replaced 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 are the new global model ICON (together with the MPI for Meteorology), for which full experiments with the existing 3DVar have just been started. The stand–alone runs with IFS initialization have already shown a significant improvement compared to GME.

For the regional model COSMO an LETKF is under development. Most technical implementations have been done and testing is underway. It is expected to replace the current nudging scheme by the LETKF during 2015.

8.14 Council for Scientific and Industrial Research (CSIR), South Africa

Francois Engelbrecht presented on the modeling activities at the CSIR, South Africa.

The Council for Scientific and Industrial Research (CSIR) in South Africa has developed a seamless forecasting system based on a variable-resolution atmospheric model, the conformal-cubic atmospheric model (CCAM) of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia. The model is used for routine short-range weather forecasting. A 7-day forecast is issued once a day, having 50 km resolution in the horizontal over Africa. This forecast is subsequently downscaled to 15 km resolution over southern Africa, 8 km resolution over the southwestern Cape region of South Africa, and 1 km resolution over False Bay. The forecast system does not include a data assimilation

system and is initialized using the analysis fields of the Global Forecasting System (GFS). The CSIR intends to replace the 50 km resolution forecast over Africa with a 50 km resolution global forecast during 2014. The current 50 km resolution forecast has been shown to predict circulation patterns over southern Africa skilfully for at least 4 days (using 24-hr persistence as reference forecast). The 15 km resolution 24-hr rainfall forecasts have similarly been shown to be skilful, and comparable in skill to 12 km resolution forecasts of the Unified Model (UM) running at the South African Weather Service (SAWS). A multi-model ensemble based on the CCAM and UM forecasts have been shown to be more skilful than the individual model forecasts.

A 12-member ensemble CCAM seasonal forecast is issued once a month. The forecast is 6 months ahead with a lead time of 1 month. Lagged-average forecasting is used to generate the different ensemble members. These forecasts have a resolution of 200 km in the horizontal, and use predicted sea-surface temperature anomalies (obtained from international centres) as lower boundary condition. Hindcasts performed for the period 1979-2012 have shown the system to be skilful in predicting summer rainfall totals over southern Africa – after statistical downscaling to rainfall has been performed using 850 hPa geopotential heights as predictor. The CCAM model is also used for the projection of future climate change over Africa. The most recent projections are to contribute to the Coordinated Regional Downscaling Experiment (CORDEX) and have a resolution of 50 km in the horizontal globally. The CSIR and CSIRO are collaborating to downscale a large ensemble of Coupled Model Intercomparrison Project Phase 5 (CMIP5) coupled global climate models (CGCMs) using this experimental design, for a number of Representative Concentration Pathways (RCPs).

The most recent development at the CSIR is the development of a new coupled model on the equi-angular gnomonic cubic grid, in collaboration with the CSIRO and the Japanese Agency for Marine Earth Science and Technology (JAMSTEC). This model uses as atmospheric component the Variable-resolution Coupled Model (VCAM), which uses the same physics as CCAM. The ocean component is the Parallel Cubic Ocean Model (PCOM) provided by JAMSTEC. The CSIRO Atmosphere-Biosphere Land-Exchange Model (CABLE) is use as land-surface component, and there are plans to use the PISCES system for ocean biochemistry and the ocean carbon cycle. Through this three-way collaboration, the partners intend to contribute projections of future climate change to CMIP6. The CSIR has also developed and maintains a non-hydrostatic meso-scale model, which uses an equation set consistent with the non-hydrostatic version of CCAM. This model is used for theoretical cloud-resolving simulations.

9. RECENT DEVELOPMENT IN NUMERICAL PREDICTION

9.1 Recent developments in numerical methods

Michael Baldauf mainly reported from the ECMWF annual seminar on 'Recent developments in numerical methods for atmosphere and ocean modelling 2013' held from 2 to 5 Sept. 2013 at ECMWF in Reading. This meeting was organized by Nils Wedi and consisted of invited 1h-talks mostly given by representatives of the numerics section of the global modelling centres. The last such seminars took place in 2004, 1998, and 1991. Information given there has been combined with the WGNE survey on dynamical cores (by M. Tolstykh).

Important topics treated have been:

- Requirements for modern dynamical cores - among them scalability is currently of larger interest;
- Horizontal grids and the different approaches to avoid or reduce the occurrence of spurious modes;

- Spectral dynamical cores as an alternative to avoid such spurious modes. They remain competitive due to the development of efficient fast Legendre transformations;
- Vertical grids: the need for proper vertical weightings in heavily stretched grids was mentioned;
- Time integration: There are several schemes used: the classical semi-implicit Leapfrog scheme, split-explicit Runge-Kutta schemes and Predictor-Corrector schemes. A relatively new approach in the atmospheric community is the use of IMEX Runge-Kutta methods;
- Advection schemes for tracers should be both conservative and consistent with the continuity equation. For both items standard solutions exist now. The widely used Semi-Lagrangian approach can be made fully conservative: this is in particular of interest for a larger number of tracers. However, on unstructured grids conservative SL is probably too inefficient;
- Finite element based methods further find increasing interest. There are several models under construction using continuous/discontinuous Galerkin methods.

After the talk it was decided to proceed with the above-mentioned dynamical core survey in WGNE. The question arose, if WGNE should trigger common comparisons concerning scalability of different models.

9.2 Recent development in data assimilation

Tom Hamill joined the meeting via telephone from the USA. He reported on the activities of the WMO/THORPEX Data Assimilation and Observing Systems Committee (DAOS). When THORPEX is ended, DAOS will continue on as a WWRP committee. One of the first items presented was a draft of the proposed terms of reference for DAOS under WWRP. The draft text was presented in the slides. WGNE participants were asked to provide feedback on this, if they had any, to Tom Hamill and Roger Saunders, the DAOS co-chairs. Other recent activities of the DAOS included developing a recommendation on a standardized terminology for assimilation methods (produced by Andrew Lorenc, and part of the 2013 WGNE Blue Book). DAOS members were also active in a 24-26 April 2013 workshop at the Met Office to develop consistency in radar data formats across the world; WMO/CBS is acting on these recommendations. DAOS members, led by NCEP and the University of Maryland's Daryl Kleist, were responsible for the organization of the 6th WMO Data Assimilation Symposium, held during Oct 2013 in Camp Springs, MD. The symposium was a great success despite a last-minute change of venue due to the US government shutdown. Presentations from the symposium can be found online at http://das6.cscamm.umd.edu/ . DAOS and the WMO are profoundly thankful to the University of Maryland for agreeing to host the symposium on short notice given the government shutdown, and to Daryl Kleist and Kayo Ide for their intense last-minute work to make this happen.

DAOS also keeps the NWP community up to date on changes in observing systems and assimilation methods. For observing systems, contributions to the global observing system (GOS) by nations are increasing, for example with new Chinese satellites (e.g., FY-3) and Indian satellites (Oceansat). These new satellite systems may be crucial in the coming years should the current US polar-orbiting weather satellite, Suomi-NPP, fail before a replacement can be put in orbit and commissioned. Recent data impact studies have confirmed previous findings that satellite systems, especially temperature sounders, provide the largest data impact, i.e., the largest reduction in analysis error. Hence the failure of one polar orbiter can be expected to have a substantial effect on forecast accuracy unless its data is replaced by data from another comparable system. In-situ observations and other observation types, however, still have a substantial impact and are very important for ancillary applications such as for the bias correction of satellite radiances. With regards to nowcast and convective weather applications, assimilation of new types of near surface

observations is increasing, with not just radar data, but novel data sources such as power output from solar cells, measurements of surface pressure from cellular phones, and roadside networks of temperature and humidity.

While substantial development continues on 4D-variational data assimilation (4D-Var) systems, especially computationally efficient "weak constraint" methods that permit the forecast model to be imperfect, over the last few years there has been much more development of "hybridized" systems that incorporate both variational minimization and the use of ensembles for estimating the background-error covariances and/or for quality control background checks. The ensemble systems are readily parallelizable over many processors, an attractive characteristic given that massively parallel architectures look to continue as the dominant paradigm for the indefinite future.

Following Hamill's presentation, there was WGNE discussion as to whether a WMO/DAOS-sponsored workshop on coupled data assimilation was needed. Jean-Noël Thépaut noted that ECMWF has tentative plans for such a workshop, so it may be possible for DAOS to co-sponsor such an event. There was also discussion as to whether DAOS should have a role in the configuration of the GOS, for example contributing to recommendations for equatorial crossing times of Asian polar-orbiting satellites given the potential failure of the US satellite. J.-N. Thépaut noted that the operational centres coordinated admirably on this topic within the last year without DAOS, though that did not preclude a role for the committee in the future.

9.3 Recent development in ensemble prediction

Chiashi Muroi summarized recent activities of operational ensemble prediction system. DWD and BoM's EPSs are in developing stage and ensemble approach is now mainstreaming in operational centers. Considerations of near-surface model error representation are common issues in many NWP centers. ECMWF upgraded coupling to NEMO, surface initial perturbations and wave-ocean 1-way coupling in 2013. Increasing development of cloud-permitting regional ensembles are now recent topics in NWP. Handling of high-resolution fine dataset from EPS will be general issues for future HPC.

Carolyn Reynolds (NRL), Chiashi Muroi (JMA) and Tom Hamill (NOAA) presented current issues and challenges in ensemble forecasting. The number of articles in AMS journals per year concerning research in ensemble forecasting has increased dramatically over the last two decades (from less than 10 articles per year in 1993 to over 100 articles per year in 2013). Research in ensemble data assimilation, model uncertainty, and calibration and post-processing has also increased markedly. Centers continue to explore methods to account for model uncertainty in ensemble design through, e.g., stochastic methods, parameter variations, multi-model ensembles, and there is increased focus on integrating parameterization developers and ensemble developers in this line of research (e.g., the Joint SRNWP Physical Parameterizations and ensemble prediction systems workshop, in Madrid, Spain, in 2013). The utility of reforecasting for ensemble calibration has been clearly demonstrated, but issues remain concerning wide-spread adaption of reforecasts in environments of limited computational resources. Multi-model ensembles are proliferating for many different applications, and issues concerning multi-model ensembles (such as calibration-reforecasting and data transfer and latency issues) were mentioned. Many centers are testing coupling to (or incorporating uncertainty from) other components of the earth system, and this will require close collaboration between researchers working on different system components to ensure that coupled systems outperform uncoupled systems.

9.4 Recent development in mesoscale NWP

Jeanette Onvlee reported on recent developments in mesoscale NWP.

On convection-permitting (CP) scales, the assimilation of high-resolution observations is becoming commonplace. Emphasis is shifting towards deriving optimum impact for these data. The development of flow-dependent assimilation algorithms (4D-Var, hybrid ensemble assimilation) is growing rapidly. A new technique suitable for capturing phase errors (image warping) is shown. Experimentation on scales down to 100m is increasing explosively for various reasons. It is unclear how to handle physics parametrizations (convection and turbulence but e.g. also radiation) on those scales, and experimentation is needed to clarify this. One way to do this would be to extend the present grey zone project down to 100m scales. An issue of concern is the quality of physiographic data, which can sometimes very negatively impact CP model forecast quality.

CP ensembles are being developed at a great pace. Despite the use of many different types of perturbations, CP ensembles still tend to be very under-dispersive, indicating that we are not yet capturing the relevant sources of uncertainty.

CP models and ensembles may add value to global models for forecasting typhoon intensity, precipitation and winds. To assess this, an RDP is being prepared to start exchange and common verification of these models, and intercomparison with their global counterparts. The possibilities of learning from, and interacting with, WGNE activities in this field should be further explored.

10. SCIENCE TALKS

10.1 Using atmospheric CO2 for earth system model evaluation

Rachel Law from CAWCR introduced the Earth System Model version 1 of the Australian Community Climate and Earth System Simulator (ACCESS). ACCESS-ESM1 is a climate model configuration of ACCESS to which the carbon cycle has been added. Sensitivity tests and simulation results were shown for the component models, indicating that modelled carbon fluxes were similar to those produced by other models participating in CMIP5. Preliminary coupled model simulations indicate that further work is required to spin-up the carbon pools and produce near zero carbon fluxes to the atmosphere under pre-industrial conditions. The presentation also demonstrated how atmospheric CO2 measurements could be used to assess carbon fluxes from models or derived from observations. Two studies were introduced. In the first, measurements from Cape Grim, Tasmania were used to evaluate land carbon fluxes from SE Australia. The results suggested a mismatch in seasonality, possibly due to the modelled carbon fluxes only accounting for natural vegetation and neglecting crops grown through winter. The second study used Macquarie Island and Cape Grim measurements to assess the seasonality of southern ocean carbon uptake, an assessment only possible due to the focussed attention given to instrument development and operation resulting in a very high precision measurement record.

10.2 An integrated facility for research in climate and weather simulation and analysis

Tim Pugh from CAWCR provided an overview of a multi-organisation (BoM, CSIRO, ANU/NCI, CoECSS) project to develop a virtual laboratory and web portal called "the Climate and Weather Science Laboratory" (CWSLab). The goals of the virtual laboratory are to:

- To reduce the technical barriers to using state of the art tools;

- To facilitate the sharing of experiments, workflows, software, data and results with the climate and weather community;
- To ensure the integrity, discoverability, and accessibility of software and data;
- To improve the reproducibility and traceability of model simulation and data processing;
- To reduce the time to conduct scientific research studies; and
- To elevate the collaboration and contributions to the development of the Australian Community Climate Earth-System Simulator (ACCESS)

The laboratory utilises the ACCESS infrastructure to support coupled and uncoupled model simulations of climate and weather phenomena. Additionally, the laboratory provides a workflow facility for the analysis of climate simulations, which will assist in the assessments of Australian climate change and contribute to the future assessment reports of the United Nations Intergovernmental Panel on Climate Change (IPCC). Finally, the laboratory provides access to an international data publishing service through the Earth System Grid (ESG) and a local Australian data publishing service and repository for the Australian community.

11. LINKS BETWEEN WCRP MODELLING GROUPS AND WGNE

11.1 WGCM and WGNE links

Peter Gleckler (PCMDI) discussed several connections between the WGNE and WGCM, namely high-resolution model intercomparison and the benchmarking of climate model performance with well-established metrics. It was reported that several modeling groups contributed high-resolution (~25km) AMIP experiments to CMIP5 with companion "time-slice" AGCM simulations that used mid-21st century SSTs from a coupled model configuration as boundary forcing. Given the need to further explore the added value of higher resolution in climate change experiments, there is considerable interest to increase the opportunities for high-resolution intercomparison in CMIP6. It is expected that a formal "MIP" will be organized, and hope that the WGNE will be available to provide some guidance given WGNE's experiences with high resolution NWP, the Grey Zone, and other projects. It was decided that Julio Bacmeister will provide this link (see action items).

Peter Gleckler also briefed the WGNE on several efforts to advance the benchmarking of climate model performance, a topic that has been of interest to WGNE for many years. As a testament to the increased use of objective tests, several examples were shown from the IPCC WGI AR5. One highlight was use of sea-ice metrics to define minimum standards of performance for models included in the multi-model ensemble of 21st century Arctic sea-ice loss.

As the future of CMIP include DECK experiments (Diagnosis, Evaluation, and Characterization of Klima;
see http://onlinelibrary.wiley.com/doi/10.1002/2014EO090001/pdf), it is envisaged that routine model evaluation will become much more efficient and systematic, and ultimately aid the model development process by quantifying systematic model errors in individual models as new simulations become available. In support of the WGNE/WGCM metrics panel, PCMDI has developed a package to readily enable modelling groups to compare their newer model versions with all models that have been included in CMIP3 and CMIP5. This and other related efforts is expected to provide modeling groups with useful diagnostic feedback even before they make their simulations available for evaluation by the broader research community.

11.2 WGSIP activities

Andy Brown presented on recent developments related to the Working Group on Seasonal to Interannual (WGSIP) activities on behalf of the co-chairs, Adam Scaife and Francisco Doblas-Reyes.

Andy explained how the activities of WGSIP is related to User Interface Platform; and Research Modelling and Prediction pillars of the GFCS as well as to the WCRP Grand Challenge #1 on skillful regional climate predictions at seasonal to decadal time scales. The work of WGSIP is also closely integrated with the operational predictions provided through the 12 Global Producing Centres. Andy made brief mention of the (1st) International workshop on seasonal to decadal prediction that was held in Toulouse, France in May 2013 and the Climate-system Historical Forecast Project (CHFP) and the link to its data server: http://chfps.cima.fcen.uba.ar/ The CHFP dataset is can be considered as the "CMIP for seasonal forecasting".

Andy showed evidence that extratropical forecast skill is emerging on seasonal timescales and specifically related to Northern Annular Mode (NAM) in winter Sea Level Pressure. Although the signal to noise is small requiring large ensembles, all models show some skill and the predictability of the NAM is much higher than in previous operational systems. The aims of the WGSIP-SPARC Stratosphere Historical Forecast Project to investigate improved predictability through better representation of the stratosphere in models were highlighted as well as the ongoing efforts with WGCM to address decadal predictions. The approach and results of using the first few years from the CMIP-5 runs were discussed and the new research initiative to exchange in real time decadal forecasts as per the request of WMO Commission for Climatology.

Andy concluded the presentation with a summary of a draft decadal prediction protocol for CMIP6 that is being developed jointly by WGSIP/WGCM/CLIVAR following agreement amongst these groups via the Decadal Climate Prediction Panel.

12. MJO AND SUB-SEASONAL TO SEASONAL PREDICTION RESEARCH

12.1 Sub-seasonal to seasonal prediction project

Harry Hendon presented on S2S.

The background, goals and current status of the S2S project, which is co-sponsored by the WWRP and WCRP, were summarized (project web page: http://www.wmo.int/pages/prog/arep/wwrp/new/S2S_project_main_page.html) The aim of S2S is to improve forecast skill and understanding on the sub-seasonal to seasonal timescale (lead time 2-12 weeks)with special emphasis on high-impact weather events, to promote the initiative's uptake by operational centres and exploitation by the applications community and to capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services. This is a 5 year project, 2013-18 and a Project Office has recently opened in Jeju Island, hosted by KMA. A trust fund supports the project activities. A key activity of S2S is the creation of a forecast/hindcast data base, styled after TIGGE. It will be hosted at ECMWF and will include upper ocean output as well as standard atmospheric fields. Archiving is expected to begin in late 2014, with commitments from at least 10 centres to provide forecasts/hindcasts.

S2S research activity is focused in 3 themes: Service-oriented, Underpinning predictability, and Forecast System Development. The project also has a strong Education/Outreach component, noting the first S2S scientific conference was held at NCEP 10-13 Feb 2014.

The research activities are organized in 5 demonstration subprojects that also have strong links to other WWRP/WCRP projects/panels: (Monsoons (CLVIAR-AAMP), MJO (WGNE MJO task force), Africa (CBS and SERA), Extreme Weather, and Verification (JWGFVR).

A strong link of S2S to WGNE is already established through the collaboration with the MJO Task Force for the MJO project. However 3 other possible joint projects with WGNE were presented: a) Representation/prediction of teleconnections, b) Systematic errors in monsoon regions but with a focus on intraseasonal variability, and c) initialization/ensemble generation for S2S. Possible ways that WGNE could promote these activities are to help organize workshops and design/promote target experiments. As a first step, it was suggested that a session on teleconnections could be organized at the next Systematic Errors Workshop. S2S also agreed to keep WGNE informed of their next workshop and steering committee meeting, to which WGNE input will be sought.

12.2 MJO Task Force

Matt Wheeler reported that the MJO Task Force, which joined WGNE a little over 1 year ago, continues to make progress towards its overall goal to facilitate improvements of the MJO in weather and climate models. We have 6 current subprojects:

1. Process-oriented diagnostics/metrics for MJO simulation,
2. Boreal summer monsoon ISV monitoring and forecast metrics,
3. Assessment of CMIP5 model capability to simulate realistic intraseasonal variability,
4. MJO TF + GASS Multi-Model Diabatic Processes Experiment,
5. MJO air-sea interaction,
6. The MJO and the Maritime Continent (with S2S).

These subprojects are in various stages of development, with #6 being the least developed and requiring further thought and refinement of the proposal. For subproject #4 we ask WGNE to utilize and advertise the availability of the soon to be released datasets for studying a wide variety of processes and phenomena (i.e. not just the MJO). There are a number of papers that are being worked on by various members of the Task Force: A review of MJO air-sea interaction; MJO in CMIP5; MJO real-time forecasting verification; and 3 papers on the MJO vertical structure and diabatic heating project. Our next face-to-face meeting will be on 16th August in Montreal. Matt indicated his intention to step down as co-chair in August and highlighted the need to rotate about 2-3 members.

13. WGNE SYSTEMATIC VERIFICATIONS AND COMPARISONS

13.1 Tropical Cyclone Verification

Chiashi Muroi made a report about TC verification for 2012. The aim of this verification is to detect the progresses of NWP models, encourage and make feedbacks to model developers. ECMWF performed quite well in all basins for 2012. NCEP made a large progress attributed to the implementation of hybrid EnKF/Var. All NWP centers predict the unusual westward recurvature of Hurricane Sandy around 5 days before landfall on the East coast of the US. Some regional models were included in the TC verification. In regards to track forecasts, regional model showed only small advantages, however, TC intensities were well-expressed in fine mesh regional models.

13.2 Precipitation Verification

François Bouyssel reminded members that recommendations on QPF verification have been provided by Laurie Wilson last November and that these methods are being tested in some

NWP centers. He requested the centre representatives to make short presentations on their findings:

Xueshun Shen presented QPF verification over China. ECMWF gives better forecast. Other centers have comparable performance and common deficiencies: rainfall rate become stronger and stronger with the forecast length increasing over Sichuan Basin (steep orography).

Michael Baldauf provides an update of QPF verification over Germany for 1, 2 and 3 days forecasts for 2013 seasons.

Chiashi Muroi reported QPF verification over Japan. All centers are gradually getting better. ECMWF performs better recently. EDI has been computed on 6h accumulated rainfall. For 0.5mm/6h threshold, ECMWF performs better in summer, Japan in winter.

Michael Ek presented QPF verification over USA. Intercomparison of ETS has been shown. NAM, NAMX and GFS model forecast have been compared with FSS scores.

Jean-Noël presented QPF verification done at ECMWF (by Thomas Haiden & colleagues) and presented some results of an in-depth study testing the scores recommended by Laurie. A report has been written and will be available on the WGNE Website.

François Bouyssel reported QPF verification intercomparison over France. Arome, Arpege and IFS 6h accumulated rainfall have been compared using FSS.

14. RECENT DEVELOPMENTS IN HIGH-RESOLUTION NWP

Gary Dietachmayer reported on recent developments in high-resolution NWP at modelling centres.

Building largely on the context previously set by Onvlee's "Mesoscale NWP developments" talk, this presentation reviewed high-resolution NWP activity across all of the WGNE members and centres. It was argued that the following, admittedly loose and by no means complete, themes could be identified:

- The push for high-resolution was as strong for global as for mesoscale models, and was a very strong driver for improvements in software scalability and dynamical-core development.
- Whilst the very highest resolution will come from limited-area models, there is still a lot of freedom in the design of these systems (e.g., number of levels of nesting, situation-adaptive selection of run-time domains from a set covering the domain of interest, system maintenance cost/complexity versus maximizing resolution), and different centres are pursuing different strategies.
- Re-confirmation (if it was ever required) of the need for ensemble treatment when working with high-resolution NWP.
- The challenge posed to model physics if we are to make effective use of high-resolution models ….
- But also the predictability opportunity available when strong local forcing is present (e.g., highly-detailed land-surface forcing in high resolution urban models).

15. GLOBAL ATMOSPHERIC SYSTEM STUDIES (GASS), INCLUDING THE GASS ATMOSPHERIC BOUNDARY LAYER STUDY (GABLS)

Martin Miller presented on behalf of the co-chair of GASS, namely Jon Petch and Stephan Klein.

GASS has been a major success story over the past twenty years or so with more than 40 projects that have addressed clouds, convection and boundary layer issues. There are currently 13 active projects and the report identified several of these wide-ranging activities. Results and papers were well advanced for the MJO diagnostics study, including the interesting result that models with good MJO in forecast mode did not necessarily have good MJO statistics in climate-type simulations. Newer projects include a Transpose-AMIP-type study (CAUSES) to investigate the warm bias in near-surface air temperature exhibited by many climate models over the continental USA in summer. The GABLS activity have concentrated on stable boundary layer cases which are highly problematical for NWP and climate models, and has extended its studies to a very stable boundary layer example over Antarctica.

GASS has collaboration across the entire WCRP/CAS programmes and reports annually to WGNE whose members are key participants in GASS projects.

16. THE GREY ZONE PROJECT

Martin Miller presented on the grey zone project that was specifically established by WGNE to address the increasingly urgent problems associated with NWP and related activities in which the horizontal grid spacings are below 10kms. At such resolutions convective motions become partially resolved and pose as yet unanswered questions as to the veracity of the convective fluxes (both resolved and parametrized), and what should be done to counter this very unsatisfactory situation. The progress of this important project was reported. The initial case study was chosen to be that of a maritime cold-air outbreak, a common wintertime phenomenon with active convection. It was noted that over 20 modelling groups were currently participating. The global modellers were just beginning to submit results but many LAM (with and without convection parametrizations) and LES simulations had been run already. Analysis of these runs was in progress and early results already showed that major errors were present if the correct partitioning between resolved and parametrized fluxes was not achieved as a function of scale.

Although this project started quite slowly it is now in full spate and many exciting results should be forthcoming in the coming year or so that will be of great importance to WGNE members' home institutions.

17. GLOBAL LAND ATMOSPHERE SYSTEM STUDY (GLASS)

Martin Best reported that there are a number of projects in GLASS which have just completed, are ongoing, or about to start. The GLACE-CMIP5 experiment that was designed to address how the land surface influences future climate change has now been completed. This experiment concluded that for the Mediterranean region, up to 25% of the climate change signal for temperature is due to reduced soil moisture impacting on the atmosphere. Effects on lower precipitation amounts can also be found in this region due to the reduced soil moisture, although the signal is noisier than that for temperature.

The GWSP3 project is about to be launched. This project has been designed to deliver a new long term (~100 year) surface re-analysis using multiple models. It will also explore the

uncertainties due to the input atmospheric data as well as the uncertainties in future land surface states due to land cover and land-use change.

The PLUMBER project has been designed as a benchmarking project, with the land models compared to a number of both physically based and empirical benchmarks. The results have shown that the models are similar in their performance compared to the benchmarks, but the models need further development in water restricted regions. This project is close to completion, but there is still an opportunity for other models to be involved. Whilst there are a few operational centres already contributing, it would be good to include a few more.

Initial results from the project to investigate land atmosphere coupling (DICE) are now available. This project was designed to look at the land and boundary layer components separately as well as being coupled. In addition, further uncoupled experiments have been designed to establish which boundary layer models show more sensitivity to the land surface and vice versa. The initial results have been contaminated by many of the land surface models having far too much evaporation, due to a missing process in these models. This is being addressed by the land modelling groups and new results will be supplied from each group. However, despite the contamination, the results show some interesting differences in response from the various models.

18. VERIFICATION AGAINST OWN ANALYSIS

Chiashi Muroi from JMA introduced the result of the survey regarding multi-analyses verification. In general, the differences between analyses are not negligible and the influences of analysis fields on verification results might be large when comparing scores of verification against own analysis and that against other centre's analyses. This survey briefly indicates the sensitivity of verification scores on the choice of analysis for Z500, VW850, T850 and PSEA scores. In extra-tropics, the differences of Z500/ACC between multiple analyses are small and Z500/ACC is the most reliable score to measure forecast accuracy. The score of Z500/RMSE and VW850/RMS vector wind error as well as ACC are also reliable for over day 2 forecast ranges. On the other hand, score of PSEA and T850 are quite sensitive to the choice of analysis. Especially in tropics, these scores show strange behaviours in that RMSE of some centres decrease along to the forecast time if forecasts are verified against other centre's analysis.

WGNE29 furthered the discussion of WGNE28 on the topic of verification against analyses. Verification against analyses is conceptually attractive in that one gets a sense of the global or hemispheric error characteristics, not just the errors where the observations are concentrated. Verification against analyses can be problematic in that the analyses can be very different from one centre to another, as discussed in WGNE28. This is largely because a key assumption in data assimilation, that the background forecast (which observations adjust in the assimilation process) is unbiased. Different centres with different modeling systems can have differently biased background forecasts, and in the absence of new observations that background is reflected in the analysis. Another major source of differences are the different methods for estimating bias corrections for satellite radiances.

At WGNE29, Chiashi Muroi (JMA) showed results produced by Takafumi Kanehama concerning verification of TIGGE forecasts against multiple analyses. With only rare exceptions, each of the centres' models verified best against their own analysis, especially for the short-lead forecasts. This characteristic was more prominent for 850 hPa temperature and sea-level pressure than for 500 hPa geoopotential height. Jean-Noël Thépaut of ECMWF presented the work of Munehiko Yamaguchi et al. on the topic of whether ensemble spread-error relationships are accurately diagnosed using analyses. The work first showed that 24-h forecasts of tropical 850 hPa temperatures scored substantially better against their own analysis than against ERA, the >10-year old ECMWF reanalysis.

They then described a procedure for leveraging the forward operator of the data assimilation system to convert model forecasts to synthetic observations, allowing comparisons of forecasts against observation types that have not been commonly used in the past for verification, such as satellite radiances. In examining spread-error relationships, one expects consistency between the magnitudes of squared error vs. the sum of ensemble variance and analysis/observation-error variance. They found, both for Northern Hemisphere 700 hPa temperature and for a channel of AMSU-A radiances peaking near 700 hPa, that when verifying against analyses, it appeared that 24-h forecasts were over-dispersive. However, they appeared under-dispersive with respect to the observations. A naive verification against analysis data could thus lead to making incorrect decisions about the dispersion characteristics of the ensemble prediction system.

In the discussion, it was agreed that the centres would be wise to emphasize more and more the verification against observations. There still was interest in verifying against analyses, but the procedure of regularly verifying against other analyses, not just one's own, was judged rather burdensome. There was interest in having some consensus analysis for verification, possibly synthesizing information from the better of the global analyses, but the procedure for performing that synthesis is still a topic for further research. WGNE suggested that DAOS and or THORPEX/TIGGE-PDP groups might be more suitable WMO groups for coordinating future research activities on this topic.

19. AEROSOL PROJECT: PROGRESS AND NEXT STEPS

Saulo Freitas presented on progress with regards to the WGNE aerosol project, highlighting the proposed case studies, the participants and a brief description of their modeling systems, preliminary results, a presentation of ECMWF findings and the setting up of a dedicated webpage.

The case studies are related to a dust storm event over Egypt (18 April 2012), a Beijing air pollution case (12-16 January 2013) pollution of China and the persistent biomass burning case in Brazil between 05 and 15 September 2012.

The aerosol project aims to improve the understanding of the follow points:

- How important are aerosols for predicting the physical system (NWP, seasonal, climate) as distinct from predicting the aerosols themselves?
- How important is atmospheric model quality for air quality forecasting?
- What are the current capabilities of NWP models to simulate aerosol impacts on weather prediction?

In this way the following work was devised

- Select strong or persistent events of aerosol pollution worldwide that could be fairly represented in the current NWP model allowing the evaluation of aerosol impacts on weather prediction.
- Perform model runs both including and not the feedback from the aerosol interaction with radiation and clouds.
- Evaluate model performance in terms of AOD simulation compared to observations (e.g. AERONET/MODIS data) or any other related aerosol observation available.
- Evaluate aerosol impacts on the model results regarding 2-meter temperature and dew point temperature, 10-meter wind direction and magnitude, rainfall, surface energy budget, etc.

Three cases studies were selected based on different physical processes leading to extreme events of aerosol load over three different regions of the World:

- Case 1: Dust storm over Egypt (18 April 2012) where forecasts with and without interactive aerosols, limited to direct effect only were asked.
- Case 2: Extreme urban pollution in Beijing (12-16 January 2013) where forecasts with and without interactive aerosols, including indirect and direct effects were asked.
- Case 3: Persistent presence of biomass burning smoke in Brazil - the SAMBBA case - (September 2012) where forecasts with and without interactive aerosols, including indirect and direct effects were asked.

The table below describes the participants and the cases they are involved:

Participants	Case 1	Case 2	Case 3	Type of model	Status of the data	People involved
CPTEC			X	R	Data being analyzed (aerosol direct effect only)	Saulo Freitas, Mauricio Zarzur
JMA	X	X	X	G	Data sent (ind, dir, ind+dir, no-aer)	Taichu Tanaka, Chiasi Muroi
ECMWF	X	X	X	G	Data sent (aerosol direct effect only)	Angela Benedetti, Samuel Remy, Jean-Noel Thepaut
Météo-France/Met. Serv. Algeria	X			R	Data sent (aerosol direct effect only)	Morad Mokhtari, Bouyssel Francois
ESRL/NOAA	X	X	X	G/R	Working on the simulations	Georg Grell
NASA/ Goddard	X	X	X	G	Data sent (interactive or not)	Arlindo da Silva
NCEP	X	X	X	G	Data sent (aerosol direct effect only).	Sarah Lu, Yu-Tai Hou, Shrinivas Moorthi, and Fanglin Yang
Barcelona Super. Ctr.	X			R	Data being analyzed (aerosol direct effect only)	Oriol Casellas

The preliminaries results shown for Cases 1 and 2 in this meeting were:

- Case 1
  - Aerosol optical Depth (550 nm):
    - ⇨ NCEP: climatology does not capture the strong event (as expected).
    - ⇨ JMA/NASA/MF have a similar pattern in terms of spatial distribution.
    - ⇨ AOD values: M-France > JMA > NASA
  - Short wave radiative flux at surface (R_SW) and 2 meters temperature (T2m):
    - ⇨ JMA: low impact of aerosols and R_SW, typical absolute changes in T2m is about 0.25 K.
    - ⇨ NASA: R_SW is reduced by 100 up to 300 W m^{-2} with cooling up to 3 K.
    - ⇨ NCEP: applying a climatological distribution R_SW is reduced up to 100 Wm^{-2} everywhere with typical absolute changes in T2m about 0.25 K.
    - ⇨ M-France: presented the strongest impacts of aerosols with a much larger area with cooling up to 3 K. Also strong enhancements of mass convergence at the edges of the plume are noted.
- Case 2
  - Short wave radiative flux at surface (R_SW):
    - ⇨ Results from JMA simulations shown that the direct effect contributed with 25 to 100 W m^{-2} while the indirect effect implied on 100 to 300 W m^{-2} on reduction of the R_SW. For NASA, results shown lower, but still significative, impact. However, both simulations don't show a clear signal,

with areas with positive feedback, probably associated with non-linear processes.

- Precipitation:
  - ⇨ So far, not clear signal on the precipitation was observed, but the evaluation will continue.

To help on the model evaluations, all simulation data were sent to a CPTEC/INPE server. Models data can be accessed by the internet and evaluation, comparison and visualization can be done by using the tools developed by Mr. Mauricio Zarzur (IT technician of CPTEC) and hosted at web site http://meioambiente.cptec.inpe.br/wgne-aerosols/.

The planned dissemination of the results and publications are:

- ⇨ Results will be first showed at the next The World Weather Open Science Conference as keynote paper of the session on 'Atmospheric and Oceanic Composition'.
- ⇨ Detailed report will be prepared in 2014.
- ⇨ Concise paper with the main results will be submitted to ACP/EGU (?) on 2014/2015.

Jean-Noël Thépaut presented the first results obtained at ECMWF on the desert storm case. Including the direct effect of aerosol in their model simulation (without assimilation) reduces the short wave radiation and increases the downward long wave radiation, with beneficial impact on night time 2-meter temperatures with a clear reduction of the cold bias. An interesting feedback mechanism was also observed: Including the direct effect of aerosols in the simulation generates a local heat pool under the aerosol plume. This local heat pool increases the pressure gradient in its vicinity and increases locally the wind, which lifts more dust from the ground and increases the total AOD. The verification with observations is underway to analyze this interesting result further. Simulations including assimilation of aerosols (i.e. cycling the aerosol information from one cycle to the next) confirms and amplifies this feedback mechanism.

The members of WGNE expressed their satisfaction with the progress made on the aerosol project and encouraged Saulo to continue coordinating the initiative.

20. DRAG PROJECT: PROGRESS AND NEXT STEPS

Ayrton Zadra reported on progress with regards to the drag project.

Project goal:
Produce a first inter-comparison of surface drag from NWP global models.
Summary of Phase 1:
Nine centres (ten models) submitted the requested results, which were processed and posted on the project website (hosted by the Canadian centre),
http://collaboration.cmc.ec.gc.ca/science/rpn/drag_project/index.html ,
including the project report no. 1,
http://collaboration.cmc.ec.gc.ca/science/rpn/drag_project/documents/wgne_drag_project_report01.pdf

Overall, the largest differences among the model stresses are found over land. Even when two models produce similar values for the total parametrized stress, they may disagree on the values of the individual (PBL and SGO) components. Only a fraction of these differences may be attributed to differences in horizontal resolution, since some of the models have similar resolution and yet seem to generate different stresses. Other factors such as surface parameters (e.g. ancillary fields) and differences in the scheme formulations (e.g.

dependence on stability) may play a role and remain to be investigated. In contrast, there is less spread in the results for the stress over water (which comes from the PBL scheme only) except for the CPTEC and Meteo-France models (whose stresses tend to be weaker than the other models) and the HMCR model (which seems to produce relatively weak stresses over water, except over the southern extra-tropics).

The results obtained so far are preliminary in as much as no attempt was made to explain the differences found among the models stresses. This is left for future stages of the project, since it will probably require access to details on the individual parametrizations and to other input fields (such as upper-air profiles of winds and static stability).

Julio Bacmeister reported that the project would like to involve climate models in the WGNE surface drag intercomparison. The current protocol for NWP models called for data from two single months of forecast runs. A different protocol is needed for climate models. A reasonable compromise between ease and utility is to request data for January and July from 10 different years in an AMIP run. We can exploit an existing connection with Joan Alexander's 3-year International Space Studies Institute "team" on gravity waves in climate models. This group includes 6 climate models not currently represented in WGNE. These models employ a variety of surface drag parameterizations, so an informative comparison is possible.

The progress made with this initiative was favourably commented on by the members of WGNE and Ayrton was encouraged to continue coordinating the initiative.

21. VERIFICATION SCORES

Jean-Noël Thépaut presented scores inter comparisons between all major NWP centres, with a particular focus on the Polar Regions. Overall, ECMWF has the lead for most parameters and most areas, but models are getting closer together, in particular when verified against observations. The impact of the recent changes to the NCEP assimilation system was confirmed. 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 being the most under active and CMC being the most overactive. It was noted by Andy Brown that this feature of the MetOffice model will disappear with the implementation of the new dynamical core.

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

22. DECISIONS AND ACTIONS

22.1 Summary of recommendations

RECOMMENDATION 1: For CAS MG to consider how best to engage funding agencies on the needs for modelling development and weather research, in particular the opportunities to do so at the WWOSC.

RECOMMENDATION 2: That the climate metrics panel include GLASS hydrology expertise.

RECOMMENDATION 3: More centres to produce re-forecasts as a contribution to the S2S project.

RECOMMENDATION 4: More centres to provide verification information for the Polar Regions.

23.2 Summary of action items

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.

ACTION ITEM 2: WGNE to ensure regular workshops on systematic errors to take place at intervals not exceeding 4 years and to encourage WGNE members and modelling centres to offer hosting the next workshop.

ACTION ITEM 3: Chiashi to conduct systematic comparisons of analyses over the tropics.

ACTION ITEM 4: Michael Ek to coordinate WGNE polar prediction and predictability activities on behalf of WGNE:

- *a. Year of Polar Prediction plan to be reviewed by WGNE by end March 2014 (Mike);*
- *b. WGNE representation at the PPP steering group meeting at WWOSC (Carolyn or Mike) and at the Barcelona workshop Dec 2014 (Francois Engelbrecht?);*
- *c. Modelling centres to conduct systematic comparisons of analyses over Polar Regions (Jean-Noël Thépaut);*
- *d. WGNE to provide advice on observation strategies for model development / verification during YOPP including the relative value of single point versus grid box approaches (Francois Bouyssel and Mike Ek).*

ACTION ITEM 5: Andy Brown to circulate the spatial verification document to WGNE members.

ACTION ITEM 6: Modelling centres MUST provide and update information as required for the centre table compiled by Michael Baldauf on behalf of WGNE. Michael to provide Centres with the detail on the information required.

ACTION ITEM 7: Jean-Noël Thépaut to review with Tom Hamill the realigned TORS of Working Group on Data Assimilation and Observing Systems under WWRP.

ACTION ITEM 8: Francois Engelbrecht to circulate the report of the scalability workshop to be held at ECMWF in April 2014 and seek WGNE members views on it.

ACTION ITEM 9: Jeanette Onvlee to liaise with the grey zone team and discuss next steps and priority areas of extending the grey zone project.

ACTION ITEM 10: Julio Bacmeister as WGNE contact person to follow up on high resolution activities in CMIP6.

ACTION ITEM 11: Jean-Noël Thépaut to circulate the S2S white papers.

ACTION ITEM 12: WGNE members to consider hosting the next systematic error workshop including a theme on teleconnections in 2016 time frame.

ACTION ITEM 13: WGNE to promote the GASS MJO project dataset to a wider scientific community.

ACTION ITEM 14: Jeanette Onvlee and Chiashi Muroi to discuss linkages between the planned RDP on LAM TC evaluation and the WGNE TC effort.

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

ACTION ITEM 16: Andy Brown, Peter Glecker and Jon Petch to discuss ways to archive and preserve precious historic GASS data sets.

ACTION ITEM 17: Saulo Freitas to explore and decide optimal way for the WGNE aerosol project to cooperate with the EUMETCHEM community and as the WGNE activity matures, decide on the feasibility of a joint workshop.

ACTION ITEM 18: Xue Shun to investigate the availability of additional data from China related to the Beijing aerosol case study

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

ACTION ITEM 20: Ayrton Zadra to convene a telecom to identify priorities on the way forward regarding the drag project.

ACTION ITEM 21: Ayrton Zadra and Francois Bouyssel to coordinate a specific presentation on physics developments at the next WGNE meeting (WGNE-30).

ACTION ITEM 22: Michael Baldauf and Francois Engelbrecht to take over the routine survey of dynamical core developments

ACTION 23: Ayrton Zadra and Elena Astakhova to consider continuation and coordination for issuing the WGNE Blue Book after 2014

ACTION ITEM 24: WGNE member and modelling centres encouraged to consider hosting WGNE-30 session tentatively planned for spring 2015 and inform co-chairs and WMO secretariat before end March 2014.

31. CLOSURE

The 30th face-to-face meeting of WGNE is tentatively for March 2015 at a location to be determined. The Co-chairs thanked Gary for the excellent arrangements by the staff of BoM for and during the meeting. The members and experts were acknowledged for their contributions and they were wished a safe travel back home.

The meeting was closed at 15:15 on 13 March 2014.

Annexes:

A. WGNE Survey on Dynamical Cores
B. Meeting Agenda
C. List of Participants

ANNEX B

MEETING AGENDA

WGNE-29, 10-13 March 2014, Melbourne, Australia

Day 1

09h10 – 10h30 **Welcome, Adoption of the Agenda, Local Arrangements** (15 min)
Co-chairs, G. Dietachmayer

Meeting Goals and Actions from last meeting (25 min)
Co-chairs

WWRP matters and implications for WGNE (35 min)
Gilbert Brunet

Feedback on CAS-16 and its technical conference (10 min)
D. Terblanche

10h30 - 11h00 Coffee

11h00 - 12h30

WCRP matters and implications for WGNE (45 min)
C Jakob

A short update on the WCRP Modelling Advisory Council (15 min)
C Jakob

Outcomes from recent workshops (emphasis on anything that may inform future work of wgne)

Physics of Weather and Climate models workshop report (10 min)
C Jakob

GOVST workshop update (10 min)
J.N. Thépaut (with input from Bill Lapenta)

Systematic Error Workshop (10 min)
A Brown

12h30 – 13h30 Lunch

13h30 – 14h30 **WWRP and WCRP Polar Prediction Projects – and WGNE role** (30 + 30 min)
T Jung

14h30 - 15h15 **Report of JWGFVR (30+15 min)**
Beth Ebert

15h15 -15h45 **Coffee**

15h45 – 17h30 **Centre Reports** (5, 20 min each)
Brazil, Canada, NCEP, JMA, DWD

Day 2

09h00 – 09h10 **Welcome by BoM Director *(tbc)***

09h10 – 10h40 **Recent developments in Numerical Methods** (30 min)
M. Baldauf

Recent developments in Data assimilation (30 min)
Tom. Hamill + J.-N. Thépaut

Recent developments in Ensemble Prediction (30 min)
C. Reynolds + C. Muroi

10h40 – 11h10 Coffee break

11h10 – 13h00 **Centre Reports** (5, 20 min each)
France, China, Russia, ECMWF, NRL

13h00 – 14h00 Lunch

14h00 – 15h40 **Centre reports** (4, 20 min each)
NCAR, Korea, BOM, UKMO

15h40 – 16h00 **Mesoscale NWP developments** (20 mn)
Jeanette Onvlee

16h00 – 16h30 Coffee break

16h30 – 18h00 **Science talks** (3x30 min each)

TBD: Bureau
Xx:xx

Xx:xx

Xx: xx

Day 3

09h00 – 10h00 **WGCM/WGNE links** (20+10 min) – to include climate metrics and ideas for specific links to wgne (eg arising from last wgcm on cmip6)
Peter Gleckler (via teleconf)

WGSIP activities *(20+10 min)*
Andy Brown (input from Adam Scaife)

10h00 – 10h30 General Discussion

10h30 - 11h00 Coffee break

11h00 - 13h00 **Sub-seasonal prediction project – and WGNE role in it** (30 + 30 min)
Harry Hendon

MJO-TF (30 min+30min) – current activities and next steps
Matthew Wheeler

13h00 – 14h00 Lunch

14h00 – 15h00	**TC verification** (30 min) *C. Muroi* **Precipitation Verification** (30 min) *Participants led by Francois Bouyssel*
15h00 – 15h30	Coffee break
15h30 – 17h30	**Recent developments in high-resolution NWP** (30 min) *G Dietachmayer* **GASS/GCSS/GABLS report and discussion** (20+10 min) *Christian Jakob* **The grey zone project** (20 min) *Christian Jakob* **GLASS report and discussion** (20+10 min) *Martin Best/Michael Ek*

Day 4

09h00 – 11h00	**Session on Aerosols – progress and next steps (1 hr)** *Participants led by S. Freitas* **Session on drag project – progress and next steps (1 hr)** *Participants led by Ayrton Zadra*
11h00 – 11h20	Coffee break
11h20 – 12h00	**Verification scores including polar verification** (40 min) *J.N. Thépaut*
12h00 – 13h30	Lunch
13h30 – 14h30	**Discussion on verification against own analysis** (30 min) *Participants led by T. Hamill*
14h30 – 15h30	**Meeting summary and discussion of future WGNE activities, including workshops and projects** (60 min) *Co-chairs, Participants*
15h30 – 16h00	**Decisions and Actions** *Co-chairs*
16h00	**Close**

ANNEX C

WGNE-29, Melbourne, Australia, 10-13 March 2014
LIST OF PARTICIPANTS

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