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REPORT OF THE TWENTY THIRD SESSION OF THE WORKING GROUP ON NUMERICAL EXPERIMENTATION (WGNE)

(Shanghai Met Bureau, Shanghai, 22-26 October 2007)

SUPPORTING NUMERICAL EXPERIMENTATION RESEARCH ACTIVITIES OF THE:

WMO/IOC/ICSU WORLD CLIMATE RESEARCH PROGRAMME

WMO WORLD WEATHER RESEARCH PROGRAMME

WMO GLOBAL ATMOSPHERE WATCH PROGRAMME

AND RESEARCH LINKS TO

OPERATIONAL WEATHER AND CLIMATE PREDICTION

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PREFACE

The twenty-third session of the CAS/JSC-WCRP Working Group on Numerical Experimentation (WGNE), held jointly with the tenth session of the GEWEX Modelling and Prediction Panel (GMPP), was kindly hosted by Shanghai Met Bureau, Shanghai, 22-26 October 2007 and sponsored by the World Climate Research Programme (WCRP) and the World Weather Research Programme (WWRP). GEWEX is the Global Energy and Water Cycle Experiment of WCRP. The session was opened at 0900 hours on 22 October by the Chair of WGNE, Dr M. Miller. The list of participants in the session is given in the Appendix A.

Dr Dehui Chen, Assistant-president of the Chinese Academy of Meteorological Sciences (CAMS), the local host and member, WGNE, welcomed the participants. On behalf of all participants, Dr Miller expressed his thanks to Dr Xu Tang, Director-General, Shanghai Regional Center and Dr Chen Dehui for hosting the joint session of WGNE and GMPP and the excellent arrangements made. He expressed his appreciation also to the staff of Met Bureau, Shanghai, for the efforts and time they had put into the organization of the session. In his welcome address, Dr Tang stressed the responsibility of meteorological service organizations for ensuring the safety of life, the protection of property and the well-being of their inhabitants by providing better predictions and services. However, due to the requirements from all level of governments for multi-hazard prevention, we must provide not only more precise weather prediction, but also provide integrated early warnings for meteorological hazards and their natural and social impacts based on the NWP products. He expressed the hope that WGNE will continue to put particular emphasis on public safety and welfare by encouraging members to improve the performance of their numerical predictions. He noted that Shanghai and the eastern region of China where it is located have experienced heavy losses both in human life and property from the high frequency natural disasters such as typhoons, heavy rainfall etc. The experience of the Super typhoon “WIPHA”, which affected the eastern part of China during 18-20, September of this year, tells us the importance of the information from Numerical Weather Prediction (NWP) products of the typhoon tracking forecast.

The opening address for the Session was read out by Dr Dehui Chen on behalf of Dr Renhe Zhang (President of CAMS) who could not be present. WGNE has been one of the important expert groups of WMO for a long time. Dr Renhe Zhang noted that this WGNE/GMPP meeting will provide a good opportunity to the Chinese colleagues to learn from the international NWP experts to foster the NWP research and the operational NWP system development in the country. He was pleased to note that the CAMS and CMA are actively participating in the session and are strongly supporting the activities of WGNE/GMPP; a large number of (about 15) Chinese scientists and experts are attending the meeting; these come from the national research academy and operational center, Shanghai and Chengdu regional meteorological centers and LASG/IAP of Chinese Academy of Sciences.

The Chair continued by extending his greetings to the participants in the session. He welcomed Dr M. Béland, President of the WMO Commission for Atmospheric Science (CAS) and G. Brunet, Chair, of the CAS Joint Scientific Committee of the World Weather Research Programme (JSC-WWRP). The Chair was pleased to welcome the invited experts.

ROLE OF WGNE IN SUPPORT OF WCRP AND THE CAS PROGRAMMES

WGNE, as a joint working group of the JSC-WCRP and the CAS programmes WWRP and the Global Atmosphere Watch (GAW) programme, has the basic responsibility of fostering the development of atmospheric models for use in weather, climate, water and environmental prediction and studies on all space and timescales. In the WCRP, WGNE is at the core of the global modelling effort and co-ordination between WGNE, WGCM and WGSIP is maintained primarily through ex officio meeting attendances. WGNE also works in close conjunction with the GEWEX particularly in the development of atmospheric model parametrizations, with WGNE sessions held jointly with the GMPP (but not in 2006). The WGNE Chair is a member of the WCRP Modelling Panel (WMP) and the CAS Management Group. Also WGNE is represented on the WCRP Observations and Assimilation Panel (WOAP), It has specific WWRP-THORPEX sessions at its meetings and is increasingly addressing environmental aspects of modelling related to NWP and GAW modelling activities. Many of the activities of WGNE are underpinned by the close relationship between research and operational (NWP) centres. It is the work of these centres that influences much of the research, development and refinement of the physics and dynamics of atmospheric models.

1. RELEVANT RECOMMENDATIONS FOR THE DEVELOPMENT OF WGNE/GMPP ACTIVITIES

1.1 Twenty-eigth session of the Joint Scientific Committee (JSC) of the WCRP

V. Satyan briefed the session on the relevant main recommendations from the twenty-eigth session of the JSC, Zanzibar, Tanzania, 26-30 March 2007. In its review of the WCRP crosscutting topic, ''Monsoons'', the JSC noted the following:

- There is a large number of national and multi-national monsoon programmes and activities. The idea of holding an International Monsoon Year (as component of an International Monsoon Study 2007-2011) created interest and the support of the JSC.
- A need to build an integrated view of global monsoon systems was expressed by several participants. There is an even stronger need for increased coordination between the many regional monsoon activities.
- It was recommended that a short term task team (one year) be appointed (Chairs B. Wang and J. Matsumoto) to develop a 5 year Implementation Plan, building on and integrating the existing plans for Year of Tropical Convection (YOTC) (joint with THORPEX), the Asian Monsoon Year and to ensure the monsoon data sets are exchanged and appropriately archived and that the appropriate modelling studies are pursued.

- Strong links with THORPEX should continue to be developed through YOTC.
- The Implementation Plan should have a global focus, integrating the various regional studies and giving them coherence.
- The consensus was that the crosscut should be deeply rooted in CLIVAR and GEWEX projects.
- CLIVAR and GEWEX should organise further pan WCRP workshops building on the progress of the first pan WCRP Monsoon Workshop.
- The JSC endorsed the WCRP crosscutting Monsoon Initiative.
- The JSC commented that the monsoon crosscut should include all the monsoon groups with a broader perspective, led by CLIVAR and GEWEX with participation of SPARC, CliC and WGNE and several activities outside WCRP (particularly THORPEX).
- The proposals for and concepts of an Asian Monsoon Year and an International Year of Tropical Convection should be considered in the context of an International Monsoon Study 2007-2011, a 5-year strategy of WCRP monsoon research, which would include issues related to the East African Monsoon, capacity building and application of observations and predictions in monsoon regions for societal benefit.

Chair of WGNE, in his brief report to the JSC-WCRP had noted the importance of metrics for climate models, mentioned difficulties in modelling the diurnal cycle and the need for much higher resolution climate models. There was an agreement to include metrics and parameterisation issues in the WCRP model summit. These metrics could help identify models that would have a level of sophistication and accuracy required for future assessments and identify models not complying with the minimal requirements.

The JSC-WCRP agreed that there was a window of opportunity for reviewing and advancing model development in view of the fact that many institutions are in the process of preparing their models for a possible AR5.

V.Satyan also briefed the session about the main WCRP events scheduled for 2007-2008:

- Interpreting Climate Change Simulations: Capacity Building for Developing Nations Training Seminar Trieste, Italy, November 26-30, 2007
- UNFCCC - COP13, Bali, Indonesia, 03-14 December 2007. Side event in which WCRP will participate: " Improved Decision Making for Climate Adaptations: Providing a Science Base"
- Third WCRP International Conference on Reanalysis, Tokyo, Japan, 28 Jan-1 Feb, 2008
- 4th ICTP Workshop on the Theory & Use of Regional Climate Models: 'Applying RCMs to Developing Nations in Support of Climate Change Assessment and Extended-Range Prediction, Trieste, Italy, March 3 - 14, 2008
- 29th session of the Joint Scientific Committee (JSC-WCRP), Arcachon, France, 31 Mar- 4 April, 2008

1.2 Report on the WCRP observations and assimilation Panel (WOAP)

A. Lorenc, WGNE representative on WCRP observations and assimilation Panel (WOAP), repeated WOAP's question to the last WGNE meeting, about how to coordinate and facilitate coupled data ssimilation research which is not driven by operational forecasting. This question was returned to later in the discussion on re-analyses. The requirements of the main forecasting centres are expanding into coupled models for seasonal forecasting. These coupled systems are then being made available for partly-coupled re-analyses used for other purposes. In some special instances, such as the EU funded GEMS project at ECMWF to assimilate atmospheric constituents, major contracts extend these systems, and it is likely that these extensions too could be carried over into re-analysis. It was concluded that attempting to organise a more general method to add other components to operational systems would be too difficult (for the level of reliability needed for re-analysis) and not worth it.

1.3 Report from the GEWEX Scientific Steering Group, including matters relevant to the development and status of the GMPP

C. Jakob, the chair of GMPP reported on the last GEWEX SSG meeting (January 2007, Honolulu) highlighting the new activities that the SSG encouraged GMPP to undertake in 2007. Those were:

1. to engage WGNE and the wider modeling community in a discussion on the future of parametrization research within WCRP and CAS and the potential role of GMPP in those future activities (see also section 2.4)
2. for GCSS to engage with the Cloud Feedback Model Intercomparison Project (CFMIP) and to develop joint plans between GCSS and CFMIP such that the project can be co-sponsored by WGCM and GEWEX (see also section 2.3)
3. for GCSS to lead GEWEX' engagement with the joint WCRP/IGBP Aerosols-Clouds-Precipitation-Climate initiative (see also section 2.1)

The chair of GMPP stressed the strong view of the GEWEX SSG that it is absolutely crucial that the annual joint meetings of WGNE and GMPP be reinstated. It was felt that the lack of such meeting in 2006 was to the detriment of both groups and no effort should be spared to try and ensure the original annual cycle for the meetings in the future.

1.4 Report on the Barcelona meeting on monthly and seasonal forecasting

M. Déqué, WGNE representative on WGSIP, reported on a recent WGSIP meeting. The Barcelona meeting, held in Spain on 4-7 June 2007 was the opportunity to gather the whole scientific community involved in numerical seasonal (and more broadly from monthly to decadal) forecasting. Indeed, it was a triple meeting:

- Task Force on Seasonal Prediction (TFSP) open meeting
- WGSIP quasi-annual meeting
- ENSEMBLES-RT2A meeting

TFSP has been created by the WCRP Coordinated Observations and prediction of the Earth system(COPES) to propose a common evaluation exercise on seasonal forecasting capabilities of the most recent models (in particular those involved in IPCC assessment). The workshop involved 180 attendants (from 30 countries). It covered 3 ½ days with oral, poster, and discussion sessions. The questions raised were:

- Assessing limitations of seasonal prediction
- Assessing value of SP for end users
- Link with IPCC process
- Role of the stratosphere
- ENSO errors (in continuation of the WGNE meeting on systematic errors held in February 2007 in San Francisco)

The experiment protocol, based on 2 streams was recalled: one forecast per month (1979-2005) or one forecast per season (1960-2005), 6-month range, 9 members, no use of observations beyond the forecast start date (two-tier sea surface temperature possible, but not observed sst forcing). There were 3 sessions at the TSFP workshop:

1. To assess the quality, as well as value, of forecasts, model fidelity and ocean-atmosphere interactions.
2. To address seasonal prediction from a wide-ranging multi- disciplinary perspective looking at the role of cryospheric processes, stratospheric processes and air-land interactions on seasonal prediction, as well as the role of ocean initialization. This Session was co-organized by other WCRP Projects (SPARC, GEWEX and CliC).
3. To assess seasonal forecasts at a regional scale and highlight issues important for interfacing seasonal forecasts with applications including calibration, downscaling and validation, looking at whether there is an emerging consensus on approach and methodology. This session was co-organized by the CLIVAR Monsoon Panels (VAMOS, AAMP and VACS).

The WGSIP meeting covered one and a half day discussions and overviews on the San Francisco workshop on systematic errors (February 2007), the proposed validation protocol for ocean-atmosphere models and the TFSP data handling strategy. Reports from CLIVAR regional panels and from national centers were given. The next meeting in planned in autumn 2008 in Brazil.

1.5 Relevant Activities under Commission for Atmospheric Sciences (CAS)

G. Brunet reported the activities in support of CAS. A full activity report of the last meeting in Oslo, September 2007, is available on the WMO CAS website (see also section 5.1):
http://www.wmo.int/pages/prog/arep/cas/CASmanagementgroup2ndsession.html

2. PHYSICAL PARAMETRIZATIONS IN MODELS

WGNE's close working relationship with GMPP (the GEWEX modelling and prediction panel), provides the focus for the development, refinement and evaluation of atmospheric model parametrizations, notably those of cloud and radiation, land surface processes and soil moisture and the atmospheric boundary layer. The discussions at the joint meetings of WGNE and GMPP, encompassing the GEWEX Cloud System Study (GCSS), the Global Land-Atmosphere System Study (GLASS), the GEWEX Atmospheric Boundary Layer Study (GABLS), the progress of the Coordinated Enhanced Observing Period (CEOP), are described in the reports of the GMPP and the GEWEX Scientific Steering Group to the JSC-WCRP. The WGNE community provides comprehensive gridded output from global data assimilation systems for CEOP and an increasing number of modeling groups are utilizing CEOP data in research and development activities.

C. Jakob, the GMPP chair, introduced the GMPP sessions by providing a brief overview over GMPP's terms of reference and current membership. He stressed again the importance of the GMPP-WGNE partnership in furthering the important area of parametrization research and referred to the importance of the discussion at this meeting how to progress this important research area within WCRP and beyond (see also item 3.9).

2.1 GCSS: Progress report including new results and case studies and the GPCI

P. Siebesma, the GCSS chair gave an overview over GCSS activities. The year of 2007 has been an exciting one where especially a number of new activities have been initiated, most notably a collaboration between the Cloud Feedback Model Intercomparison Project (CFMIP, see section 2.3), as well as a new

collaboration between ILEAPS, GCSS, and IGAC centered around the theme: “Aerosols, Clouds, Precipitation and Climate” (ACPC). Internally, within GCSS, a new working group has started chaired by Ulrike Lohmann that will concentrate exclusively on “Cloud Microphysics”. The existing working groups have been largely working on wrapping up existing case studies and discussing new future plans. A central key event in 2008 will be the PAN-GCSS meeting at Meteo France, Toulouse, France where all working groups and external collaborating organizations (CFMIP, ARM, RICO community, A-TRAIN community) will meet to present and discuss present work and future directions.

The GCSS chair outlined the success of GCSS over the last 5 or so years by presenting some very impressive examples of the impact the work of GCSS had on developments in the parametrization of cloudy boundary layers.

2.2 GLASS and GABLS: progress reports

In the absence of the chairs of GLASS and GABLS, the GMPP chair gave a very brief overview over current activities in the two programs. GLASS is successfully progressing all its activities. Special emphasis in 2008 will be on the second phase of the GLASS Land-Atmosphere Coupling Experiment (GLACE-2), which has the aim of assessing the impact of land surface initialization on forecast skill across collection of GCM systems. Another focus of activity is the Land Use and Climate: IDentification of robust impacts (LUCID) study. Through modeling studies this project will investigate if the perturbation of biophysical variables and of fluxes exchanged at the land/atmosphere interface induced by the anthropogenic land-cover changes significantly modifies the atmospheric and/or oceanic circulation. GABLS has continued its second process study - GABLS2. The goal of the GABLS2 inter-comparison of LES and column models is on the behavior and performance of the various models in comparison with the available observations, with a special focus on the diurnal cycle at clear skies over dry land. Work on this study is progressing well. A new study - GABLS3 - is under construction and will be the main focus of activities in 2008. The focus of the GABLS3 intercomparison case is on the decoupling of the boundary layer around sunset, the representation of the low-level jet, and the morning transition. The GMPP chair stressed that the work of both groups is progressing very well and that they form a central part to GMPP’s efforts to improve parametrizations in current NWP and climate models.

2.3 A new GCSS collaboration with CFMIP2 and the possible involvement of WGNE members

The GCSS chair reported on a few new activities, in particular new collaborations with CFMIP and the IGBP/iLEAPS.

i) Cloud Climate Feedback Intercomparison Project (CFMIP)

At the CFMIP/Ensembles workshop on “assessment of cloud and water feedback processes in ensembles of GCM simulation” in Paris in April 2007, a joint working plan has been formulated by CFMIP and GCSS that outlines the collaboration of the projects on the second phase of CFMIP. The plan is available on the web (http://cfmip.metoffice.com/CFMIP2.html). As a result of the discussion it was agreed to have co-chairs from both CFMIP and GCSS to lead CFMIP-2. Those are Sandrine Bony, Mark Webb (CFMIP), Chris Bretherton and George Tselioudis (GCSS). The document contains plans to carry out process studies of the physical mechanisms that can be linked to the uncertainty of the cloud climate feedback.

ii) Aerosols, Clouds, Precipitation and Climate (ACPC)

A planning group meeting from representatives from GEWEX, iLEAPS and IGBP has been held in Frankfurt (March 2007). A white paper on the theme of aerosols, clouds, precipitation and climate has been written. Also a community building meeting on this theme was scheduled at NCAR, Boulder in October 2007 addressing a number of key questions. The meeting at NCAR was a succesfull meeting with around 70 attendees from all three communities (GEWEX, iLEAPS and IGBP). A subsequent meeting is now planned in Bern, Switzerland, January 28-30, sponsored by the International Space Science Institute (ISSI).

2.4 Discussion on priorities in parametrization development for CAS and WCRP

The chair of GMPP introduced a joint WGNE-GMPP discussion on the future of parametrization development in WCRP and CAS. This discussion resulted from the overall impression in both GMPP and WGNE that in contrast to the great advances in computing and general model development, the scientific field of parametrization development has not advanced similarly and is arguably in decline especially for moist processes such as clouds and convection. The chairs of GMPP and WGNE proposed a

re-organization of parametrization development within CAS and WCRP, possibly under the umbrella of WGNE. An interesting discussion lending general support to the proposal ensued. The chairs of WGNE and GMPP were tasked to provide a white paper on this issue outlining their proposal for presentation at the relevant CAS and WCRP leadership meetings.

3. STUDIES AND COMPARISONS OF ATMOSPHERIC MODEL SIMULATIONS

3.1 General Model Intercomparisons

Model inter-comparison exercises are a key element in meeting a basic WGNE objective of identifying errors in atmospheric models, appreciating their causes and reducing or eliminating these errors.

Model Intercomparison Project

The original Atmospheric Model Intercomparison Project (AMIP), conducted by the Programme for Climate Model Diagnosis and Intercomparison (PCMDI) at the Lawrence Livermore National Laboratory, USA, with the support of the US Department of Energy was an important and far-reaching WGNE-sponsored intercomparison, and in recent years has been extended to coupled models under WGCM guidance.

P. Gleckler of PCMDI gave an update on the 3rd phase of the Coupled Model Intercomparison Project (CMIP3). This project continues to be an activity of importance to the WGNE, among other reasons because the WGNE's AMIP benchmark experiment has been been folded into the larger CMIP activity. Briefings of this and other WCRP model intercomparions usually involve research summaries, but on this occasion the emphasis was to elaborate on how CMIP3 has transformed how multi-model evaluation is performed by the research community. Gleckler cited statistics on the number of CMIP3 papers published (now over 250), the disciplines that have been explored, and the expected continuation of its utility. An ensuing discussion addressed whether or not the WGNE should consider the design of any experiments that might complement the next phase of the WGCM's CMIP (now in the planning stages) but no actions at this time were taken.

WGNE Systematic Errors workshop, San Francisco, February 12-16, 2007

P. Gleckler briefly summarized the WGNE workshop on Systematic Errors in NWP and Climate models, led by PCMDI and held in San Francisco the second week of February, 2007. The workshop was the latest in a series, the first held in Toronto (1988) and the second in Melbourne (2000) - all with some WMO support. The 2007 workshop was nominally organized around time-scales (weather, intra-seasonal to interannual, decadal to century). In an effort to bridge the diverse topics covered, the WGCM, GMPP, and WGSIP all contributed to workshop's scientific organization. Invited overview talks attempted to draw links across time-scale, with most contributed papers presented as posters. Break-out session (part of each afternoon) topics included: model metrics, diurnal cycle, monsoons and intra-seasonal oscillations, ENSO, and perturbed physics ensembles. Approximately 185 scientists from 19 countries attended the workshop. Over 100 poster and oral presentations are accessible via the workshop's website:
http://www-pcmdi.llnl.gov/wgne2007/presentations

Several overarching themes emerged from the workshop. Examination of climate model error structure and growth in weather prediction mode was demonstrated to be insightful by several groups. As a result of fast processes (e.g., boundary layer, convection, radiation and clouds), climate biases are often manifest within a few days of initialization, which may provide better opportunities for diagnosing the root of common errors. Analogously, the value of running initialized coupled models in forecast mode over seasonal timescales was noted, allowing diagnosis of slower processes, e.g., those associated with ENSO. Accurate simulation of the diurnal cycle was identified as a key difficiency in GCMs - a long list of problems were discussed at the workshop. Models with suffiecient horizontal resolution (e.g., less than 4km) do somewhat better at simulating the diurnal cycle. This was just one reason why the issue of model resolution was frequently raised during the week. Higher resolution is expected to yield improved simulations and better diagnosis of errors at resolutions feasible for century-scale simulations; however it is clear that better physical understanding is the predominant limiting factor to further reducing systematic errors. Finally, the importance of metrics for climate models was emphasized from a variety of perspectives. Compared to the NWP community, efforts to gauge progress (and relative skill) of climate models is lagging, although some progress is now being made. Further details are provided by the WGNE chair's workshop summary, available in the Appendix D of the 2007 WGNE report.

Aqua-Planet Experiments (APE)

D. Williamson reported on the progress of the WGNE Aqua-Planet Experiment (APE) being led by Mike Blackburn and Brian Hoskins at the University of Reading and David Williamson at NCAR. The details of the experiment are available at http://www.met.reading.ac.uk/~mike/APE. The experiment is designed to provide a benchmark of current model behavior and to stimulate research to understand differences arising from: (1) different models, (2) different subgrid-scale parameterization suites, (3) different dynamical cores, and (4) different methods of coupling model dynamics and parameterizations. As reported in the twenty-first and twenty-second sessions of the WGNE, a Workshop was held 20-22 April 2005 at the University of Reading, UK to discuss the results, summarize current model behavior and produce a summary of research questions arising from the experiment. Many of the ideas discussed at that workshop appear in the report of the twenty-first session of the WGNE. At the time of the APE workshop most participating groups had completed only the "CONTROL" experiment and the data for many of the other experiments in the intercomparison were not available.

Thirteen groups have now submitted their data for all eight experiments to the APE database at the University of Reading. In addition one group has submitted a short run of a very high resolution simulation without parameterizations of the "CONTROL" experiment. The data have been quality controlled, with minor problems corrected, and made available to the participating groups. Additional data have also being collected to allow the diagnosis of the vertical structures of the primary tropical propagating features in the models. Comparative analysis is now underway. The second and last APE Workshop will be held at the Chiba Institute for Science, Choshi, Chiba, Japan, 13-15 November 2007. The workshop will review and discuss the diagnostic studies arising from the intercomparison and plan for papers to be submitted to journals.Topics to be discussed at the workshop include:

1. The basic intercomparison diagnostics highlighting areas of agreement and spread between the models. These will cover global budgets, the hydrological cycle, mean state response to the meridional SST profile, etc.
2. The response to zonally asymmetric SST anomalies.
3. Tropical variability including both the diurnal cycle and tropical wave activity.
4. The zonal mean state and meridional transports with comparison with theoretical models.
5. Mid-latitude variability including low frequency modes and storm-track transients.
6. Resolution sensitivity and convergence which has been studied in only a few of the models.
7. Tropical transient features including a diagnosis of the vertical structures of the primary tropical propagating features.

There will also be discussions of possible future directions, such as models coupled to swamp oceans, with aqua planet mirror runs using SST averaged from the swamp runs, to study the role of transients and intra-seasonal variability. However any formal intercomparison will be considered a new project.

Williamson showed examples of a variety of APE statistics being examined. These all showed a wide range of behavior between models. The statistics included global average mass of the atmosphere and its meridional distribution, and tropical wave propagation characteristics. He also showed similar variations in statistics with just one model, the NCAR CAM3, over a range of resolutions from T42 to T340.

WGNE continues to endorse the application of atmospheric models to very simplified surface conditions for the purpose of examining the behaviors of physical parameterizations and the interactions of parameterizations with the dynamical cores. In particular, "aqua-planet" experiments such as APE with a basic sea surface temperature distribution is proving to be a useful vehicle in this regard.

"Transpose" AMIP

D. Williamson reported on the progress in Transpose AMIP, a WGNE proposal for the intercomparison of weather forecasts made by climate models. The goal of the approach is to obtain the benefits for climate model development and evaluation that have been realized in weather prediction model development by applying climate models to weather forecasts. The goal of the intercomparison is to encourage climate modelling groups to implement this forecast strategy into their development process and to compare the characteristics of current models. The method allows direct comparison of parameterized variables such as clouds and precipitation with observations from field programs. Thus the emphasis in Transpose AMIP is on the behavior of the parameterization suite rather than traditional NWP skill scores. The goal of Transpose AMIP is not to identify the best forecast model, but to learn about the parameterization errors of the models, their commonalities and differences. Development of a complete analysis system is not needed. Initial conditions can be obtained from NWP reanalyses. This WGNE

initiative was initially prototyped and developed jointly by NCAR and PCMDI and is described in Phillips et al. (2004). That development was supported by the US Department of Energy and is referred to as CAPT, the CCPP-ARM Parameterization Testbed, CCPP being the Climate Change Prediction Project and ARM the Atmospheric Radiation Measurement program.

The formal announcement of Transpose AMIP and call for participation has been out for some time. The proposal is modest at this stage and based on what Williamson can realistically analyze himself. It is deliberately limited in order to minimize the initial effort for the participating modelling groups. Past experience has shown that once a group is set up to do forecasts with a climate model, it requires little effort to do additional forecasts. The data to be exchanged can be augmented if others are willing to do the associated analyses. In addition, it is anticipate that future intercomparisons for additional periods and other ARM-type sites will be organized to examine a variety of phenomena. The proposed forecast periods are ARM IOPs in March 2000 and June/July 1997. 5 day forecasts are to be made daily from 00Z, initialized from ERA40. Data to be collected are RMS and Bias Skill Scores (calculated daily) averaged over each IOP for 850 and 250 mb wind in the tropics and 500 mb height, 850, 500, and 250 mb temperature and mslp in the Northern and Southern Hemispheres. In addition 3-hourly profile data for days 0-5 of each forecast at the ARM SGP site are to be submitted. The requested fields are instantaneous values of temperature, specific humidity, and precipitable water, and 3-hourly averaged values for parameterized heating, parameterized moistening, precipitation, latent heat flux, and sensible heat flux.

The intercomparison analyses will include the types of analyses included in Boyle et al. (2005) and Williamson et al. (2005) that can be performed with the data listed above. It is suggested that modeling groups retain individual parameterization terms for subsequent exchange and analyses as differences between the models are identified and hypotheses are put forward. However, it is also easy and cheap to rerun forecasts to resample.

The complete sets of requested fields from two groups are now available at NCAR for the intercomparison. The groups are the Numerical Prediction Division, Japan Meteorological Agency; and NCAR. A partial set from GFDL is also in the database. Two groups are in the process of transferring the data to NCAR: the Climate Model Development and Evaluation group of the Hadley Centre; and Experimental Climate Prediction Center, Scripps Institute of Oceanography. The Hadley Centre is submitting forecasts from both the climate and NWP configurations of their model. Two other groups have declared their interest in participating but have not yet submitted data: Department of Meteorology, Florida State University; and CSIRO. Williamson presented some preliminary comparisons of the parameterization behaviors in the atmospheric column at the ARM SGP site for the three models in the database. These models have quite different behaviors there.

Any additional groups that are interested in participating should email David Williamson (wmson@ucar.ucar). It is not too late to join the effort. Since the data being requested are rather limited, the data exchange is turning out to be rather straightforward.

References:

Phillips, T. J., G. L. Potter, D. L. Williamson, R. T. Cederwall,J. S. Boyle, M. Fiorino, J. J. Hnilo, J. G. Olson, S. Xie, J. J. Yio, 2004: Evaluating Parameterizations in General Circulation Models:Climate Simulation Meets Weather Prediction, Bull. Amer. Meteor. Soc., 85, 1903-1915.

Boyle, J., D. Williamson, R. Cederwall, M. Fiorino, J. Hnilo, J. Olson, T. Phillips, G. Potter and S. Xie, 2005: Diagnosis of Community Atmospheric Model 2 (CAM2) in numerical weather forecast configuration at Atmospheric Radiation Measurement sites,JGR, Vol.110, D15S15, doi:10.1029/2004JD005042.

Williamson, D. L., J. Boyle, R. Cederwall, M. Fiorino, J. Hnilo,J. Olson, T. Phillips, G. Potter and S. Xie, 2005: Moisture and Temperature balances at the Atmospheric Radiation Measurement Southern Great Plains Site in forecasts with the Community Atmosphere Model (CAM2), JGR, Vol.110, D15S16, doi:10.1029/

3.2 Regional Climate Modelling

Proposal for a Regional Climate Modelling Workshop

A proposal received from C.Jones on an RCM workshop co-sponsored by ICTP and WCRP to be held at ICTP, Trieste, Italy March 3-14 2008 was presented by V.Satyan. The workshop is entitled '' Applying RCMs to Developing Nations in Support of Climate Change Assessment and Extended-Range Prediction'' with co-directors: F. Giorgi (ICTP), L. Sun (IRI/Columbia) and C.Jones (UQAM/CRCMD).

The meeting will be over 2 weeks. Week 1 will have a conference -discussion style with invited speakers and contributed papers.Week 2 will be a training week, with hands-on training in the use of RCMs, running and designing exercises over various developing nation areas *(e.g. mainly tropical and sub-tropical land regions).*The 1st week will be of interest to all RCM scientists.

The 2nd week is specifically targeted at developing nation scientists.The RCMs to be used are: RegCM3 for climate change and NCEP-RSM for seasonal prediction.RegCM3 will be supported by ICTP staff and NCEP-RSM will be supported by NCEP, IRI and ECPC staff.

Students can concentrate on one of the disciplines in more detail or try exercises addressing both disciplines.The students will be expected to prepare and present a report of their work during the 2nd week. The aims of the 1st week are:

1. To have a community-wide discussion on the needs, potential and problems in using RCMs in developing nations for both climate (change) and extended-range prediction.

2. To have a community wide discussion on the limitations associated with RCM downscaling in developing nations and the care needed in subsequent provision of RCM data to external 3rd parties(i.e. to not oversell what RCMs can offer and start a dialogue about how RCM data can be sensibly used by 3rd parties.)

3. To have a discussion on recent progress and issues related to RCM use, particularly with respect to climate change (e.g. resolution, parameterization, ensembles & uncertainty) and to bring these developments into the forum of developing nation scientists

4. To increase personnel, knowledge, tools and data exchange, with espect to RCMs, between developed and developing nations with an aim to increase RCM expertise and capabilities on the ground in developing nations.
5. To provide concrete examples of the use of RCMs in Developing Nations (Six examples will be given, 1 each for Africa, Asia and South America both for climate change and seasonal prediction).

6. To initiate a community-wide discussion regarding a coordinated GCM-RCM domwscaling project concentrated on climate sensitive regions of Africa.

7. To discuss the quality of (AO) GCM simulated climate variability over tropical and sub-tropical land regions. i.e. defining the quality of RCM lateral (atmospheric) and surface (SST) boundary conditions.

8. Highlight some of the key parameterization issues for RCMs over tropical and sub-tropical land regions: e.g. organized convection, land surface-atmosphere interactions, representation of vegetation.

The 1st week should consist of 18 invited talks, 20-24 contributed talks plus a poster session. Students are invited to present their work

There has been extremely high interest in this workshop within the community such that a repeat event in 2009 is already under discussion.

Y. Takeuchi briefly introduced the configuration of atmosphere-ocean-coupled regional climate model developed by Meteorological Research Institute (MRI) of JMA. The targets of RCM are reproduction of regional climate for 1981 to 2000 and projection for 2081-2100. It aims consistent projection of atmosphere and ocean around Japan with high resolution. The lateral boundary is given by MRI-CGCM2.3 with the resolution of T42 or an Earth System Model (ESM).

Stretched-Grid Model Intercomparison Project (SGMIP)

The Stretched-Grid Model Intercomparison Project (SGMIP) was presented by M.Deque.The aim of this project is to explore variable-resolution stretched-grid approach to regional climate modeling. It is based on four models: C-CAM from CSIRO (Australia), GEM from RPN (Environment Canada), ARPEGE from Météo-France and GEOS from NASA/GSFC. Each model uses a different technique to achieve high resolution over one part of the globe, with the horizontal resolution of a standard GCM (at minimum) over the rest of the globe. Two major questions are raised by the project. Are regional biases of stretched grid (SG) GCMs smaller than those of uniform grid (UG) GCMs with the same number of global grid points? Are regional biases of SG-GCMs close to those of fine resolution UG-GCMs with the same fine global resolution as that of the region of interest?

The SGMIP-2 experiment answered positively to these questions. It was based on the following protocol:

- Number of grid-points: that of the 1°x1º uniform grid
- Area of interest: 20°-60º N and 130º-60º W (North America)
- Regional resolution: 0.5ºx0.5º
- Period: 25 years (1979-2003) driven by monthly observed sst and sea-ice

The next phase (SGMIP-3) will include exploration of climate change scenarios, in conjunction with the NARCCAP project. It will also include other areas of focus (e.g. Europe). The WGNE recommends exploring, as far as possible, the comparison between this approach, and the more traditional approach by limited area modelling (web site of SGMIP: http://essic.umd.edu/~foxrab/sgmip.html).

3.3 National Climate or Global Change Modelling Programmes

WGNE noted with interest reports of developments in climate modelling activities in Australia, Germany, Japan and USA.

Australia (K.Puri)

K. Puri reported on the developments in climate modelling activities at BMRC, Australia. The Australian Community Climate and Earth System Simulator (ACCESS) is a coupled climate and earth system simulator to be developed as a joint initiative of the Bureau of Meteorology and CSIRO in cooperation with the university community in Australia. The main objectives are to:

- Develop a *national* approach to climate and weather prediction model development
- Focus on the needs of a wide range of stakeholders:
  - Providing the best possible services
  - Analysing climate impacts and adaptation
  - Linkages with relevant University research
  - Meeting policy needs in natural resource management

At the initial stage of the project a Blueprint and Project Plan for ACCESS were prepared that define the scope and components of ACCESS ('Blueprint for ACCESS', K. Puri, June 2005, 'Project Plan for ACCESS', K. Puri, September 2005). The key recommendations in the ACCESS Project Plan submitted in September 2005 that involved significant changes in the modelling activities at the Bureau and CSIRO were:

1. ACCESS should import the Met Office atmospheric model HadGAM1 to provide the initial atmospheric model for ACCESS;
2. The Met Office 4DVAR scheme should be imported to form the atmospheric data assimilation module in ACCESS.

The Met Office model and the associated data assimilation system, together with components developed at the Bureau and CSIRO, offer considerable advantages for applications to both weather prediction and climate change. Research licenses for use of these systems have been signed between the Met Office and the Bureau and CSIRO. Recommendations for other components of ACCESS such as the ocean and land-surface/carbon cycle models were to use locally developed systems (the ocean model is based on the GFDL MOM-4 models). These recommendations were supported at a Workshop held in November 2005 and subsequently by the ACCESS Steering Committee (SC).

Significant progress has been made in the implementation of the UM and a number of applications have been successfully executed in the ACCESS environment. These include (i) daily full forecast/assimilation cycles for global and limited area domains from Bureau data base are being run; (ii) a 12-year AMIP-type climate run has been completed and more are planned; (iii) the single column model has been built and is being used by parametrisation scientists in ACCESS and Universities; (iv) work to couple the ocean/sea-ice models (AusCOM/CICE) and carbon/land surface model (CABLE) with UM has commenced. Detailed testing of the NWP system will commence in 1Q 2008 in preparation for operational implementation.

Although initial development of the ACCESS infrastructure has been aimed at implementing key ACCESS modules on the Bureau/CSIRO High Performance Computing and Communication Centre (HPCCC) computing environment it is recognized that ACCESS will be used by a wide group of researchers spread around Australia and the infrastructure will have to enable this.

ACCESS has the potential to become the one of the biggest environmental initiatives in Australia. Significant progress has been made over the past six months. ACCESS will aim to build on this progress as more resources become available in order to meet the timelines for the various applications, and in an attempt to satisfy one of its key objectives, namely to develop a 'world class' modelling system.

Japan (Y. Takeuchi)

Y. Takeuchi introduced a five year initiative (JFY2007-JFY2011) named the Innovative Program of Climate Change Projection for the 21st century, also known as KAKUSHIN Program, launched by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in April 2007. The program is the successor of the "Kyo-sei" Project (JFY2002-JFY2006) and promoted under the Third Science and Technology Basic Plan (JFY2006-JFY2010) launched by the Cabinet.

The KAKUSHIN Program intends to contribute to the possible Intergovernmental Panel on Climate Change (IPCC) fifth Assessment Report (AR5) in close coordination with studies outside the Program in impact, adaptation and action strategies. Three participating groups and their studies are categorized into long-term global environmental projection by the Frontier Research Center for Global Change (FRCGC) group, near-term climate prediction by the Center for Climate System Research (CCSR) group, and projection of changes in extremes by the Meteorological Research Institute (MRI) group. The Earth Simulator is further utilized in those researches.

In addition, Y. Takeuchi briefly reported the Next Generation Supercomputer System Project funded by MEXT. The next-generation supercomputer system being developed by RIKEN will start its operation in JFY2010 and the benchmark programs include the Nonhydrostatic ICosahedral Atmospheric Model (NICAM) for Global-Cloud Resolving simulations and a super-resolution ocean general circulation model (OGCM).

USA (R.Rosen)

R. Rosen reported on NOAA's plans for global change modeling and the steps it is taking toward developing a unified modeling framework for climate and weather analysis and prediction. Rosen spoke about NOAA's plans for climate modeling and the progress it has made to date in implementing these plans. He noted there is an increasing demand from policy and decision makers for climate information on regional and local scales, and this demand is driving climate models toward higher resolution. At the same time, extended range forecasts of high-impact weather are also being sought, and the potential for more extreme events, like hurricanes, in a warmer world is of considerable interest. Together, these developments are helping forge stronger linkages between weather and climate modeling in the U.S.

To meet the demands for more regional climate information, NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) is developing a new generation of high-resolution atmospheric and oceanic climate models. An ocean model with up to an order finer resolution than that used by GFDL for IPCC AR4 provides more realistic Gulf Stream and eddy features in the North Atlantic, and it will be coupled to an atmospheric model with 100 km resolution to examine decadal to multi-decadal predictability of the climate system (including changes to the Atlantic meridional overturning circulation and other potential climate surprises). A 25-km resolution atmospheric model with advanced physics has been developed to assess the competing effects under global warming of higher sea surface temperatures and changes in vertical wind shear on future tropical storm climatologies. Finally, a global "cloud-resolving" model with a 5-km resolution and a nonhydrostatic version of GFDL's cubed-sphere dynamical core with explicit deep convection has been developed and will be used to improve our understanding of cloud-climate interactions.

Rosen presented GFDL's roadmap for Earth system modeling through FY 2016. The strategy is to advance both model complexity and resolution, but doing so will require orders of magnitude more computing resource than was available for IPCC AR4. To this end, NOAA and the U.S. Department of Energy (DoE) are entering into a collaboration to allow GFDL high-resolution models to run on DoE's new generation of high-performance, petaflop class computers. This new capability will bring challenges in manipulating, analyzing, and visualizing the terabyte-scale output from high-resolution models, and WGNE-23 discussed these challenges in the context of data interoperability.

Russia (M.Tolstykh)

The current status and development plans concerning Russian model of climate system developed at the Institute of Numerical Mathematics, Russian Academy of Sciences (INMCM) were presented. The atmospheric model currently has the resolution of 4x5 degrees lat/lon, 21 levels with the uppermost level at 10 hPa. The dynamical core is finite-difference semi-implicit one based on the C grid. The model includes

deep and shallow convection (Betts, 1986), large scale condensation; orographic (Palmer et al., 1986) and non-orographic (Hines, 1997) gravity wave drag. Radiation code was developed by (Galin, 1998). It includes 18 SW and 10 LW spectral intervals; H_20, CO_2, CH_4, O_3, N_2O, sulfate aerosol (direct and indirect effect). Parameterization of land surface, soil and vegetation processes is described in (Volodin and Lykossov, 1998). Ocean model has the spatial resolution of 2x2.5 degrees lat/lon, 33 levels. Vertical sigma-coordinate is used. The model is integrated using implicit time-splitting scheme. Mixed layer parameterization is from (Philander, Pacanovsky, 1981). The model includes isopicnic horizontal diffusion. Rigid lid was used so far as an upper boundary condition. The sea ice model is currently without ice dynamics.

Coupling of atmosphere and ocean is done using linear interpolation of surface fluxes and SST. There is no momentum and heat flux adjustment; however, there is fresh water flux adjustment in GIN, Barentz and Kara seas.

The INMCM model includes the evolution of carbon in land ecosystem (plant and soil carbon, including photosynthesis, respiration, land use), ocean (carbon advection, biology pump, dissolving) and atmosphere (uniform distribution, assuming mixed state). Also, the model includes methane flux from wet soils and methane destruction in the atmosphere.

Some results from numerical experiments with the INMCM model were presented.

In response to the new IPCC requirements, the following work will be carried out in 2008:
- Increase of the horizontal resolution for atmospheric model to 2x2.5 degrees lat/lon;
- Increase of the horizontal resolution for ocean model 0.5x1.0 degrees lat/lon;
- Incorporation of sea ice dynamics;
- Suppression of fresh water flux adjustment.

Later on, the number of vertical levels will be increased to at least 40, the atmospheric chemistry will be included.

Canada (P. Gauthier)

A number of research projects have a longer term view in which the operational models are coupled to chemistry, ocean, and hydrological models. Coupling with chemistry has been developed for a contract study for ESA on the value of online vs. offline coupling of atmospheric chemistry to a general circulation model (Ménard *et al.*, 2007), here the GEM-global model with a stratospheric extension up to 0.1 hPa. Coupling with an ocean coastal model on the Atlantic led to the implementation of a storm surge forecast system that is now used to issue emergency warnings. An atmosphere-ocean-ice model has been developed for the Gulf of Saint-Lawrence. The 2-way coupling improves air temperature, precipitation and low-level clouds. It also improves the ice forecast which find applications to route the ships in the Gulf to increase the efficiency and security of the St. Lawrence seaway. A Global Atmosphere-Ocean-Ice system is developed through a collaboration between Environment Canada, the Department of Fisheries and Oceans (DFO), the Department of National Defense (DND) and the MERCATOR consortium in Europe. The objective is to establish an operational Canadian global coupled atmosphere-ocean-ice assimilation and modelling system.
Coupling with hydrological models is being developed for application to agro-environmental studies. In this context, EC is proposing a testbed for the Great Lakes and Ottawa river for the *Hydrological Ensemble Prediction Experiment* (HEPEX). It consists in using outputs from the ensemble prediction system to drive a hydrological model and produce 2-week forecasts once a week. Other hydrological studies are concerned with a Canadian Precipitation Analysis (CaPa) which aims at unifying the rainfall measurements taken in Canada in a common database so that they can be used to produce a precipitation analysis over Canada. This would be very useful for the validation of precipitation forecasts.

3.4 Climate Model Metrics

WGNE has been involved in developing standard climate model diagnostics and metrics for some years. The goal of such metrics is to objectively measure model quality or skill and suitable metrics depend on the intended applications. The application for climate models includes the prediction of future climates for which no verification data will be available within the lifetime of the model. WGNE discussed the issue of climate model metrics at some length with many questions and issues resulting.

P. Gleckler discussed efforts to develop routine metrics for climate models, which unlike the NWP community, have yet to be established.In recent years there has been an increasing interest in developing performance metrics for climate models and several groups are now exploring possible approaches. Establishment of a set of standard metrics could encourage all modeling groups to provide at least a minimal standardized summary of model strengths and weaknesses, which would facilitate monitoring and

documenting of changes in model performance. A hierarchy of metrics could be designed to help assess the simulation of a variety of processes and phenomena on a range of time and space scales. Although work on optimizing the utility of metrics is in early stages, it is widely believed that the metrics of most value will almost certainly be application dependent. There have been some initial attempts to construct a single index of model performance, based on a somewhat arbitrary set of metrics. Consensus view however is that there is little scientific justification for using indices of this kind to make judgments concerning the relative reliability of models for any particular application. Ultimately, metrics may guide the interpretation of the model results - some models may be given more weight when making predictions of future climate change.This is a difficult and controversial area that is certain to be explored. Metrics that assess phenomena are important for intercomparison, but weighting climate predictions really needs to be based on a more systematic assessment of model physics and dynamics. Community-based efforts (e.g., the WGNE ad-hoc metrics group) are underway to explore and establish a set of standard metrics relevant for climate models

3.5 Progress with the SURFA project

D. Majewski reported on the current status of the project. The SURFace Flux Analysis (SURFA) project will evaluate and inter-compare global surface flux products (over ocean and land) from the operational products of a number of the main NWP centres and this will provide a good opportunity for estimating and determining the quality of model surface fluxes, of considerable relevance to atmospheric and coupled modelling communities and oceanographers.

At the previous WGNE meeting in Boulder (Oct. 2006) D. Majewski had been appointed WGNE point of contact to define the list of model variables to be archived and the WCRP Working Group on Surface Fluxes (WGSF) will coordinate archiving the in-situ measurement data; all data (model forecasts and observations) will be stored at NOAA National Climate Data Center (NCDC).

In January 2007 the final list of model variables (2 constant fields, 16 instantaneous variables, 13 accumulated ones and 3 optional ones), grid specifications (global with a resolution of 0.25° x 0.25°) and forecast ranges (12h to 36h at 3-hourly intervals from 12 UTC forecast) have been set up and distributed to the 14 global NWP centres. ECMWF provided first test data to Huai-min Zhang (NCDC) in March 2007, and in June 2007 a regular data transfer from ECMWF to NCDC has been established. Observational data from some OceanSITES have been archived at NCDC, too. Since July 2007 NWP and observational data are now available through a Web Interface (ftp://eclipse.ncdc.noaa.gov/raid1b/surfa). The flux evaluation over land will be a joint effort of NCDC and Oak Ridge National Laboratory (ORNL); ORNL is the DAAC for the FLUXNET project. A Web-service oriented evaluation is planned which allows data downloads in multiple formats.

WGNE appreciated the progress of SURFA in 2007 and encouraged NCDC to enlarge the number of participating global NWP centres in 2008.

4. DATA ASSIMILATION AND ANALYSIS

4.1 Reanalysis Activities

The WCRP is a strong advocate of multi-year reanalyses of the atmospheric circulation with state-of-the-art assimilation/analysis schemes. WGNE was briefed about progress in reanalysis projects from ECMWF and JMA.

ECMWF (M. Miller) ERA-Interim

Production of ERA-Interim started in summer 2006, following a comprehensive set of preparatory experiments. The first eight years, from 1989 to 1996, have now been completed, and production is expected to reach present during the second half of 2008. Comparisons with ERA-40 indicate significant improvements in analysis quality, as summarised in ECMWF Newsletter No. 110, Winter 2006/07.

The interim reanalysis is making good progress. The clear superiority of ERA-Interim products over ERA-40 has been confirmed and many of the shortcomings of ERA-40 (e.g. the incorrect hydrological cycle and the too strong stratospheric Brewer-Dobson circulation) appear to be resolved. It is now expected that the reanalysis will catch up with real-time by the end of 2008.

ERA-Interim is based on IFS Cycle 31r2, model resolution T255L60, with 12 hour 4D-Var and a comprehensive handling of observational biases. Adaptive bias correction is applied to all assimilated

radiances (Auligné et al., 2006), as well as to surface pressure station data (Vasiljevic et al., 2006). Based on ERA-40 feedback information, radiosonde temperature records have been homogenized (Haimberger, 2007) and remaining biases due to seasonal variations in solar heating have been corrected using a refinement of the approach adopted for ERA-40 (Andrae et al., 2004). New bias corrections for altimeter wave height data from the European Remote Sensing ERS satellites were created for use in ERA-Interim, based on a comparison with buoy measurements.

ERA-Interim benefits from several developments of the ECMWF forecasting system and other changes in response to the problems experienced in ERA-40. These include the new humidity analysis, improved model physics, direct assimilation of SSM/I radiances, more selective use of HIRS radiances, use of variational bias correction and use of 4D-Var. All of these influence precipitation over the tropical oceans in the background forecasts. A further indication of improvement of the hydrological cycle in ERA-Interim is seen in the global balance of precipitation and evaporation. ERA-40 showed a general excess of precipitation over evaporation, which becomes pronounced after mid-1991. In contrast, precipitation and evaporation are close to global balance in ERA-Interim after 1991, with precipitation somewhat higher than evaporation in the first three years.

Japan Meteorological Agency (Y. Takeuchi)

Y. Takeuchi presented the progress in the reanalysis activities in Japan. The Japanese 25-year Reanalysis Project (JRA-25) is the five-year joint project of JMA and Central Research Institute of Electric Power Industry (CRIEPI) from 2001 to 2005. The calculation was completed in spring 2006 and the products have already released. JRA-25 has been handed over to JMA Climate Data Assimilation System (JCDAS) after 2005.

Wide applications derived from JRA-25 are shown, including 1) globally-averaged monthly prediction, 2) reasonable TC representation rates, 3) application for climate monitoring, 4) time series of monthly mean equatorial zonal index in the Eastern Pacific, 5) source for standard verification system for long range forecast of WMO, 6) reproduction of El Nino event in 1986/87, and 7) some downscale application. In addition, extended applications such as exhibition of a museum, atmospheric reference for launching a rocket by JAXA, precipitation climatology map, database for agricultural meteorological application are demonstrated.

The JRA-25 data are available only for research use and the user can download the data via internet from a server at JMA with a simple registration. The details are described at JRA-25 official page <http://jra.kishou.go.jp/index_en.html>. The paper of JRA-25 was published in the Journal of Meteorological Society of Japan.

Y. Takeuchi announced that the 3rd WCRP International Conference on Reanalysis sponsored by WCRP, JMA, CRIEPI and the University of Tokyo will be held in Tokyo from 28th January to 1st February 2008.

Finally, he reported the plans of the next Japanese Reanalysis JRA-50 and its rough configuration. The production will start in 2009.

D. Williamson emphasized the need to have reanalyses data on the native analysis grid for applications such as Transpose AMIP. This allows the individual modelling groups to interpolate directly to their model grids to create initial conditions for forecasts, and for detailed verifications. The modelling groups can then retain structures that are often lost when the data are interpolated to standard pressure levels. These structures can be important in the behaviors of the parameterizations, which is the primary emphasis of Transpose AMIP. The data on the native grid are often not included in the original reanalysis distributions, and negotiation is often needed to acquire them. Although such negotiations have generally been successful, they can substantially delay progress. It should be noted however, that these data are not needed for the entire reanalysis periods. Generally they are only needed for a limited number of relatively short case studies. WGNE endorsed the concept of making the native model grid reanalyses data available as a standard practice for such limited applications.

4.2 Data assimilation activity within WCRP. Observing systems and results of OSEs, also CBS work

A. Lorenc reviewed activities to determine observing system requirements and suggested that the following areas are lacking: formal consideration of relative value of observations & computers, at the high levels which fund both; observation evaluation techniques which properly value calibration & lack of bias;

understanding of requirements for short-period high-resolution NWP. Lorenc reported on the following activities:

- WOAP has not met in the last year; an outstanding issue has been discussed under 1.2. WOAP is helping to promote the WCRP 3rd International Conference on Reanalysis. 28Jan-1Feb'08. Tokyo.
- SPARC DAWG met September 4-7, 2007.
- WMO CBS ET-EGOS is organising the Fourth WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction (Geneva, Switzerland, 3–5 March 2008)
- THORPEX working group on Data Assimilation and Observing Strategies has an email group on data assimilation issues.
- WWRP/THORPEX is sponsoring a Workshop on 4D-Var and Ensemble Kalman Filter Inter-comparisons Buenos Aires - Argentina, 10-13 Nov 2008.
- The next WMO DA Symposium is expected to take place in 2009 in the Melbourne area. WGNE encouraged WWRP/AREP to now set up an organising committee for this symposium. (P. Gauthier was proposed as a WGNE representative).

Experience with EnKF and 4D-Var

A. Lorenc gave a talk explaining why advanced methods, allowing for time-evolution of errors, are desirable for NWP. The Ensemble Kalman Filter and 4D-Var do this in different ways; each has different strengths. He said the best approach, affordable by main NWP centres, should be to combine the two. Both however make similar Gaussian approximations for errors, which are not really valid for an atmosphere where coherent structures like cyclones, fronts and inversions are important, so future research needs to develop the methods to allow for these.

Y. Takeuchi reported the status of LETKF assimilation development and some preliminary results by using the JMA global model. An assimilation experiment with the TL159L40 global model in northern summer shows significant improvement with LETKF over the Northern Hemisphere and Tropics against 4D-Var by introducing an adaptive bias correction of satellite data in the LETKF assimilation. In contrast, the worse performance over the Southern hemisphere against 4D-Var suggests more investigation should be necessary. He also showed a significant case for typhoon track forecast by means of the LETKF assimilation, in which case typhoon track cannot be well simulated by using 4D-Var assimilation system.

SMOS Data Assimilation Study and International Soil Moisture Working Group Activities

P.J. van Oevelen reported on this topic. Soil moisture information is critical for understanding the global water and energy cycles, for predicting precipitation and for advising local water resource managers. Improved global observations and model estimates of soil moisture are needed on a priority basis.

Two activities were presented related to soil moisture. The first is the land surface activities that are undertaken by ECMWF under the European Space Agencies funded SMOS Data Assimilation Study (DA Study). The Soil Moisture Ocean Salinity (SMOS) mission is an ESA earth explorer mission that should provide global information on Soil Moisture and Ocean Salinity using an L-band radiometer. The second activity is a report on status and achievements of the International Soil Moisture Working Group (ISMWG).

The SMOS DA Study will focus for the land part on the assimilation of SMOS L-band brightness temperatures and the level-2 soil moisture product as provided by ESA. The complete study will consist of 3 main parts. First the monitoring of Level 1c brightness temperatures and assimilation of brightness temperatures over land which has two subtasks namely: a) Near Real Time monitoring of global brightness temperatures, and b): Evaluation of the possible impact of SMOS measurements on the weather forecast quality. Part 2 will be the assimilation of SMOS derived surface soil moisture and Part 3 will be assimilation of SMOS derived surface salinity.

The International Soil Moisture Working Group has three main objectives: 1) To support international cooperation in research and applications supporting soil moisture satellite missions; 2) To protect satellite missions dealing with soil moisture observations; and 3) To support the development of an in-situ global soil moisture network.

In 2007 the ISMWG has been able to facilitate in the support of the Portuguese Meteorological Institute to set-up a –in-situ soil moisture data hosting facility with seed money from the European Space Agency in particular the SMOS Project.

For the coming years the working group will continue in seeking support for this activity, to ralley the international community to contribute data from their existing in-situ soil moisture networks, to expand and

add new networks, to develop protocols and mechanisms and to promote the development and use of (in-situ) soil moisture data.

D. Majewski reported on new developments in soil moisture analysis (SMA) at DWD. The current variational SMA scheme for the 7-km COSMO-EU model requires two additional forecast runs to derive the gradient of the temperature at 2m with respect to soil moisture. To avoid this computational cost and the cumbersome maintenance the gradient is now parameterized based on the surface energy balance equation. Under the assumption that small changes of the soil moisture do not change radiation and ground heat fluxes but only the sensible and latent heat fluxes, the gradient of the temperature at 2m (around local noon) with respect to soil moisture is a function of the latent heat flux around noon and several soil and plant related parameters. First evaluations of this new approach indicate that the results are generally comparable or even better than the current scheme. The new scheme will form the bases for an SMA of the global model GME.

Y. Takeuchi reviewed modifications of the land surface scheme for JMA-GSM related to sensitivity of snow and soil processes to near surface temperature. Shortcomings of the current land surface scheme are overestimate of thaw, warming bias over snow region and insufficient diurnal cycle of near surface temperature. A new Simplified Biosphere (SiB) model can simulate snow-cover reasonably during thawing season, however, some new shortcomings are revealed such as cooling bias in the snow covered region and remarkably low temperature in the polar night. Then refinement of the new SiB model has been worked on.The uppermost soil layer thickness, snow density dependency of thermal conductivity, and the other sophisticated snow processes are examined. Air convection in snow layers and solar zenith angle dependency of snow albedo are also examined. According to the sensitivity experiments, near surface temperature in the snow cover region is sensitive to not only snow albedo but thermal conduction in the snow mass.

A. Lorenc reported the soil moisture assimilation work at the UK Met Office.The assimilation of soil moisture was implicated in summer forecast biases over land in 2006. Considerable effort has been put into understanding the problems, which were largely corrected by a change to the bare soil albedos, a change to the soil moisture super-saturation formulation, the introduction of biogenic aerosols and changes to convective cloud. Beside such changes, the focus of NWP developments has been to utilise available data such as a satellite snow cover product. On the earth system modelling side the focus is the Joint UK Land Environment Simulator (JULES) community model. A stand-alone version of JULES is used for carbon assimilation research; there are plans to collaborate to use it for research into soil moisture assimilation for NWP.

4.3 Earth System assimilation

The new developments in the assimilation of parameters pertinent to the Earth System but not routinely analysed by current data assimilation systems are being monitored by WGNE. These include analyses of greenhouse gases, aerosols and reactive gases. Earth system science such as the GEMS (Global and regional Earth-system Monitoring using Satellite and in-situ data) project will increasingly deman cross-project liaison within WCRP and CAS. The GEMS FP6 Integrated Project has the objective of developing an operational capability for global analysis of greenhouse and reactive gases and aerosols through assimilation of satellite data and for global forecasting of reactive gases and aerosols and is led by ECMWF. It has the further objective of providing retrospective analyses (or reanalyses) for the period 2003-2007, when observational capability is at its best. In doing so, it draws on data, scientific and technical developments and validation provided by partners in the project. ECMWF also has the task of providing data and support to other components of the project, for surface-flux inversions and regional-air quality (RAQ) forecasting in particular. Activities comprise both scientific and technical development of ECMWF's global data assimilation system, which is carried out in as integrated a way as possible between the greenhouse-gas, reactive-gas and aerosol components, and technical development in the areas of data provision, archiving, verification software and web services. Good progress has been made in all elements of the work over the past year.

5. NUMERICAL WEATHER PREDICTION TOPICS

5.1 World Weather Research Programme (WWRP) and THORPEX

G. Brunet, Chair of the JSC WWRP, presented the status of the implementation of a World Weather Research Programme including the status of actions on decisions made at the JSC-WWRP meeting in Geneva, April 2007. A full report of the meeting is available on the WMO website and an updated activity report is included in the last CAS meeting in Oslo, September 2007. In particular, G. Brunet pointed out the initiation of the development of a Strategic and Implementation Plan for WWRP.

Highlights of the discussion

- The JSC-WWRP held its first meeting from 23 to 25 April 2007 at the WMO Headquarters (Geneva, Switzerland). Following the directive of CAS-XIV, the meeting reviewed recent activities of the various working groups of the programme and discussed the development of a strategic science and technical implementation plan for WWRP and a work programme aligned with the WMO Long-term plan. The meeting organized by WMO's Atmospheric Research and Environment Programme Department (AREP) and chaired by Dr Gilbert Brunet (Canada) was well-attended by members of the JSC-WWRP, chairpersons of the working groups and expert teams of WWRP and leading atmospheric research experts. Participants were enthusiastic and committed to providing the overall scientific guidance for WWRP, in particular, and in furthering the work of the Commission of Atmospheric Sciences, in general. A detailed report on the first session of the JSC WWRP meeting is available on the WMO website and contains a summary of all the presentations made, decisions arrived at during the three day meeting, outline of the WWRP Strategic Plan (2008-2015) and timetable for its preparation. The CAS/AREP Programme Structure Schematic and revised structure of the new WWRP Tropical Meteorology Research activity are also given in the appendices.

- The International Training Workshop on Tropical Cyclone Disaster Reduction was held in Guangzhou China from 26 to 30 March 2007. The meeting chair was Prof. Lianshou Chen. 60 participants including 9 lectures from 15 countries which are affected by tropical cyclone disaster attended the workshop. The workshop objectives were to provide training and experiences on new knowledge in recent tropical cyclone research advances, to apply some of the research results into operational tropical cyclone prediction in order to raise the capability of tropical cyclone forecast and warning, to be aware of the issues associated with early warning systems, societal impacts and disaster mitigation. The lectures of the workshop were organized including tropical cyclone track forecasting techniques, structure and intensity change forecast related to CBLAST, tropical cyclone rainfall, wind, storm surge, coastal flooding, geological hazard, tropical cyclone warning systems, societal impacts and disaster reduction. The workshop was evaluated by all of the formal trainees organized by WMO to assess how well this workshop was so as to improve future workshops. Three parts including course review, overall logistics, lecture instructors were put into evaluation.

- A future direction in tropical cyclone forecasting will be in probabilistic forecasting. Research is required as to how to best utilize ensemble prediction system outputs to generate these probabilistic forecast products. The TIGGE System will be a useful source for research. Tropical cyclone panel will explore re-establishing the Limited Area Modeling Workshop around 2009.

- The topic of impact of climate change on tropical cyclone activity/intensity has been addressed in two statements summarizing the present state of knowledge. This is an appropriate topic for the tropical cyclone panel of the WGTMR. The panel considers whether a meeting of the expert team on this topic should meet formally or conduct their deliberations via email, and coordinate this activity with the world climate research program as appropriate. On the other hand, it seems needed to produce a formal WMO report updating the status of this topic at least each two years and produce a report at each IWTC.

- A major activity of the monsoon panel of the WGTMR continues the quadrennial International Workshop on Monsoon (IWM) series. The IWM-IV will take place in October 2008, and a corresponding publication on monsoon research will be completed in 2009.

- TMR monsoon panel will facilitate cooperation and coordination among those existing field experiments which will advance understanding physical processes of monsoon severe weather such as heavy rainfall associated with Meiyu (Baiu/ Changma) front. The efforts should be directed at forming an alliance of field experiments which have existed in China and Japan. Some research projects on severe monsoon weather events can be cooperated with WCRP CLIVAR and GEWEX monsoon project.

- The monsoon panel will serve as consultant to NMHSs in the monsoon regions to provide advices to improve the research and forecast of severe monsoon weather events. Visits, meetings, special topic workshops are the kind of channels providing advices/products to NMHSs affected by monsoon.

- Progress Beijing 2008 FDP. The first training workshop of B08FDP was held from 10 to 20 April 2007. An introduction of each system was focusing on major functions, basic operating principals, and products provided MAPLE/ARMOR nowcasting system was developed at McGill University in

Montréal, Québec, Canada, has been accepted as a new member of B08FDP. Planning Meeting held in July, 2007 Beijing for 2007 Operations (July-August) 2007 Trials conducted July-August 2007 3rd B08 FDP Review Workshop to be held Qingdao 27-29 September, 2007

- Vancouver 2010 FDP/RDP. The Meteorological Service of Canada (MSC) is exploring the potential of a winter nowcasting FDP linked with the 2010 Winter Olympics in Vancouver. Several meetings have been held so far, including an internal MSC scoping activity following information gathering exercise conducted at the WSN05 meeting in Toulouse, 2005. International interest was evident at the latter. The proposal is still very tentative.

- Meeting of the Joint Nowcasting Applications and Services Steering Committee (JONAS) between PWSP-WWRP on Nowcasting Applications (Geneva, 18-20 April, 2007). The interim JONASSC meet for the first time 18-20 April, 2007 in Geneva to consider the development of a joint PWSP-WWRP Nowcasting Applications implementation plan. Specific issues discussed included: Public Weather Services (PWS) Nowcasting Applications Framework; Components for PWS Nowcasting Service Delivery; Building on Existing Initiatives and Identifying New Opportunities; Terms of reference (TOR) for the JONAS; Long Term Plan for Activities including reporting responsibilities to CAS and CBS and role this SC in relation to WWRP NWG. A strategic plan is now under preparation and with target completion date of 30 October, 2007. Enhancing capability to assess economic and societal impact with the initiative remains a key challenge. The strong link with the WWRP NWG is included to avoid duplication and to enhance the overall effectiveness of both groups.

- Proposed Nowcasting and Very Short Range Weather Forecasting (WSN09) Symposium in Canada, Summer 2009. It is proposed to hold the next World Weather Research Program (WWRP) Symposium on Nowcasting and Very Short Range Weather Forecasting (WSN09) 30 Aug-4 Sep 2009 in Whistler BC, Canada. The aim of the Symposium will be to examine the capabilities, opportunities and requirements for improved forecasts in the 0-6 hour nowcasting timeframe. Emphasis will be placed on systems that forecast all types of high impact weather. At the last Symposium in Toulouse, mainly summer convective hazards (heavy rain, hail, lightning, high winds) were considered. This Symposium will attempt to broaden the scope to consider hazards that occur in other seasons, such as snowstorms, blizzards, fog, and freezing precipitation. Papers that cover short term forecasting systems for drainage basins, cities, airports, forest fire situations, roads, etc, will be solicited. Articles that cover the use of new high resolution numerical forecast models (1-5 km scales) and special instrumentation networks will also be encouraged.

  It is possible that a WWRP RDP will be developed in association with the Vancouver 2010 Olympics. In addition, plans are underway for a significant Nowcasting research component as part of the weather forecasting for Vancouver 2010. In Toronto, a Canadian Airport Nowcasting Project (CAN-Now) is underway and should be producing routine products by the summer of 2009. So both locations will offer opportunities to discuss local research work on Nowcasting. Paul Joe and George Isaac have agreed to chair the Local Arrangements and Scientific Program Committees. Environment Canada will act as the official host. Other scientific bodies, besides WMO, will be solicited for their support.

THORPEX

THORPEX is developed and implemented as a part of the WMO World Weather Research Programme (WWRP). The international co-ordination for THORPEX has been established under the auspices of the WMO Commission for Atmospheric Science (CAS) through its Science Steering Committee for the WWRP and WGNE. The THORPEX International Science Steering Committee (ISSC) establishes the core research objectives with guidance from the THORPEX International Core Steering Committee (ICSC) whose members are nominated by Permanent representatives of countries with the WMO.

At the WGNE meeting there was a session devoted to THORPEX, which reviewed the status and plans of THORPEX and the wide-ranging opportunities for collaboration and synergy with WCRP and other bodies. The plans for the THORPEX Pacific Asian Regional Campaign (T-PARC) were of particular note, and this 'campaign' promises to make a major contribution to our understanding of meteorology in the Pacific basin.

The use of ensemble methods now forms a cornerstone of forecasting on all timescales, and WGNE hoped that the rapidly progressing THORPEX Interactive Grand Global Ensemble (TIGGE) project will help accelerate the effective use of ensemble forecasting information.

- The CAS International Core Steering Committee (ICSC) for THORPEX met in the WMO Headquarters in Geneva, 25 April to 27 April 2007. The ICSC proceeded with the work assigned by the CAS, the WMO Executive Council and the Fourteenth World Meteorological Congress. This included reviews of the progress in planning and further development of THORPEX on the global and regional level, financial and administrative matters related to THORPEX management, the International Programme Office (IPO) and Trust Fund. A complete ICSC report is available on the WMO website.

- Update on Current and Planned Activities of the THORPEX Predictability and Dynamical Processes (PDP) Working Group. The PDP WG has established 8 Interest Groups (IGs) to engage the community in a discussion on 8 relevant PDP topics. These topics are (1) The role of Rossby wave dynamics in predictability (2) Organized tropical convection (e.g., MJO) and weather prediction on sub-seasonal time scales (3) Predictability of tropical cyclones and their extratropical transition (4) The impact of ET on the downstream midlatitude predictability (5) Theoretical aspects of ensemble prediction (6) Atmospheric blocking, low-frequency variability and their role in predictability (7) The impact of moist processes on dynamical processes and predictability in the extratropics (8) AMMA and aspects of tropical-extratropical interactions.

- PDP WG is currently in the process of preparing a summary paper based on the reports of the IG leaders for BAMS. The IG leaders were asked to summarize the most important development in their field over the last 5 years and the most relevant research issue based on the discussion in their respective groups. The PDP WG submitted a proposal for a paper to the chief editor of BAMS on August 22 2007. The PDP WG has not received a response, yet, but we assume that the response will be positive. The PDP WG hopes to have a draft approved by all co-authors (two co-chairs of the PDP WG and the two co-leaders of each IG) by mid-November. The PDP WG is planning to send, then, the manuscript to the members of the former SAB for review. We will ask them to return their comments before the holidays. In 2009 the PDP WG highest priority will be the evaluation of the results of the 2008/2009 field programs and the organization of a PDP summer school.

- The current activities and short-term priorities of the North American THORPEX Regional Committee are (NATRC):

- The North American Regional is participating in the THORPEX cluster within the International Polar Year (IPY) including several led or co-led by researchers from this region. Our IPY Efforts with include modeling and observational projects include: i) A Canadian project termed STAR (Storm studies of the Arctic) designed to provide a better understanding of the physical features of Arctic storms and their hazards, the processes controlling them, and our predictive capabilities for them. STAR will use field observations, high-resolution modeling and remote sensing, including CLOUDSAT. STAR includes an international research team with investigators from the operational and academic communities. ii) Another Canadian project called TAWEPI (THORPEX Arctic Weather and Environmental Prediction Initiative). A centerpiece and legacy of TAWEPI is the development and application of a high-resolution polar version of the GEMS model. The effort will use field campaign measurements, modeling, data assimilation and process studies to help to enhance the Polar-GEM weather and environmental forecasting capabilities, and improve our understanding of Arctic climate and influence on world weather. iii) Another project with significant North American involvement is CONCORDIASI, which is primarily a French-US collaboration. CONCORDIASI will use in-situ measurements to improve satellite data assimilation over Antarctica. The project will also address ozone depletion, the microphysics of stratospheric clouds, vortex dynamics, adaptive use of in-situ sensing, improved prediction of precipitation and understanding of how Antarctic processes influence weather events at lower latitudes. iv) US and Canadian investigators are also participating in a number of IPY projects including a major US involvement in the Arctic High-Resolution Data Assimilation, Modeling and Reanalysis project and US and Canadian involvement in the Greenland Flow Distortion Experiment. Additional IPY-THORPEX participation has been proposed.

- “Climate and Weather Modelling Summit” (to date a tentative title), European Centre for Medium- Range Weather Forecasts, Reading, United Kingdom, 6-9 May 2008.

WCRP is organizing the International Modeling Summit on Climate Prediction 6-9 May 2008 at ECMWF Reading UK with a goal to develop a modeling strategy to implement the requirements of the WCRP strategic plan and to advance the seamless aspects of climate and weather prediction. WWRP is co-sponsoring the meeting.

The Summit will have five themes, which are listed below:

1. Implementing the WCRP and WWRP strategy of seamless prediction of weather and climate, including extreme events.
2. Human and computing resources needed to build the next generation models to simulate and predict high impact weather and climate.
3. Balancing a multi-model strategy vs. a unified modeling framework.
4. Balancing comprehensive Earth system models vs. the realism of the representation of the physical climate system, including regional models.
5. Strategy for using and enhancing high-end computing capability.

The committee's first tasks will be to refine and expand these questions, to develop an agenda for the meeting, and formulate a list of invitees.

THORPEX Regional Plans

THORPEX PACIFIC-ASIA Regional Campaign

WGNE, in its session in 2006, had welcomed the proposed T-PARC campaign by THORPEX and agreed with THORPEX that it is a major experiment planned by the THORPEX community. To THORPEX this experiment is very important as its success would underpin support for THORPEX for the next 5 years. THORPEX requested the Director of NCAR to help ensure NSF support to T-PARC. WGNE queried if there are any plans for reanalysis for the T-PARC period and suggested this should be considered now itself and not after the campaign.

The THORPEX Pacific Asian Regional Campaign (T-PARC), is being undertaken in collaboration with Asian Regional Committee and European investigators. The North American goals include advancing knowledge and improving prediction of i) the genesis, track, landfall, and evolution of rapid tropical cyclones over the western North Pacific including rapid intensification and other changes in storm structure, ii) the extratropical transition of tropical cyclones, iii) winter cyclones and iv) how the interaction of these events with the Asian waveguides generate subsequent high impact weather events through propagating Rossby wave trains. The T-PARC research efforts to improve forecast skill include investigating the dependence of forecast skill on the design of the global observing system, the use of ensemble forecast systems (e.g., TIGGE and NAEFS), and testing current and future assimilation and modeling systems. T-PARC participation within tour region includes investigators from Canada, Mexico and the US. Within the US, T-PARC includes a large grants program with ~15 funded projects that are led by researchers from the academic community.

Japan (Y. Takeuchi)

Y. Takeuchi introduced the configuration of Typhoon Heavy Rainfall 08 (TH08) experiment as a component of TPARC2008. In the experiment, various special observations such as ground based GPS sonde, radiosonde on board research vessels of JMA, dropsonde with an aircraft and rapid scan with MTSAT-2 are planned to investigate the predictability of the recurvature of tropical cyclones for the periods from August to September 2008. To support the targeting observations in TPARC2008, JMA has set up a website for sensitivity analysis products.

As an activity closely related to TPARC2008, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) / Institute of Observational Research for Global Change (IORGC) is planning an observation study named Pacific Area Long-term Atmospheric observation for Understanding climate change (PALAU-2008) in the western tropical Pacific early summer in 2008.

The North American region (G. Brunet)

The North American region has a significant focus on ensemble prediction and research with the operational North American Ensemble Forecast System (NAEFS) and participation in TIGGE. The region's operational modeling centers participate in TIGGE with NCAR serving as an archive center. Approximately 50 researchers have registered to obtain TIGGE data from NCAR. While TIGGE is a research effort, NAEFS is a new multi-model operational ensemble system run jointly by the Meteorological Service of Canada (MSC) and the U.S. National Weather Service (NWS). NAEFS produces forecasts out to week 2 for use by MSC, NWS and the National Meteorological Service of Mexico. Together TIGGE and NAEFS have the potential to increase the use of ensemble products for research with a potential path toward the operational implementation of the research findings.

Southern Hemisphere (K. Puri)

A Southern Hemisphere Science Plan was developed in 2005 and 2006 by scientists knowledgeable in Southern Hemisphere Meteorology, and is available via the WMO THORPEX web page at http://www.wmo.int/pages/prog/arep/thorpex/plans.html.

The SH Science Plan developed a rationale for a Southern Hemisphere regional focus for THORPEX that emphasises a number of features that are unique to the hemisphere. An Implementation Plan was subsequently developed and finalised at a three-day workshop held in Melbourne, Australia, in May 2007.

Overall the Plan has been deliberately designed at this stage to be modest. There are, for example, no plans for "big science" new field programmes or network design experiments. Working groups have been established for three areas:

Societal and Economic Research and Applications

The initial focus is on three key user groups: emergency management, agriculture, and health. Three projects will be carried out:

a) Inventory of High-Impact Weather Forecast Opportunities in the Southern Hemisphere
b) Facilitate transfer of THORPEX advances to operational forecast offices in support of end user requirements

c) Research on User Requirements and Potential Benefits

Data Assimilation and Observing Strategies (DAOS)

Most of the focus will be on improving the data assimilation of existing and experimental observing systems, although aspects associated with adaptive data assimilation may also be addressed. Assessing the influence of data assimilation and observing strategies on regional NWP forecasts of high impact weather events requires both a suitable number of events and local knowledge of the important aspects of these events. Collaboration between the Southern Hemisphere agencies is therefore essential in order for these assessments to be reliable, and this collaboration is the key aspect of this theme. This collaboration is greatly enhanced by the National Institute of Water and Atmospheric Research (New Zealand), South African Weather Service and Australian Bureau of Meteorology all using the same NWP system.

Three projects will be carried out:

a) Assessment and improvement of observing system impact on regional NWP in the Southern Hemisphere.
b) Assessment of 3DVAR versus 4DVAR in Southern Hemisphere regional NWP.
c) Convective and Tropical Assimilation

Predictability and Dynamical Processes

The production of a report involving authors from countries from across the Southern Hemisphere should form an ongoing theme for the Predictability and Dynamical Processes subprogramme. The first such report based on the Science Plan will review the state of the science across the Southern Hemisphere relevant to the four subprogrammes of THORPEX. Later reports will be on dynamics, structure and forecasting of major rain fall producing systems, on simulation of severe weather environments using high resolution limited area models, and on other aspects of the science that are chosen as suitable foci, during the ten years of the THORPEX programme.

In addition to the following initial projects, it is hoped that future activities will encompass cooperation on research and simulation of the Madden Julian Oscillation, which is an important part of one of the THORPEX objectives, namely improving forecasts in the second week of the THORPEX time scale.

a) Publish Review Papers on the predictability of SH High Impact Weather Systems
b) Major rainfall producing systems
c) Impact of High Latitude processes on hemispheric predictability
d) High Resolution Analysis and Forecasting of High Impact Weather
e) Web Forum Real Time Discussion on Dynamics and Predictability

In addition to projects conducted by these working groups, given that tropical convection, including the MJO and tropical cyclones, are responsible for high impact weather in the Southern Hemisphere on a number of time scales, the THORPEX SHRC will be directly engaged with tropical weather/climate research and prediction through collaboration with the Year Of Tropical Convection. This is in line with the recommendation made by the International Core Steering Committee at its meeting in Geneva in April 2007.

The Plan projects largely draw on focussing and coordinating existing and planned research to contribute to THORPEX objectives. But their overall success will depend on continuing commitment from individual scientists, and support from their institutions, particularly in making time available and facilitating meeting opportunities, to reap the benefits of this unique, coordinated approach across the hemisphere.

Europe (D. Majewski)

D. Majewski reported on the THORPEX European Plan (Version 1.0 dated 7 June 2007) drafted by G.C. Craig, E. Richard et al. This plan builds on the THORPEX Science Plan and focuses on implementation reflecting the special circumstances of meteorological research in Europe like the large number of nations and important trans-national organizations (EUMETNET, EUMSETSAT and ECMWF). Significant emphasis is placed on limited area modelling and multi-model ensembles. In the section “Scientific Challenges” high impact weather in Europe is related to 14 weather phenomena like PV streamers, extratropical cyclones, Mediterranean cyclones or deep mid-latitude convection. For each of these phenomena the current understanding and key research questions are shortly summarized. Action plans are finally formulated for “Predictability and dynamical processes”, “Observing systems/Data assimilation and observing strategies”, “Societal and economic research and applications” and “TIGGE – Global and Regional”. TIGGE-LAM, the limited area modelling component of TIGGE, will be a major contribution of Europe to THORPEX.

5.2 WWRP-THORPEX and WCRP

G. Brunet reported on the progress on the **White Paper: Towards A Seamless Process for the Prediction of Weather and Climate**. There are significant similarities in the societal benefits and the much of the science underpinning both WWRP-THORPEX and WCRP. The science outcomes and the societal benefits will be enhanced significantly from strengthened collaboration between these programs. The JSC-WCRP, the JSC-WWRP and the THORPEX International Core Steering Committee (ICSC) are keen to strengthen this collaboration and it has been agreed that it would be desirable for these communities to develop two "white papers". White paper 1 (WP1) would cover important general scientific/technical areas for collaboration between WWRP-THORPEX and WCRP – as agreed by John Church (Chair for the JSC-WCRP) and Dave Burridge (ICSC Chair). This WP1 first version was prepared by a joint WWRP-THORPEX/WCRP drafting team comprised of: Gilbert Brunet (Environment Canada), Randall Dole (NOAA), Brian Hoskins (Reading U.), George Kiladis (NOAA), Ben Kirtman (GMU/COLA), Mitch Moncrieff (NCAR), Rebecca E. Morss (NCAR), Saroja Polaravapu (Environment Canada), Mel Shapiro (NOAA), Julia Slingo (Reading U.), Istvan Szunyogh (Maryland U.) and Duane Waliser (JPL). The first draft of WP1 was circulated to a wider scientific audience. It has received to date numerous feedbacks and additional contributions from the two research communities that will significantly help strengthening the discussion on data assimilation, surface processes and tropical meteorology issues. A judicious rewriting of the WPI is ongoing and will hopefully broaden and reinforce the support from the research communities. We anticipate getting other contributions until mid October at the latest. It is expected to have a final version for endorsement by the WWRP and WCRP JSCs in fall 2007.

Forecast systems and the MJO

G. Brunet in collaboration with H. Lin and J. Derome presented the output of two global atmospheric general circulation models (GCMs) participating in the second phase of the Canadian Historical Forecasting Project (HFP2) is utilized to assess the forecast skill of the Madden-Julian Oscillation (MJO). Spacetime spectral analysis of the daily precipitation in near-equilibrium integrations reveals that the two models behave differently in simulating the convectively coupled equatorial waves that include the MJO, Kelvin, equatorial Rossby (ER) and mixed Rossby-gravity (MRG) waves. An objective of this study is to examine how the MJO forecast skill is influenced by the model's ability in representing the convectively coupled equatorial waves. The results show that the model with a better representation of the tropical convectively coupled waves produces a significantly better forecast skill for the MJO. The difference is larger in winter than in summer. There are some features that are common for the two models. The forecast skill is better in winter than in summer. Forecasts initialized with a large amplitude of the MJO are found to be more skillful than those with a weak MJO signal in the initial condition. The forecast skill is dependent on the phase of MJO at the initialcondition. Forecasts initialized with an MJO that has an active convection in tropical Africa and Indian Ocean sector have a better forecast skill than those initialized with a different phase of the MJO.

K. Puri presented information relevant to WGNE on the progress and plans of the US-CLIVAR Madden-Julian Oscillation Working Group (MJO WG). The MJO WG, chaired by Duane Waliser of JPL/Caltech and Ken Sperber of PCMDI, has tasked itself with the goal to develop a set of diagnostics to be used for assessing both MJO simulation fidelity and forecast skill, among others. Details of the membership of the MJO WG and a full list of its goals and activities are provided at http://www.usclivar.org/Organization/MJO_WG.html.

The selection and development of MJO diagnostics for assessing model simulations has been mostly completed, with graphics, descriptions, and code available at http://climate.snu.ac.kr/mjo_metrics/index.htm. The uniform application of these diagnostics to a number of contemporary GCMs has started. Feedback on this particular activity is welcome.

For the development of MJO forecast metrics, discussions to date have led to the adoption of the so-called Wheeler-Hendon combined EOF index, whereby daily forecast model output is projected onto a pair of EOFs, computed from observations, of the combined fields of 850 hPa zonal winds, 200 hPa zonal winds, and OLR, averaged for 15°S-15°N. A number of operational centres (NCEP, ECMWF, UKMO, CMA, and Australian Bureau of Meteorology) have already adopted this for their real time model output, with the indices being displayed in real time on the Experimental MJO Prediction website as a proof-of-concept (http://www.cdc.noaa.gov/MJO/Forecasts/index_phase.html). The MJO WG plans to eventually to produce a multi-model ensemble of these index values, but standard calculations need to be agreed upon in order to properly implement and interpret this measure. To facilitate this standardization of the calculation, the MJO WG, in conjunction with WGNE, would like to propose participation by further operational modelling centres. WGNE welcomed the proposal as it fits well with its interest in improving the maintenance of tropical waves, and in particular the MJO, in models. As a follow up, the MJO WG has been requested to draft a letter with details and description of the project that would be sent to all modelling centres by the Chair of WGNE.

A. Lorenc presented some animations from THORPEX research, demonstrating the ability of the Met Office and ECMWF 15-day ensemble systems to forecast the evolution of the Wheeler and Hendon MJO index. The ECMWF forecasts tended to lose more amplitude, but had slightly better correlations.

Y. Takeuchi showed predictability of eastward propagation of MJO in the active period in August 2007. In the case the operational GSM of JMA seems to predict the phase of MJO successfully up to 9 day forecast but representation of the amplitude is insufficient.

He also introduced upgrade of JMA's one-month EPS with initial perturbations based on a breeding method. In order to assess the predictability of the MJO, JMA has developed tropical initial perturbations for the one-month EPS by modifying the operational Breeding of Growing Mode (BGM) method. Obtained perturbations depend on the magnitude of norm. Large-scale mode is characterized by growing eastward propagating zonal wavenumber 1 components of the first baroclinic structure with a phase speed of 30 m/s. The large-scale mode is decoupled with the convective activity, and has similar characteristics to the dry Kelvin waves observed by Milliff and Madden (1996). As a result, perturbations in Tropics were included in one-month EPS on 2 March 2007.

5.3 The Year Of Tropical Convection (YOTC) in the WWRP-THORPEX context

A Year of Tropical Convection (YOTC)

WCRP and WWRP-THORPEX are proposing a year of coordinated observing, modeling and forecasting of organized tropical convection and its influences on predictability as a contribution to the United Nations Year of Planet Earth to compliment the International Polar Year (IPY). This effort is intended to exploit the vast amounts of existing and emerging observations and computational resources in conjunction with the development of new, high-resolution modeling frameworks, with the objective of advancing the characterization, diagnosis, modelling and prediction of multi-scale convective/dynamic interactions and processes, including the two-way interaction between tropical and extra-tropical weather/climate. This activity and its ultimate success will be based on the coordination of a wide range of ongoing and planned international programmatic activities (e.g., GEWEX/CEOP, THORPEX/TIGGE, WWRP Tropical Meterology Research(TRM), EOS, GOOS). It seeks to leverage the most benefit from recent investments in Earth Science infrastructure. The significant data gathering, archiving and dissemination challenges associated with the vast amounts of satellite data, disparate in-situ data sets and high-resolution model output require the breadth and functionality of the data services anticipated to come from the new WMO Information System (WIS), and thus YOTC is proposed as one of its initial projects.

The data archive for the "year of observations (2008)" will include operational analyses and forecasts. It is important that the archive also include the global operational analyses on their native grids so that Transpose AMIP like studies can be carried for any period within the YOTC.

C.Jakob, the GMPP chair, reported on the latest developments in the planning of the Year of Tropical Convection (YOTC). He also presented the latest version of the science plan, highlighting the important role WGNE members will have to play in supporting the programme as well as the importance of a parametrization science programme as part of YOTC. Input to the science plan had previously been provided to the YOTC leaders. A planning team for YOTC has been formed and will meet for the first time on 13/14 November in Arlington. Both the chair of WGNE and GMPP are members of the team and will attend the meeting.

5.4 Model developments

WGNE noted the substantial improvements in the resolution of global and deep convection permitting forecast models in progress or planned in the next few years. Grid-lengths of several kms are now in use for forecasting; and these resolutions will become affordable for GCM use in the coming years.The prospect of climate simulations with grids of order one kilometre is an issue of international activity and debate, and WGNE will continue to monitor such developments.

Recent results showing the need for model resolutions of 100 kms or better to properly define the statistics of extra-tropical storm tracks were noted. This contrasts with typical climate model resolutions substantially poorer than this, a matter of serious concern to the group.

WGNE noted that plans for unified (coupled) forecast systems that will provide forecasts from days out to seasons, typically by progressively degrading the resolution with forecast range, will provide new opportunities for ensemble techniques, including initial perturbations, stochastic parametrizations and metrics, and bring even closer collaboration between the NWP and climate communities.

Experience with convection-permitting models in NWP

Deutscher Wetterdienst (M. Baldauf)

M. Baldauf reported on the developments at the Deutscher Wetterdienst. On 16 April, 2007 the German Weather Service (DWD) had increased its model chain: in addition to the global model GME (~40 km grid length) and the regional model COSMO-EU (7 km grid length), the convection permitting (meso-γ), very short-range forecast model COSMO-DE with a grid length of 2.8 km is in use.

The emphasis of the COSMO-DE model lies in the prediction of severe weather events related on the one hand to deep moist convection leading e.g. to super- and multi-cell thunderstorms or squall lines and on the other hand to interactions with fine scale topography which can induce e.g. severe downslope winds or Foehn-storms.The currently used COSMO-DE-configuration covers the domain of Germany, smaller parts of its neighbouring countries and also a bigger part of the Alpine region with 421*461*50 gridpoints and a horizontal resolution of 2.8 km.

A meso-γ-model has special requirements concerning data assimilation: at this scale highly resolved, rapidly updated data fields are needed, which can in principle be delivered by radar observations. The German radar network has a spatial resolution of radially 1 km and laterally 1° and a temporal resolution of 5 min. for the precipitation scan. The assimilation method should be fast and also relatively easy to implement. The latent heat nudging (LHN) approach fulfills these requirements.

The dynamical formulation of the COSMO-DE is similar to that of COSMO-EU: it is a non-hydrostatic, fully compressible model in advection form. But there are some differences in the numerical formulation. It now uses a two-timelevel integration scheme based on the Runge-Kutta-method of 3rd order for the prediction of the three cartesian wind components u, v, w, the pressure perturbation p' from a hydrostatic base state, and the temperature perturbation T'. This allows the use of an upwind advection scheme of 5^{th} order in the horizontal with Courant-numbers up to 1.4. For the 6 humidity variables (mass fractions of moisture, cloud and rain water, cloud ice, snow and graupel) several Courant-number-independent Euler- and Semi-Lagrange-schemes can be used. Idealised tests of this new dynamical core with linear mountain flow and nonlinear density current simulations performed very well.

One of the most far reaching differences between COSMO-EU and COSMO-DE is the treatment of deep convection. COSMO-DE resolves the bigger parts of convection with its whole life cycle, i.e. the

generation of updrafts, latent heat release, formation of ice particles and cold downdrafts, which can generate gust fronts. For the smaller scales of convection the sligthly modified shallow convection scheme of the Tiedtke Cumulus parameterization scheme is used. This parameterization especially delivers the transport of moisture from the boundary layer to a height of about 3 km and therefore avoids the overestimation of low cloud coverage. Without a deep convection parameterization the need for a faster sedimenting ice phase is necessary. Therefore the former 5-class microphysics scheme was extended by a new precipitation class 'graupel'.

In the second part of the lecture, test cases were shown which demonstrate the ability of the model to simulate more realistically events with frontally driven convection. Also dynamical effects as downslope winds and lee waves can be better simulated due to the higher horizontal resolution. But there are problems in the simulation of convective events which are not synoptically driven (air mass convection, test case 7th June 2007). A possible explanation for this could lie in a too diffusive planetary boundary layer.

UK Met Office (A. Lorenc)

For theoretical reasons, and because results from its 4km UK model have been of mixed quality, the Met Office's strategy (unlike most centres actually running such models operationally) is to move as soon as practical to a grid-length close to 1km. A 1.5km grid covering the UK should be feasible on the upgraded computer in 2009.

A. Lorenc mentioned experiments at the Met Office by Glenn Shutts, who has run the eddy-resolving cloud model for a tropical belt. Interesting results about the mechanisms driving equatorial waves had been obtained. These experiments show the potential of global convection-resolving models to give insights into parametrisations, even if we cannot afford to run them as operational forecast tools.

New Numerical developments and test cases

D.Williamson reported on the 2007 Workshop on the Solution of Partial Differential Equations on the Sphere held 24-27 September at the Met Office in Exeter, UK. The purpose of the workshop was to address the issue of the dependence of errors in general circulation models on their dynamical cores and to advance the state-of-the-art for numerical weather prediction and climate simulation through improvements to the dynamical cores. The programme and presentations are available on the workshop web site: http://www.metoffice.gov.uk/conference/pdes2007/. Topics covered in 2007 included 1) Adaptive methods and variable resolution, 2) Spatial discretisation methods including spectral transform, finite element, spectral element, discontinuous Galerkin, multi-moment and radial basis functions on polyhedral, latitude-longitude, Yin-Yang, and unstructured grids, 3) Temporal discretisation methods including semi-implicit and Laplace transform filtering, 4) Comparison studies of methods to establish equivalent resolutions of different methods when in a climate equilibrium, 5) Computational performance, 6)proposed test cases including annular mode autocorrelation time scales, unsteady solid body rotation, specified forcings, aqua-planet, and nonhydrostatic tests, 7) Equations sets including alpha model,regularization methods, and global hydrostatic and non-hydrostatic models, along with possible next generation models in spheroidal coordinated. There is a tremendous effort in the field to develop and evaluate improved numerical methods for global atmospheric models. At the moment, no particular approach appears to be heading toward a dominant role such as the spectral transform did two and a half decades ago.

Russia (M.Tolstykh)

Today, many global spectral models use the reduced grid (i.e. the grid where the number of points in longitude is gradually reduced while approaching the poles). The construction of the finite-difference SL-AV model, where some part of calculations is carried out in the space of Fourier coefficients in longitude, enables the implementation of the reduced grid. The reduced grid was implemented and successfully tested in the framework of the shallow-water prototype for the SL-AV model with the standard test set by Williamson et al (JCP 1992). It turned out that the results are quite sensitive to the choice of the grid, however, the proper construction of the reduced grid provides the results hardly distinguishable from the ones obtained with the full grid. It is planned to implement the reduced grid in the full 3D version of the SL-AV model.

5.5 Model Verification

With global models attaining much higher resolutions, and mesoscale models being routinely run at most operational centres, consideration is being given to additional skill scores to the conventional ones that are more appropriate for such resolutions. Furthermore there is an increasing requirement to provide measures of model performance for predicting weather elements and severe weather events. The joint WGNE/WWRP working group on verification (JWGV) is now considering this important subject.

There are a number of WGNE projects involved with the validation of forecasts. New developments were discussed including the development of methods to verify high resolution spatial forecasts; verification methods for rare events; incorporation of scaling methods into verification processes; approaches to account for observational uncertainty in verification measures and analyses; development of methods that are customer dependent and appropriate for studies of forecast value; and verification of probability distribution functions.

Activities of the WWRP/WGNE Joint Working Group on Verification (JWGV) were reported by Ms. B. Brown, JWGV Chair. A number of WGNE projects focus on verification of forecasts from numerical weather prediction (NWP) models. The JWGV supports these activities by developing guidelines for forecast evaluation approaches for NWP models; organizing outreach activities; and encouraging and undertaking development of new methods that are appropriate for high resolution forecasts and which provide information that is relevant and meaningful for users.

Membership in the JWGV includes Dr F. Atger (Meteo France); Dr H. Brooks (NSSL, U.S.A.); Ms B. Brown (Chair; NCAR, Boulder, U.S.A.); Dr B. Casati (MSC, Canada); Dr U. Damrath (DWD, Germany); Dr E. Ebert (BMRC, Australia); Dr A. Ghelli (ECMWF, U.K.); Dr P. Nurmi (FMI, Finland); Dr D. Stephenson (U. Exeter, U.K.); Dr C. Wilson (UKMO, U.K.); and Dr L. Wilson (MSC, Canada). In addition, the working group activities are aided and enhanced by a number of additional contributors and collaborators, including Dr M. Mittermaier (UKMO, UK); Mr. M. Pocernich (NCAR, USA); S. Mason (Columbia University, USA); and Dr E. Gilleland (NCAR, USA).

The Third International Workshop on Verification Methods and a tutorial on forecast verification were organized by the JWGV and took place from 29 January through 2 February, 2007. The workshop and tutorial were co-sponsored by the World Weather Research Program (WWRP); the European Cooperation in the field of Scientific and Technical Research (COST); and the European Centre for Medium Range Weather Forecasts (ECMWF); and was held at the ECMWF in Reading, UK. Approximately 30 students from many countries and continents participated in the two day workshop. Tutorial lectures (http://www.ecmwf.int/newsevents/meetings/workshops/2007/jwgv/lecture_notes/index.html) covered a wide range of topics, from a discussion of basic verification concepts to an explanation of the concepts underlying the evaluation of probabilistic and ensemble forecasts. The students also learned how to apply a verification software package and used these tools to complete group verification projects; the students presented project results at the workshop. The students' feedback on the tutorial was consistently very positive. To meet the needs of the many students who could not be accommodated in the class (due to limited space), the JWGV would be very interested in organizing similar tutorials in the future.

The Third International Workshop on Verification Methods followed the verification tutorial. The workshop had 131 participants from 32 National Meteorological and Hydrological Services (NMHSs), 3 international organizations, 13 government agencies, 11 universities and 3 private weather service providers. The workshop focused on new verification techniques and issues related to the practice of forecast verification, as well as contributed presentations on verification methodologies applied to a variety of forecasts (including forecasts of phenomena outside of atmospheric sciences, such as economics) and the development of new verification packages (e.g., the verification package in "R"). Subjects covered included verification of ensemble/probability forecasts, extreme events, and forecast value and user issues. Four invited talks were presented, as well as many contributed presentations and posters (http://www.ecmwf.int/newsevents/meetings/workshops/2007/jwgv/workshop_presentations/index.html). A special issue of *Meteorological Applications* has been organized to summarize the results of the workshop; an article describing the state-of-the-art in verification was prepared by JWGV members and submitted as a contribution to this special issue.

The JWGV held two coordination meetings; the first meeting took place in Reading, UK, on 3 February 2007, following the verification workshop. The JWGV held a second coordination meeting at the conference of the European Meteorological Society in El Escorial, Spain, in early October.

JWGV members continued to participate in a number of specific projects, including the Mesoscale Alpine Project Forecast Demonstration (MAP D-Phase). The JWGV's role in MAP has primarily been advisory. E.Ebert, L. Wilson, and B. Brown continued to serve on the steering committee for the THORPEX Interactive Grand Global Ensemble (TIGGE), and coordinated with the Societal and Economic Research and Applications Program (SERA) for THORPEX. JWGV members formulated and presented a proposed verification strategy for TIGGE.

B. Brown, E. Ebert, and L. Wilson participated in planning and development efforts fort the Beijing Olympics (B08) Forecast Demonstration Project (FDP) and Research Demonstration Project (RDP). E. Ebert

and others have developed a Real-Time Forecast Verification (RTFV) system in coordination with the Beijing Meteorological Bureau, which will be used for evaluation of the B08 FDP nowcasts and short-range forecasts. This system will provide an opportunity to demonstrate the use of new verification methods, as well as the use of a real-time verification system.

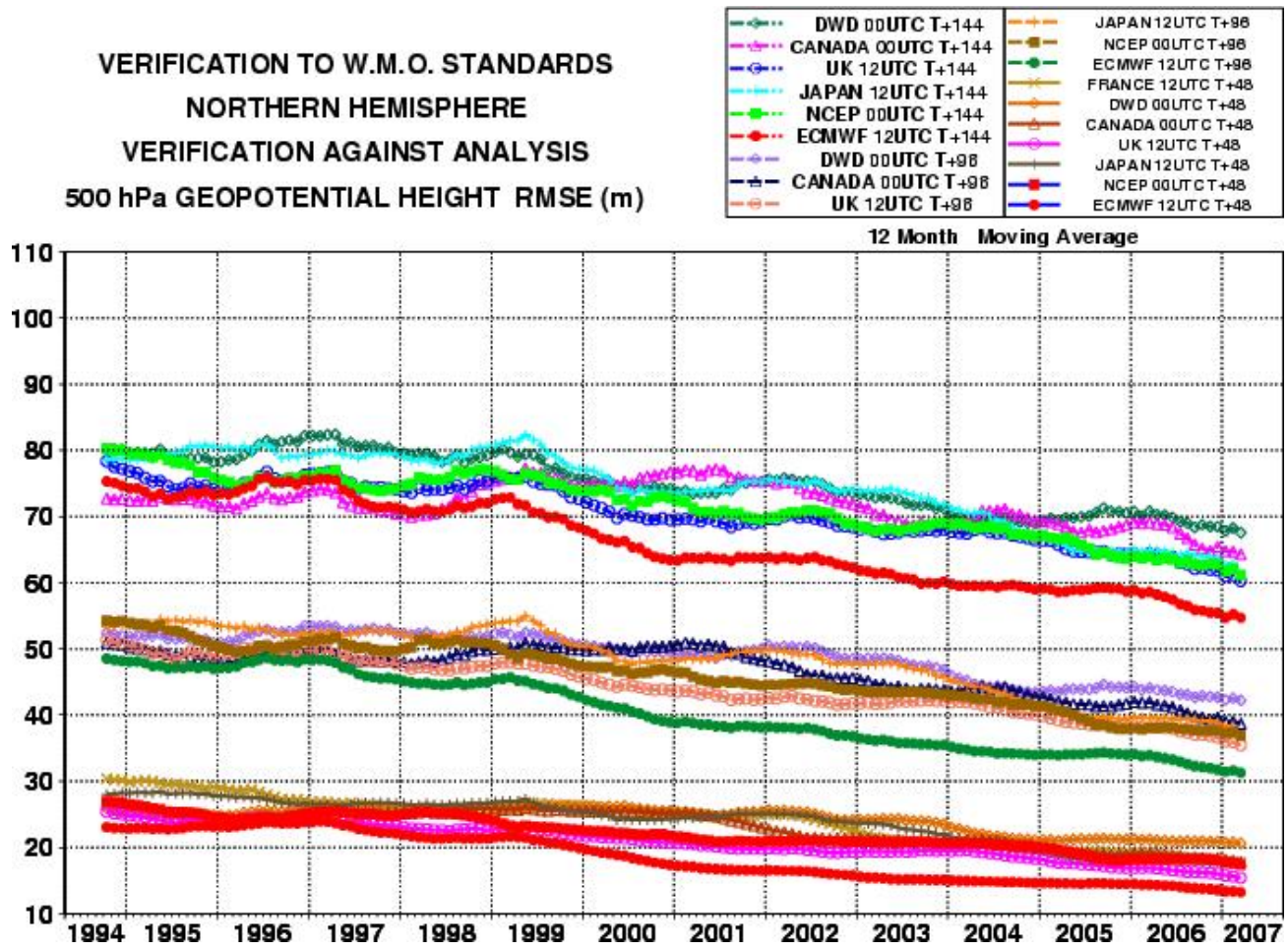
New advances in verification methodologies continued, including the development and testing of improved methods for evaluation of spatial forecasts, ensemble forecasts and forecasts of extremes, as well as new diagnostic approaches and user-focused verification methods; many of these new developments were reported at the Third International Workshop on Forecast Verification. Members of the JWGV are helping to coordinate (and are participating in) a project designed to assess and intercompare the capabilities of many of the new spatial verification methods (http://www.rap.ucar.edu/projects/icp/index.html).

The JWGV continued to support the verification web page (http://www.bom.gov.au/bmrc/wefor/staff/eee/verif/verif_web_page.html) and coordinated the on-line verification discussion group. In addition, L. Wilson and P. Nurmi extended the online verification tutorial for EUMETCAL (the "European Virtual Organisation for Meteorological Training"). This on-line training course is available at http://www.eumetcal.org.uk/eumetcal/verification/www/english/courses/msgcrs/index.htm.

The JWGV continued development of a document defining a recommended set of verification methods to be used for evaluation of cloud forecasts provided by NWP models. This report will be expanded and extended, incorporating recommendations from WGNE. The JWGV is also interested in participating in any efforts undertaken by WGNE with regard to methods for evaluation of climate forecasts.

Trends in performance of the models of the main operational forecasting centres

As is usual at its sessions, WGNE reviewed the progress in skill of daily forecasts produced by a number of the main operational centres over the past year as presented by M. Miller.This WGNE initiative is being conducted at the DWD, NCEP, BMRC, CMA, JMA, CMC, the Met Office and Meteo-France. Quantitative global precipitation forecasts from the above are being verified against surface stations in these relatively data rich areas (some Centres also include their limited area model forecasts in the verification). A series of scores such as bias, Heike skill score, equitable threat score are used. . Examples of the twelve-month running means of verification scores (root mean square error against own analyses) for 500 hPa geopotential in the northern and southern hemisphere at lead-times of two, four and six days, are shown respectively in Figures 1 and 2. It was noted that there is clear evidence from several Centres that the skill of precipitation forecasts in mid-latitudes was increasing.


VERIFICATION TO W.M.O. STANDARDS
NORTHERN HEMISPHERE
VERIFICATION AGAINST ANALYSIS
500 hPa GEOPOTENTIAL HEIGHT RMSE (m)
DWD 00UTC T+144
CANADA 00UTC T+144
UK 12UTC T+144
JAPAN 12UTC T+144
NCEP 00UTC T+144
ECMWF 12UTC T+144
DWD 00UTC T+96
CANADA 00UTC T+96
UK 12UTC T+96
JAPAN 12UTC T+96
NCEP 00UTC T+96
ECMWF 12UTC T+96
FRANCE 12UTC T+48
DWD 00UTC T+48
CANADA 00UTC T+48
UK 12UTC T+48
JAPAN 12UTC T+48
NCEP 00UTC T+48
ECMWF 12UTC T+48
12 Month Moving Average
110
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1994
1995
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1997
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Figure 1.

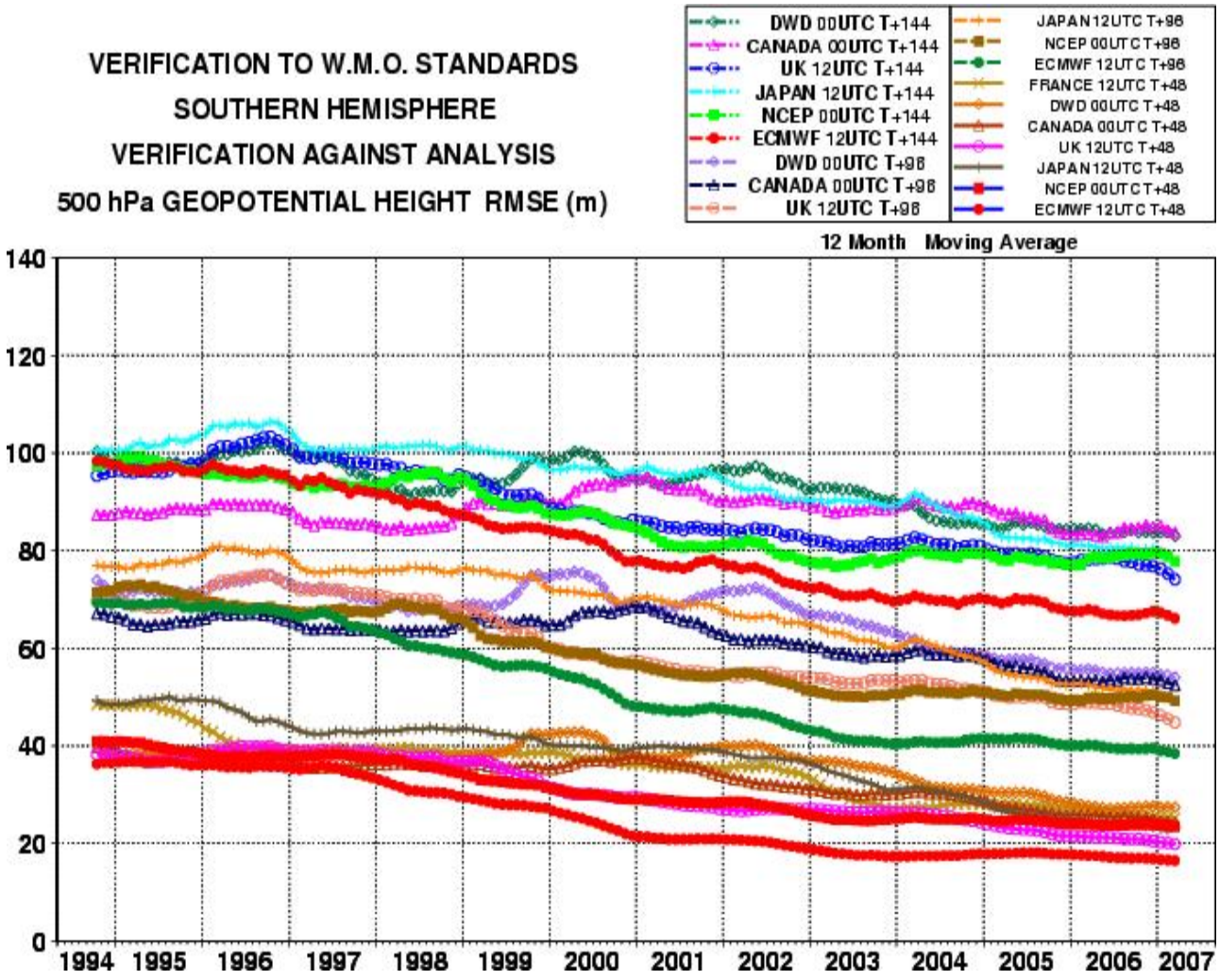

Figure 2.

Inter-comparison and verification of Typhoon Track Forecasts

Y. Takeuchi reported on this topic. This model intercomparison was started in 1991 for the western North Pacific area with the participation of ECMWF, UKMO and JMA. CMC, DWD, NCEP, BoM, Météo-France, NRL and CPTEC joined subsequently and the verification area was also expanded to North Atlantic area, eastern North Pacific area, southern hemisphere, northern Indian ocean and central Pacific area. Eleven NWP centers participated in the 2006 intercomparison.

Full results related to typhoon track forecast including a multi-model ensemble can be browsed on the web site. Visit http://nwp-verif.kishou.go.jp/wgne_tc/index.html (user id and password are required).

The performance of tropical cyclone track forecasting is measured by forecast error and detection rate. The ECMWF and JMA models show small forecast errors and high detection rates. The UKMO model is characterized by the highest detection rate for all ocean areas. The NCEP model also shows small forecast errors in North Atlantic area. Preliminary result on verification of TC genesis is shown as detection rate against lead time by backtrace of low pressure feature from TC genesis.

The trends of typhoon track forecast error by a multi-center ensemble composed of deterministic forecasts by ECMWF, JMA and UKMO for the last 16 years are also shown. Y. Takeuchi remarked that four day forecast with the multi-model ensemble in 2006 reached about 300km, which is almost the same score as two day forecast in 1995, for western North Pacific area.

An example of multi-center grand ensemble was also shown by using EPS forecasts provided by JMA, ECMWF and NCEP. Multi-center ensemble showed good reliability for whole range of strike probability.

Verification and Comparison of Precipitation Forecasts at various Centres

BMRC

K. Puri presented the studies conducted at Bureau of Meteorology Research Centre (BMRC). Daily rainfall from NWP QPFs has been verified at 1º spatial resolution over Australia since 1997. Rainfall prediction in the tropics has not significantly improved over that time. In the last few years the frequency bias for rain ≥ 1 mm d^{-1} has been close to the ideal value of unity in all seasons for all models except DWD. All of the global models underestimate the frequency of heavier rain ≥ 20 mm d^{-1} in the tropics, with the Canadian and US models having the least bias.

In mid-latitudes QPF accuracy as measured by the equitable threat score has improved for many models, with typical seasonal values now in the range 0.4 to 0.6, compared to 0.3 to 0.5 in 1997. The frequency bias for all models is close to one for rain ≥ 1 mm d^{-1} and only slightly less than one for rain ≥ 20 mm d^{-1} (except for the US global model and the Australian regional model, both of which predict too much heavy rain).

The ECMWF model continues to outperform the other models in making accurate predictions of rain system location, with over 60% of predicted mid-latitude rain systems having displacement errors of 1º or less in both 24h and 48h forecasts.

Further details can be found on the Australian QPF verification web site http://www.bom.gov.au/bmrc/wefor/staff/eee/wgne/QPFverif.html.

France (M. Déqué)

The operational precipitation forecasts (6-30 h) are compared on a 0.5°x0.5° grid over France against data from rain-gauges of the French national observation network. Heidke Skill scores have been calculated for forecasts from DWD, Met Office, ECMWF, JMA, NCEP and Météo-France over the last 3 years, aggregated by seasons. They show a superiority of ECMWF forecasts for the threshold 1mm/day as well as for 10 mm/day. All graphs can be seen at: http://www.meteo.fr/special/minisites/WGNE/.

Additional results have been shown for the Météo-France model. A comparison of the global ARPEGE versus limited area ALADIN (horizontal resolution twice as large) shows that before the introduction of 3DVAR assimilation in ALADIN (in 2005) the gain of a higher resolution was marginal, but in the recent period, ALADIN performs better than ARPEGE.

JMA (Y. Takeuchi)

Y. Takeuchi reported on the intercomparison of precipitation forecasts over Japan. Main purpose of the WGNE-QPF over Japan is verification of participating models for extra-tropical cyclone, typhoon, summer monsoon, winter monsoon, and thunderstorm in summer. The verification is performed with reference data of high-dense (17km^2) surface raingauge network (AMeDAS) at grid points with the resolution of 80km. BoM, DWD, ECMWF, NCEP, UKMO and JMA are participating in this verification exercise as of October 2007. He showed verification results for two day QPFs to estimate the total performance. All models have bias characterized by underestimate for heavy rain and overestimate for light rain especially for summer season. The BoM model shows large decrease of bias score in general compared to the previous year due to a model change. He also showed a couple of case studies on heavy rain in Baiu season and typhoon induced heavy rain and remarked some models succeeded in the prediction with a leading time of three days. A web page on WGNE-QPFs verification over Japan has been maintained by JMA for browsing the verification results. He announced that JMA plans to distribute the QPF data set with 0.25 degree resolution after the implementation of the high resolution global model in November 2007.

5.6 Recent Developments/Activities in Monthly and Seasonal Forecasting

The ENSEMBLES European project (M. Déqué)

The ENSEMBLES-RT2A meeting (Barcelona, March 2007) covered one and a half days of discussions in parallel with WGSIP meeting. ENSEMBLES is a project funded by the European Commission (FP6, GOCE-CT-2003-505539). RT2A is the part of this project devoted to seasonal to decadal prediction.

The first stream is now complete. It is characterized by 11 years (1991-2001), 2 seasons (November and May start), 4 models (ECMWF, Met Office, MPI and Météo-France), and the exploration of ensemble techniques (so-called perturbed parameterizations and stochastic physics). The second stream is in progress. This stream will be the European contribution to TFSP stream-2 (TFSP stream-1 corresponding to DEMETER database).

In Europe, operational seasonal forecasting is organized around the EUROSIP consortium, gathering ECMWF, the Met Office and Météo-France. In 2007 System III was introduced with higher resolution models and longer hindcast periods. The present status is now 41 members for each model, 7-month lag, and at least 25-year reference period (with 11 members and 12 hindcasts/year). DWD, NCEP and INM (Spain) are in discussions to join the consortium.

ECMWF (M. Miller)

Monthly Forecasting

During the past year, the atmospheric component of the monthly forecasting system has changed several times to be consistent with the EPS system: IFS Cycles 31R1 was introduced in September 2006, 31R2 in December 2006 and 32R2 in June 2006. The ocean component of the monthly forecasting system has also been upgraded: the new ocean operational analysis is used to generate initial conditions, and the oceanic perturbations have been modified to be consistent with the seasonal forecasting System 3. The changes in the ocean initial conditions have been implemented in June 2007.

The performance of the monthly forecasting system over the past year has been particularly good in winter and spring 2007. The ROC scores of 2-metre temperature for day 12-18 over DJF were the highest since the start of the monthly forecasting system. The scores for day 19-32 were in line with the scores of the previous year. In the Tropics, the model displayed good skill in predicting the onset of the 2006 Indian and African monsoons. It also had good skill in predicting the onset of the MJO event of December 2006 about 20 days in advance.

The VAREPS technique is further exploited to develop a unified system, expected to become operational towards the end of 2007 or beginning of 2008. In this unified system, the model is integrated uncoupled at T399 resolution to D+10, and then run coupled from D+10 at T255 resolution (for 00UTC only).

Seasonal Forecasting

The new seasonal forecast System-3 was implemented operationally in March 2007. The most notable features and changes with respect to the previous System-2 are the following:

- Use of IFS cycle 31R1 at increased horizontal and vertical resolution (TL159L62)
- Improved ocean data assimilation system using a multi-variate OI scheme allowing assimilation of sub-surface temperature, salinity and altimeter data (this system has been used to produce an ocean re-analysis from 1959 onwards).
- Operational 41-member ensembles with forecast range extended from 6 to 7 months, and a few forecasts to 13 months.
- Perturbation strategy based on a combination of multiple ocean analyses, SST perturbations and atmospheric fastest-growing singular vectors.
- Extension of an 11-member subset of the ensemble to 13 months from initial dates in February, May and August, to 14 months in November
- An extended set of re-forecasts for calibration and validation, consisting of 11-member ensembles started at the beginning of each month from January 1981 to December 2005, and 13/14-month-range 5-member ensembles every 3 months.

Results obtained so far from the validation of the re-forecasts set have confirmed the indications provided by previous research experiments. In particular, System-3 integrations show a much reduced model bias in both tropical SST and atmospheric fields. The reduction of the bias is particularly notable in the tropical Pacific, and lead to improved forecast skill for ENSO indices with respects to previous seasonal forecast systems. El Niño predictions are particularly improved during the boreal summer, when the advantage of the dynamical predictions over persistence is substantial. Tropical rainfall anomalies over the Pacific during anomalous ENSO events have a more realistic amplitude and spatial distribution than in System-2. On the other hand, the amplitude of ENSO-related SST anomalies is still partially underestimated

during the boreal winter, and simulation of rainfall anomalies over tropical continents remains problematic in a number of areas.

Multi-model seasonal forecasts

The EuroSIP multi-model seasonal forecast system has continued to run throughout the year. In March 2007, when the ECMWF System 3 became operational, the multi-model system was switched to use System 3 instead of System 2.

Although detailed constraints have been set on commercial use of the multi-model data, it has been agreed that ECMWF is permitted to produce joint products for its Member States and distribute the full multi-model datasets for research and educational use.

With the introduction of System 3, revised software was introduced for the prediction of tropical storm frequency. This has now been applied to the other individual models. Multi-model tropical storm forecast products have been implemented operationally and are now available on the web. The method of combination is essentially that of Vitart et al (2007). In the last year, a number of institutes have expressed interest in contributing to the multi-model EUROSIP partnership

BMRC (K. Puri)

POAMA1 (Predictive Ocean Atmosphere Model for Australia) is the Bureau's operational seasonal to inter-annual climate prediction system based on coupled ocean and atmospheric general circulation models. The atmospheric model of POAMA is the Bureau of Meteorology unified atmospheric model (BAM). It has a horizontal resolution of T47 with 17 vertical levels. The ocean model component is the Australian Community Ocean Model version 2 (ACOM2) which is based on the Geophysical Fluid Dynamics Laboratory Modular Ocean Model (MOM version 2). The grid spacing is 2^o in the zonal direction. The meridional spacing is 0.5^o within 8^o of the equator, increasing gradually to 1.5^o near the poles, and there are 25 levels in the vertical. The ocean and atmosphere models are coupled using the OASIS coupler. The ocean data assimilation scheme is based on the optimum interpolation technique and only temperature observations in the top 500m are assimilated. Over the past year a considerable amount of effort has gone into developing POAMA1.5 which will include the latest version of BAM, 3-hourly atmosphere-ocean coupling instead of 24 hours currently, some retuning of the ocean model, and a new nudging scheme to initialise the atmospheric model. Results based on reanalyses and hindcasts indicate improvements in the skill of the new system relative to the currently operational system. POAMA1.5 is planned to be implemented operationally in early 2008.

Japanese Meteorological Agency (Y. Takeuchi)

Atmospheric General Circulation Model (AGCM) for extended forecast

Y. Takeuchi introduced major changes on AGCM for extended forecast as follows:

- Update of absorption coefficient of water vapor in the solar radiation scheme, including the continuum absorption effect,
- Introduction of the new climatology of aerosol optical depth based on satellite observation data compiled by the Atmospheric Environment Division (AED), JMA, and
- Introduction of the improved cumulus convection scheme, including trigger function and raindrop re-evaporation.

It has been shown that this new model (GSM0703C) has smaller systematic error, especially in the lower tropospheric temperature around Japan. Along with this model change, the Breeding of Growing modes (BGM) method, which is used for making perturbed initial condition, is going to be improved. The improved BGM method gives smaller initial perturbation than the current one in the tropics, and properly takes into account instability associated with the Madden Julian Oscillation (MJO); it is expected to improve the probabilistic forecasting skill of the MJO.

CGCM for seasonal forecast

As for the upgrade of the long-range EPS on 10 September 2007, the low resolution version of the GSM0703C is introduced and the number of ensemble members is increased to 50 from 31. In the new EPS, uncertainty in prescribed SST will be considered in addition to uncertainty in the initial condition. Members for seasonal EPS were increased from 31 to 51 on 10 September 2007.

In March 2008 the CGCM will be operational as ENSO prediction model. After more improvement, it will be operational as the seasonal model in the next few years.

5.7 Recent Developments at Operational Forecast Centres

Further to the information on progress in forecasting systems in earlier sections, additional reports were given from the main operational forecasting centres on recent developments/extensions/improvements in their systems. As usual, constructive discussions on problems of mutual interest took place. A summary of the resolutions/configurations of models (global and regional) now in use, and those foreseen in the next three to five years, as well as computing resources is shown in Appendix D.

ECMWF (M. Miller)

The following upgrades have been made to the operational forecasting systems:

Cycle 31r1 was implemented on 12 September 2006. This includes the following changes:

- Revisions to the cloud scheme, including treatment of ice supersaturation and new numerical treatment
- Implicit computation of convective transports
- Introduction of turbulent orographic form drag scheme and revision to sub-grid scale orographic drag scheme
- Improvement in the interaction of orography and stochastic physics for the wind gusts
- Reduction of ocean surface relative humidity from 100% to 98% (due to salinity effects)
- Revised assimilation of rain-affected radiances
- Variational bias correction of satellite radiances
- Thinning of low level AMDAR data (mainly affects Japanese AMDAR network)
- Technical changes enabling the Variable resolution EPS (VarEPS)

Cycle 31r2 was implemented on 12 December 2006. This version had only minor technical and meteorological changes, including the passive monitoring of new data. However it enabled the effective assimilation of new satellite data, i.e. winds from MTSAT (Japanese GEO satellite), and GPS radio occultation data from CHAMP, GRACE and COSMIC.
Operational assimilation of the AMSU-A and MHS instruments of METOP-A started on 12 January 2007 and operational assimilation of HIRS started on 19 March 2007.
System 3 for Seasonal Forecasting replaced System 2 in operations in March 2007. It is based on IFS Cycle 31r1, at the increased resolution T159L62, and a new version of the ocean analysis.
The near-real-time ocean analysis of System 3 was used in the Monthly Forecasting System from June 2007.
Cycle 32r2 was implemented on 5 June 2007. This version includes the following changes:

- Three-minimization version of the 4D-Var assimilation (T95/T159/T255) and revised convergence criterum
- Improved moist linear physics (cloud and convection) in the 4D-Var
- Improved parametrization of the heterogeneous ozone chemistry
- McRad: a new short-wave radiation scheme (RRTM-SW), plus McICA cloud-radiation interaction and MODIS albedo
- Retuned ice particle size
- Revised subgrid-orography scheme
- Explicit numerical treatment of convection in the moist tangent linear model used in the calculation of tropical singular vectors

Operational assimilation of IASI and ASCAT data started on 12 June 2007.

Cycle 32r3 is in an advanced stage of testing. This cycle has the following elements:

- Revision of the convection scheme, including a new formulation of the organized entrainment and of the relaxation time scale

- Reduction of the vertical diffusion above the planetary boundary layer
- Revision to subgrid orography parametrization
- New representation of soil hydrology (H-TESSEL)
- New bias correction for temperature and humidity from radiosondes
- Assimilation of more GPS radio-occultation data
- Assimilation of radiances from AMSR-E, TMI and SSMIS
- Assimilation of more SBUV ozone data

Finally, the preparation of the unified VarEPS-Monthly system is making good progress and implementation is planned for end 2007 or early in 2008.

The interim reanalysis is making good progress. The clear superiority of ERA-Interim products over ERA-40 has been confirmed and many of the shortcomings of ERA-40 (e.g. the incorrect hydrological cycle and the too strong stratospheric Brewer-Dobson circulation) appear to be resolved. It is now expected that the reanalysis will catch up with real-time by the end of 2008.

The GEMS project has just passed half-term. The three independent assimilation and forecasting systems for greenhouse gases, reactive gases and aerosols are now in an advanced stage of development and testing. Short reanalyses covering the recent satellite-rich period will start soon, and we have all reasons to believe that the main ECMWF deliverable of GEMS - a single, unified system for global environmental monitoring - will have acquired full credibility by the end of the project. A proposal for a continuation project (MACC: Monitoring Atmospheric Climate and Chemistry) has been submitted to FP7.

Hydrometcentre of Russia (HMC) (M. Tolstykh)

M. Tolstykh presented a review of the current state and prospects for the development of NWP models in Russia including activities in global and regional forecasting, data assimilation and ensemble forecasting at Hydrometcentre of Russia (HMC). In global medium-range forecasting, two models are used currently, spectral Eulerian T85L31, and finite-difference semi-Lagrangian vorticity-divergence SL-AV model with the resolution 0.72x0.9 degrees lat/lon and 28 levels. The updated version of the spectral model with T169L31 resolution is being tuned currently. The following developments of the SL-AV model were carried out during 2007:

- Reduced grid was implemented in the shallow water version.
- New T2m and RH2m analyses were developed and implemented operationally. They allowed to significantly reduce analysis bias with respect to observations and provided good initial conditions for ISBA assimilation scheme.
- Development of the non-hydrostatic core (2D version) was continued. Results of the standard tests (warm bubble, nonlinear flow over the mountain) are encouraging.
- ISBA parameterization scheme developed by Meteo-France and corresponding assimilation scheme was tuned and has entered into operations.

In regional forecasting area, Russia became the applicant member in COSMO consortium early 2007. It is planned to run COSMO model preoperationally with the horizontal resolution of 7 km over Central part of Russia by the end of 2008, when a new computer will be installed.

There is an ongoing work on 3D-Var data assimilation scheme intended to replace current OI scheme. The version of this scheme for global models is expected to reach quasioperational status by the end of 2009. The scheme will include flow-dependent forecast-error covariances based on SARMA (Spatial Autoregression and Moving Average (Tsyrulnikov M.D. and Svirenko P.I. WGNE Blue book, 2007)). The features of SARMA are:

- Spatially variable vertical and horizontal length scales (both latitude dependent and flow dependent);
- Local anisotropies;
- Representation of tilted structures characteristic for baroclinic zones.

The bias-correction scheme is being developed for AMSU-A radiances. Radiosondes are used instead of model forecasts to protect the scheme from the harmful influence of forecast bias. So far, the scheme was tested using NCEP 6-hour forecast fields. There is also a work on assimilation of GPS observations.

The ensemble prediction system using T85L31 model is still under developement. It is based on the breeding method.

So far, computer resources at HMC are very limited. The procurement for a new supercomputer at Hydrometcentre of Russia was carried out. It is expected that 11.6 Tflops peak SGI Altix 4700 computer will be installed in the first half of 2008. At the Main Geophysical Observatory (St. Petersbourg) dealing with monthly and seasonal prediction, 0.6 Tflops machine is installed.

BMRC (K. Puri)

The Australian Bureau of Meteorology has been running an operational suite of a global model (Global Assimilation Prediction, GASP) and limited area models (Limited Area Prediction System, LAPS) for over 30 years. However, recently a decision was made by the Bureau and CSIRO to jointly develop the Australian Community Climate and Earth System Simulator (ACCESS, see below for details) for applications ranging from NWP, seasonal prediction to climate/climate-change simulations. With the development of ACCESS resources are being diverted from existing model development to ACCESS-related work and we are reaching the stage where no new major developments will be made on the existing NWP systems GASP and LAPS.

Over the past year a great deal of effort has gone into the sixty-level (L60) versions of LAPS and GASP. One of the primary drivers for the raising of the model lid in the L60 systems was to allow for greater use of satellite data; additionally the new configuration should allow the use of local read-out radiances in LAPS. The systems also include improvements to the physical parametrisations and efficiency improvements in the code. Extensive parallel trials of GASP and LAPS GenSI assimilation and prediction at 60 levels with AAPP based radiances have been carried out with very encouraging positive impact seen for both systems. These systems have utilised up to 5 satellites, including the latest NOAA18 satellite, as well as NOAA 15/16/17 and NOAA18 and Aqua(AMSU-A), with AMSU-B from the NOAA series also assessed. The global and limited area 60-level systems were implemented operationally in September and October 2007 respectively. A further operational change was to run the mesoLAPS system from twice daily to four times daily. The mesoLAPS system currently does not include any data assimilation and the initial condition is obtained by interpolating from the lower resolution LAPS. Detailed testing of a 0.1^{o} x 0.1^{o}, 60 level version with data assimilation has been carried out over the past year with encouraging results. This system is planned to be implemented operationally in December 2007. No new major developments will be made on the existing NWP systems GASP and LAPS once this implementation is made as all new development will be based on ACCESS.

No major changes were made to the ensemble prediction systems during the past year. BMRC is currently running three ensemble systems: a global EPS which is undergoing operational trials; Regional EPS which is being run in a research mode; the operational seasonal prediction system.

Two new systems have been implemented operationally over the past year. The first, BLUElink Ocean Forecasting system is a joint development of the Bureau, CSIRO and the Australian Navy. The system uses the GFDL Modular Ocean Model (MOM) version 4p0d and the BLUElink Ocean Data Assimilation System that uses (i) GTS, GDAC in situ observations e.g., Argo, XBT, and (ii) JPL, Aviso, NOAA remote sensig e.g., Jason1, Envisat and AMSR-E to generate the initial ocean state. The system uses a real-time quality control system and GASP surface fluxes as the surface forcing. Seven day ocean forecasts are produced daily.

The second new system is the Australian Tsunami Warning System. The ATWS is a 4-year project that is jointly managed by the Bureau, Geoscience Australia (GA) and Emergency Management Australia (EMA) with funding support from the Australian government Department of Foreign Affairs and Trade and AusAID. The objectives of the system are (i) to provide a comprehensive tsunami warning system for Australia, (ii) to support international efforts to establish an Indian Ocean tsunami warning system and (iii) to contribute to the facilitation of tsunami warnings for the South West Pacific. The Bureau's responsibilities include (a) provide (jointly with GA) warnings to be issued from Bureau Regional Offices, (b) expand and enhance sea-level observing network, (c) install deep-ocean stations and (d) develop capability in tsunami modelling/forecasting

Météo-France (M. Déqué)

The main changes to the Météo-France NWP system in 2006/2007 concern first the global system:

assimilate more satellite data: SSMI & AIRS radiances, GPS ground delays & radio-occultation, MODIS & BUFR atmospheric motion winds, Quikscat sea surface winds, MetOp satellite data.
improvement of conventional observations assimilation: radiosonde bias correction, variational quality control, reduction of envelope orography, more wind profilers, flow-dependent quality control.
revision of ARPEGE/ALADIN physics: new microphysics (prognostic 3D clouds and precipitation) and radiation, new cloud cover representation, changes to subgrid convection, orographic drag, physiography/orography databases
better vertical resolution in the stratosphere, higher model top (5Pa, 46 levels), to facilitate radiance data assimilation
improvement to data assimilation algorithms, dynamics & postprocessing.
moved production to new NEC SX8 supercomputer (5 times more powerful than previous one)
imminent upgrade of ARPEGE resolution to T538L60 i.e. 15km over Europe (instead of 24km), with better vert. resol. near tropopause.

As far as vertical resolution is concerned here is an improvement when going from 46 to 60 levels (additional levels in the stratosphere and at the tropopause), but a degradation when extending to 70 levels (additional levels in the lower troposphere requiring new adjustments in the physics). As far as horizontal resolution is concerned, the improvement concerns all regions only if the increase in resolution of the non linear model (TL358 to TL538) is accompanied by an increase in resolution of the analyses increments (TL149 to TL224), otherwise scores over Europe are degraded in the troposphere.

As far as the LAM model is concerned, ALADIN inherits from all ARPEGE data assimilation and model physics upgrades at 9.5km resolution over western Europe (3DVar data assimilation), with assimilation of extra geostationary radiances and low-level obs. Another ALADIN system (assimilation and forecasts) runs over SW Indian Ocean (regional tropical cyclone forecasts).

The main progresses in the Météo-France mesoscale system (AROME) in 2005-207 are:

1. 2.5km resolution model and 3DVar assimilation
2. covers mainland France
3. runs in real time since January 2007
4. 3-hourly assimilation cycle, 30-h forecasts every 6 hours
5. assimilates all ARPEGE/ALADIN data plus radar Doppler wind data
6. experimental versions: one for very high resolution (resolution <1km), one for nowcasting (short forecasts every 3 hours)
7. current work focuses on optimising modelling of convective cells, and low-level objective scores.

The AROME NWP system is entered in pre-operational phase. The operational phase is planned for 2008. Details can be found at http://www.cnrm.meteo.fr/gmap/. The main changes in the observation system are:

1. GPS radio-occultation
2. ATOVS sounder from MetOp (AMSU-A, MHS)
3. Diffusiometers ERS and ASCAT (monitoring)
4. 10m wind over land in ALADIN
5. monitoring of IASI
6. Assimilation of ASCAT
7. Variational unbiasing of radiances

In a later phase, Météo-France assimilated observations will include data from SEVIRI-CSR and SSM/IS, high-density radiances, micro-waves over land and cloud and rain radiance.

Japanese Meteorological Agency (Y. Takeuchi)

Overview of the NWP system at JMA

The current NWP model suite at the Japan Meteorological Agency (JMA) consists of Global Spectral Model (GSM), Regional Spectral Model (RSM), Typhoon Model (TYM) and Meso-scale Model (MSM). A low resolution version of GSM is used in the one-week ensemble prediction system.

Recent developments of JMA models

The upgrade of MSM was implemented as MSM0705 on 16 May 2007, which included the following main changes:

- extension of forecast time from 15 hours to 33 hours for the initial times of 03, 09, 15, 21 UTC;
- extension of vertical coordinate from z* coordinate to hybrid terrain-following coordinate;
- introduction of a new trigger based on relative humidity to cumulus parameterization scheme;
- introduction of the improved Mellor-Yamada level-3 scheme, in place of diagnostic form of Deardorff scheme;
- introduction of a partial condensation scheme for the diagnose of cloud properties in radiation scheme;
- refinement of the 4D-Var configuration.

As for the use of observations, the major changes are:

- use of BUFR coded Air Motion Vector (AMV) data from GOES-11/12 and MTSAT-1R instead of SATOB coded AMV data and hourly AMV data from MTSAT-1R for global, regional and meso-scale analysis in October 2006;
- use of AP-RARS (Asia-Pacific Regional ATOVS Retransmission Service) data in February 2007 and EARS (EUMETSAT Advanced Retransmission Service) data in August 2007 for global analysis (GA);
- use of GPS-RO data from CHAMP for GA in March 2007;
- use of clear sky radiance of water vapor channel from MTSAT-1R/Imager for GA in August 2007.

Model changes in late 2007 and after

A new GSM with a resolution of about 20km will be implemented in place of current GSM, TYM and RSM on 21 November 2007. The major futures are:

- increase in the resolution from TL319L40 to TL959L60 with a topmost level raised from 0.4hPa to 0.1hPa;
- use of a new high-resolution analysis of sea surface temperature and sea ice concentration as ocean surface boundary conditions;
- use of surface snow depth data from the domestic dense observational network in the global snow depth analysis;
- introduction of a convective triggering scheme into the deep convection parameterization;
- introduction of a new 2-dimensional aerosol climatology derived from satellite observations for the radiation calculation;
- increase in the resolution of inner loop model of the four-dimensional variational (4D-Var) data assimilation system from T106L40 to T159L60;
- change of forecast time to 84 hours for operations at 00, 06 and 18 UTC;
- use of Metop/AMSU-A MHS radiance data.

As for one-week Ensemble Prediction System, the model resolution will increase from TL159L40 to TL319L60 on 21 November 2007 which is a lower resolution version of the new GSM. The initial perturbations are made by a singular vector method instead of a breeding method for the current model. In addition, a new Ensemble Prediction System for typhoon track forecasts based on a dedicated singular vector method are now in pre-operation with the same GSM as that for one-week EPS.

Major plans of NWP model are as follows: (1) implementation of a reduced grid for GSM, (2) implementation of a new Meso-scale 4D-Var Analysis based on non-hydrostatic MSM (JNoVA), (3) use of geostationary satellites CSR data other than MTSAT-1R, ASCAT surface wind data, SSMIS radiance data and GRACE GPS-RO data for GA, and (4) MTSAT-1R hourly AMV data for Meso-scale Analysis (MA). A Local Ensemble Transform Kalman Filter is also investigated for GA and MA.

UK Met Office (A. Lorenc)

The year 2007 has seen a series of upgrades to the usage of satellite data, e.g. the use of GPS occultation, and improvements to 4D-Var assimilation, which have maintained the steady improvements in global forecasts. Implementation of soil-moisture assimilation in 2006 exposed weaknesses in other model physics, giving poor summer performance over land in summer 2006. Improvements to several aspects of the model physics in May 2007 alleviated these problems, leading to an improved relative performance in summer 2007. Work to enhance the vertical resolution to 70 levels is underway.

The regional forecasting system is based on the global, with a 12km grid instead of the global's 40km; similar model and assimilation upgrades have been made. However the greater emphasis on surface weather scores for this model gives more priority to the assimilation of surface observations including visibility, cloud and precipitation. Research in these areas is expected to be implemented in the coming years.

The UK forecasting system can only be run operationally on a 4km grid (an on-demand facility for 1.5km runs for nested smaller areas is available). Current developments are focussing on a doubling of the vertical resolution, to 70-levels. With this change, performance for surface weather forecasts beat the regional model; the UK model is at the centre of developments in post-processing and development of automatic forecast products. We plan to increase the horizontal resolution of this model to a 1.5km grid in 2009, nested in the 12km regional model. A variable mesh version has been developed to facilitate this nesting.

The ensemble system consists of a global and nested region ensemble, with perturbations generated using a localised ETKF and stochastic physics, added to the main 4D-Var analyses. Recent work has consolidated this as an operational system, with products including for instance a surge forecast ensemble. The main focus is on short-period forecasts; verification now demonstrates that for this it generally beats the available alternative from ECMWF (for which of course the short-period is not the primary aim). The global ensemble is extended to 15-days as part of the TIGGE project.

Deutscher Wetterdienst (D. Majewski)

The current suite of global, regional and local NWP models of the DWD consists of: the global icosahedral-hexagonal grid point model GME with a 40 km grid spacing and 40 layers, the non-hydrostatic local model COSMO-EU (previous model name was LME) covering whole of Europe with 665 x 657 grid points, a grid spacing of 7 km and 40 layers, and the convection permitting model COSMO-DE (previous model name was LMK) covering Germany and surroundings with 421 x 461 grid points, a grid spacing of 2.8 km and 50 layers.

For COSMO-DE which was put into operation on 16 April 2007, see the separate presentation by M. Baldauf under Agenda Item 4.1.

The performance of the NWP system was highlighted on the case of winter storm "Kyrill" on 19 January 2007 which caused 13 casualties and more than 1 billion € damages in Germany alone. An early warning was already possible 48 hours ahead of this event while the high-resolution COSMO-DE provided detailed 21-h forecasts of maximum gusts to emergency response agencies.

DWD will move to its new headquarters in the summer of 2008; the site is located in Offenbach, Frankfurter Str. 135. The offices will accommodate about 900 staff members.

A new supercomputer system will be installed in the new headquarters in Q2, 2008. It will consist of 2 x 128 NEC SX9 vector processors with a sustained performance of 4.5 TFlop/s each. In 2010 another upgrade to 2 x 15 TFlop/s is planned. The main cost driver will be the operational introduction of a high-resolution regional ensemble prediction system (EPS) based on COSMO-DE, and ensemble-based data assimilation suites for all NWP models. An upgrade of GME from 40 to 20 km grid spacing and from 40 to 60 layers is planned for the end of 2008, too.

DWD supports more than 20 national meteorological services worldwide with the hydrostatic High-resolution Regional Model HRM which is used for operational regional NWP at Bosnia-Herzegovina, Brazil (INMET and DHN), Bulgaria, China (Guangdong province), Israel, Italy, Jordan, Kenya, Libya, Malawi, Mozambique, Nigeria, Oman, Pakistan, Philippines, Romania, Senegal, Spain, Tanzania, United Arab Emirates and Vietnam. GME data are provided to these countries via the internet up to four times per day to serve as lateral boundary conditions.

Meteorological Service of Canada (P. Gauthier)

This report describes the changes brought to the operational suite of the *Meteorological Service of Canada* in support of global and regional forecasts, and the global ensemble prediction system. An overview of research and development is presented to describe the status of the ongoing development of a limited-area regional model with its own variational assimilation system, the experimentation with coupled atmosphere-ocean-ice model, and coupling to a hydrological model. A regional ensemble prediction system is also being developed and will be used in the Beijing 2008 Olympics research demonstration project. Finally, the global model is now being developed and tested to include the stratosphere and raising the lid at

0.1 hPa. A preliminary version of this model was used in the framework of a study on the impact of having a full online chemistry in a general circulation model. Results with this system are presented based on 3D and 4D data assimilation experiments in which MIPAS measurements of ozone, methane and nitrous oxide were assimilated.

Recent and upcoming changes to the operational suite

The operational suite of the Meteorological Service of Canada comprises a global model producing forecasts of up to 10 days, and a regional model based on a global model with variable resolution. Experimentation with a limited-area high resolution is also being done to produce short range forecasts over the West coast, central Canada (Ontario-Québec region) and the Arctic. Table 1 summarizes the characteristics of each model configuration. These three configurations are supporter within the Global Environmental Multi-scale (GEM) model.

The global suite
Implementation of the GEM-meso-global model

The global model uses 384 CPUs of the IBM p690 computer to produce 10 day forecasts in 55 minutes on the 800×600horizontal grid with 58 vertical levels. This model was implemented on October 28, 2006. Referred to as the *GEM meso-global model*, this new version included a completely new set of physical parameterizations. The physical representation of clouds and precipitation benefited from the new Kain-Fritsch deep convection convection scheme while shallow-convection uses a Kuo transient scheme. The ISBA surface scheme was also included in this implementation with its own optimal interpolation analysis for soil moisture. The implementation of this major change required significant work to validate the model when used in the 4D-Var assimilation mode. The configuration of 4D-Var remained similar to what was implemented in March 2005 (Gauthier *et al.*, 2007; Laroche *et al.*, 2007). New background-error statistics had to be obtained to match the new vertical levels and the doubling of the number of vertical levels required that efficiency issues had to be addressed. All in all the implementation of the new model led to significant improvements observed in the standard objective evaluation scores. Verification of precipitation and clouds was noted to be particularly better when compared to surface precipitation measurements and SSM/I data. Particular attention was given to the cases of hurricanes and the new model managed to significantly improve the track of hurricanes and typhoons

Upcoming upgrades to the global forecast-assimilation suite

Following the implementation of the meso-global GEM model, work has focused on increasing the volume of data assimilated in the 4D-Var suite. The new data include SSM/I radiances, QuikScat surface winds on oceans, an adaptive bias correction scheme, changes to the data selection scheme for AMSU-a,b and SatWind data. The most significant addition was to include AIRS radiances in this implementation. The combined volume of data from will result in a 50% increase in the volume of data assimilated in the operational global data assimilation system. This is planned to become operational in February 2008.

The next step will be to extend the global model up to 0.1 hPa to include the stratosphere. A preliminary version was used to include a full stratospheric chemistry developed at the Belgium *Institute of Space and Aeronomy* (BIRA) and assimilate MIPAS measurements of chemical species. The results from these experiments indicate that the simultaneous assimilation of ozone, methane and nitrous oxide in 4D-Var brings in information on the winds particularly in regions that are lacking wind measurements, i.e., the Tropics and the stratosphere. The three species bring in similar wind correction but the intensity varies according to the *texture* of the fields which varies with latitude and regions. The presence of sharp gradients in a field yields a stronger signal that leads to more important wind increments.

This stratospheric extension required also new background-error statistics and changes in the radiation to include the Li and Barker scheme that makes it possible to take into account changes in ozone and other species in the radiation scheme. Gravity-wave drag was also introduced. These changes were introduced in an experimental version of the global GEM at the full horizontal resolution of 35 km but 80 vertical levels and the changes to radiation and gravity wave drag described above. The incremental 4D-Var assimilation used the same configuration as for the chemical data assimilation system (using only the dynamical component). The first results were extremely encouraging. It will be used to begin the preliminary work on the assimilation of additional AIRS channels and of GPS radio-occultation measurements that are both sensitive to the stratosphere.

The ensemble prediction system of the Meteorological Service of Canada (MSC) is based on a multi-model approach meaning that different versions of the model are used within the ensemble. In 2005, a

major change was brought to the analysis component when the Ensemble Kalman filter (EnKF) replaced the optimal interpolation scheme that had been in use for many years (Houtekamer *et al.*, 2005). The EnKF uses 96 members with different model configurations. The recent changes brought to the system include a FGAT approach to compare the forecasts at the appropriate observation time. The resolution of the forecasts has been increased to 400×200 with 28 vertical models, which corresponds to the previous configuration of the global model (before October 2006).

The ensemble prediction system extracts 20 members out of the 96 to produce 16-day forecasts. These members are shared with NCEP as part of the North American Ensemble Forecasting System (NAEFS). This information is also put into the THORPEX Interactive Grand Global Ensemble (TIGGE) database. The recent changes in the system resulted in significant improvements in the different scores used to evaluate the performance of the EPS (reliability, resolution and verification against radiosondes). The regional EPS is still at an early stage of development. An approach based on singular vectors is being considered but at the moment, a simple downscaling of the global ensemble forecasts yields better results. It is therefore the dowsnscaling approach that will be used for the participation to the 2008 Beijing Olympics research demonstration project.

Regional and high resolution models

The operational GEM regional model runs at a resolution of 15 km to produce 48-h forecasts on a variable resolution grid. It has exactly the same number of vertical levels as the global model. Its analysis uses a 3D-Var FGAT assimilation which uses the same observations and error statistics as the global analyis. The timestep is 450 seconds and it takes 18 minutes to complete the forecast using 400 CPUs. This model is more or less frozen as a GEM-LAM version is being developed to replace the variable resolution grid. The work done on the limited-area regional model goes in several directions including changes in the cloud micro-physics scheme and coupling with the ISBA surface model and analysis. The tangent-linear and adjoint of the model have been developed and tested to develop a 4D-Var assimilation adapted to the limited-area model.

The GEM-LAM model is used in a number of studies to compare the precipitation against the current regional model. These shows that it handles well the local forcings over lakes, orography, and upslopes flows triggering storms and intense precipitations. To be able to run in real time, it is initialized from the 12-h forecast of the operational regional model which also provides the boundary conditions. The LAM model is currently run in experimental but real-time mode over three regions: the West coast, the East coast and the Arctic region (in support of IPY). This version is also taking part in the MAP-D phase experiment over the Alps. It is also being used in preliminary work to produce high resolution forecasts for the 2010 Vancouver Winter Olympic games.

Surface processes

NCEP Environmental Modeling Center, the JCSDA and GFDL (M. Iredell)

NCEP is responsible for environmental products from minutes to years, and from scales from global to microscale, and from systems from weather to ocean to land to climate.

The Global Forecast System (GFS) had a major implementation on May 1, 2007, including the GSI analysis system. The tropical performance of the new system was particularly improved. The next GFS implementation in 2008 should include First-Order Time-extrapolation to Observations and Variational QC in the GSI.

The North American Ensemble Forecast System (NAEFS) increased membership to 20 per 6-hour cycle in March 2007. In December 2007, bias corrected GFS, combined with ensembles, new combined CMC-NCEP NAEFS prodcuts, and statistical downscaling were implemented.

The North American Meso (NAM) had a large improvement in December 2006, improving both temperature and precipitation scores.

The Real-Time Mesoscale Analysis (RTMA) is an hourly 5 km 2DVAR of sensible weather over the US. It has been improved near boundaries of land and water.

The Hurricane WRF (HWRF) had its initial implementation in the 2007 Atlantic season. In future seasons, it will be coupled to HYCOM ocean model and the multi-grid wave model.

The Multi-grid WAVEWATCH III wave model has been developed to model full two-way interactions between an arbitrary number of grids with an arbitrary number of resolutions in order to model offshore and coastal areas as well as for hurricane coupling.

The Real-Time Ocean Forecast System (RT-OFS) provides full ocean prediction for the Atlantic Ocean. It uses the collaborative HYCOM dynamical ocean model.

6. MEMBERSHIP OF THE WGNE

Membership of the WGNE was determined by consultation between the Chair of the JSC-WCRP and the President of CAS. The JSC-WCRP at its 28th session in Zanzibar in 2007 approved nominations of new members or renewals of terms of appointment of current members as appropriate, with effect from 1 January 2008. The terms of D. Majewski and Y. Takeuchi, which would expire on 31 December 2007, were each extended by two years. The term of K. Puri which would expire on 31 December 2007, was extended by one year. A. Lorenc, M. Déqué and Dehui Chen would be stepping down at the end of their terms in 31 December 2007. A. Brown (UK Met Office), F. Rabier (Meteorological Service of Canada) and Xueshun Shen (Chinese Meteorological Administration) were appointed new members for a four-year term beginning 1 January 2008. Following his appointment as WWRP Chair, G. Brunet desired to stand down immediately. P. Gauthier, (Meteorological Service of Canada) was appointed in his place. The composition of the group effective 1 January 2008 will be:

Membership	Expiry of appointment
M. Miller (Chair)	31 December 2008
P. Gauthier	" 2010
J. Hack	" 2009
M. Iredell	" 2009
D. Majewski	" 2009
K. Puri	" 2008
F. Rabier	" 2011
A. Brown	" 2011
P.L. Silva Dias	" 2008
Y. Takeuchi	" 2009
M. Tolstykh	" 2009
Xueshun Shen	" 2011

7. OTHER WGNE ACTIVITIES AND FUTURE EVENTS

7.1 Publications

A key WGNE publication for many years has been the WGNE "blue cover" numerical experimentation report series, which continues to be popular with the modelling community and is prepared on behalf of WGNE by Recherche en Prévision Numérique (RPN), Montreal since its inception. WGNE thanked the RPN for printing and distributing the WGNE 'Blue book' numerical experimentation series, the annual summary of research activities in atmospheric and oceanic modelling (No. 37, produced in April 2007). The web-based publication is now well established and most contributions were submitted through the web site www.cmc.ec.gc.ca/rpn/wgne and a few still as an attachment to an e-mail message. Overall the electronic submissions are working well and make possible the production of this report on the web site. A paper version is no longer produced. This is also linked to the WCRP website: http://www.wmo.ch/web/wcrp/wcrp-home.html.

7.2 WGNE Web site

The WGNE web site, hosted by The Canadian Meteorological centre, is now working (http://collaboration.cmc.ec.gc.ca/science/wgne/). It is password-protected. WGNE thanked the Canadian Meteorological Centre for their efforts.

7.3 Next session of WGNE

At the kind invitation of the Canadian Meteorological Centre (CMC), the next session of the WGNE, the twenty-fourth, will be held in Montreal, Canada, 3-7 November 2008.

8. CLOSURE OF SESSION

The Chair of WGNE thanked all participants for their contributions to the session and for the high level of scientific discussions. The Chair also acknowledged the excellent scientific presentations that had been given to the Session on '' Shanghai Multi-hazard Early Warning System Demonstration Project'' by Dr Xu Tang, Director, Director-general, Shanghai Regional Center China Meteorological Administration, on ''Research activities in Climate Simulation, Monsoon Study and NWP at LASG/IAP'' by Dr Bin Wang, Director, LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, on ''Recent development of NWP systems (weather and climate modelling) in CMA'' by Dr Xueshun Shen, and ''Tropical NWP development and operation in Typhoon research institute of Shanghai Meteorological Bureau'' by Dr Xudong Liang.

Finally, on behalf of all the participants, the Chairs of WGNE and GMPP expressed their appreciation to the Chinese Academy of Meteorological sciences (CAMS) and the Chinese Meteorological Administration (CMA), the Shanghai Regional Meteorological Center of CMA and the Shanghai Meteorological Bureau for hosting this session of WGNE and the excellent facilities and hospitality offered. The opportunity of interacting with many scientists and experts at the CAMS and CMA had been very valuable. Sincere gratitude was voiced to Dr Dehui Chen and supporting staff for the excellent arrangements, unstinting assistance, and refreshments that had been provided.

The twenty-third session of WGNE was closed at 1300 hours on 26 October 2007.

Appendix A

List of participants to WGNE-23/GMPP-10
Shanghai, China, 22-26 October 2007

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Appendix B

WGNE-23 and GMPP-10
22-26 October 2007, Shanghai Met Bureau
Recommendations, Actions

Agenda item	Subject	Recommendation	Responsibility
1.3	**Report from the GEWEX Scientific Steering Group, including matters relevant to the development and status of the GMPP**	WGNE was informed of plans for engaging the social science community in hydrological applications. The Task Force on Seasonal prediction (TFSP) is addressing this issue for the seasonal time scale. WGNE proposed that hydrological and precipitation validation could be linked to basin catchment scale as at least one Centre was working on this and WGNE could contribute by providing guidance from operational centres and through the JWGV.	Chairs, JWGV, GMPP, NWP centres,
1.4	**Data assimilation activity within WCRP. Observing systems and results of OSEs, also CBS work.**	WGNE was informed of plans to hold the next (Fifth) WMO Data assimilation symposium in Melbourne, Australia, in 2009. WGNE noted that two other international symposia are planned in Australia for the same period. WGNE requested Dr K. Puri to discuss the situation back in Australia and try to resolve the issue. Dr P. Gauthier was nominated the WGNE representative for the DA Symposium.	Dr K. Puri D/AREP Dr P. Gauthier
2.2	**General report on WWRP and THORPEX**	WGNE noted that WWRP's list of objectives included study of impact of climate change on tropical cyclones. WGNE expressed surprise as this was surely WCRP's task and not WWRP's. (Since the weather research rather than the climate research community is most suited to addressing questions about the effect of past climate change on tropical cyclones and the adequacy of observations in detecting change, the JSC-WWRP endorses the leadership WGTMR in organizing a workshop on the effects of climate change on tropical cyclones. Cooperation with other working groups of WWRP and the climate research community should be included. It is proposed that this collaborative effort is discussed in the weather-climate prediction white paper.)	Chair, WWRP
2.3	**TIGGE, IPY and other WG meetings**	WGNE noted WMO's keen interest in TIGGE Phase2. However WGNE noted that there were issues regarding intellectual property rights to be addressed in TIGGE phase 2. WGNE noted the continuing progress with the plans for T-PARC and the proposed Winter T-PARC also. The promise that data would be put on the GTS was welcomed. WGNE was informed of the WCRP/WWRP Modelling Summit planned for May 2008 at ECMWF, UK. WGNE suggested that question 4 in the plans should include physical parameterizations as well as higher resolution. WGNE also suggested that Data Assimilation should also be addressed by the Summit not least because it is not known how to do DA for a global convection-permitting model.	Chair, WWRP

2.4	**CAS/AREP activities/interests in China**	WGNE thanked Dr Xu Tang for the excellent presentation on 'The Shanghai Multi-Hazard Early Warning System Demonstration Project' WGNE supported this ambitious and challenging programme which emphasises the value to society of high quality NWP products.	
2.8	**THORPEX and WCRP**	WGNE was informed of the two white papers prepared under WCRP/THORPEX collaboration. WGNE stressed the need to keep the contents of the white paper manageable and focused. WGNE noted that the Chairs of WGNE, WWRP and GMPP are involved in the selection of participants and speakers for the Modelling Summit. It was noted that the THORPEX plan for Europe lacked reference to model improvements/development. It also proposed that the European contribution should stress the important role of ECMWF.	Chairs of WGNE, WWRP, and GMPP
2.10	**Forecast systems and the MJO**	WGNE noted that the MJO WG plans for evaluating the forecasts of the MJO by the NWP centers needed real time information. WGNE requested Dr Puri to collaborate with Dr K. Sperber of the MJO WG to draft a formal letter to the Centres which would be signed and distributed by the WGNE Chair.	Dr K. Puri Chair, WGNE
2.13	**AMIP, CMIP and a report on the Systematic Errors workshop**	WGNE requested Dr Glecker to email the link to Systematic Errors workshop presentations etc. to all workshop participants. WGNE was presented a proposal for running AMIP-type high-resolution experiments for possible IPCC-AR5 experiments (for the 2xCO2, short term projections). WGNE considered that some NWP centres would do such simulations provided assurances that these would be properly processed were given. However, WGNE also noted that runs at high resolution may not address some modelling problems (e.g. monsoons).	Dr P. Glecker
3.2	**GCSS: Progress report including new results and case studies and the GPCI**	WGNE was concerned that the cirrus working group had failed to engage the GCM community and suggested that the GCSS Cirrus WG prepared a state of the art report on the problems and issues of cirrus clouds in GCMs, which might lead to a simple comparison experiment for cirrus. WGNE was pleased to note the large modelling participation in the GPCI and the progress made. WGNE noted the lack of observational data for the GPCI and the need to have analysis data sets from more than one Centre.	Chair, GCSS Chair, GMPP

3.9	**Discussion on priorities in parameterization development for CAS and WCRP**	Following extensive discussions it was agreed that a summary will be provided by the Chairs of WGNE and GMPP as a separate document	Chairs, WGNE and GMP
4.7	**Regional Climate modelling and future workshop**	WGNE was pleased to see the progress of the upcoming RCM workshop in Italy in March 2008 and the high levels of interest worldwide. WGNE welcomed the proposed RCM workshop in 2009 in Brazil and thanked Brazil and UK for their interest in this event. WGNE endorsed the view of the Chair of the JSC-WCRP that in supporting such events WCRP should not be seen to be advocating a specific model because a particular group organised/cosponsored a workshop. It should also be ensured that the limitations of RCM and its applications are made clear. WGNE stressed that these workshops should not be seen as one-off events but be built into a sustained cycle of WCRP's capacity building efforts in developing countries in addressing Regional Climate Modelling, and through establishing links with the climate modelling centres. WGNE agreed with the Chair of the JSC-WCRP that the there was a need for a dedicated group in view of the increasing importance of regional climate issues to WCRP stakeholders. WGNE agrees with the suggested name 'Working Group on Regional Downscaling Techniques'.	Dr C. Jones Director, WCRP Dr V. Satyan
4.8	**Report on the activities of the Joint Working Group on Verification including new ideas etc.**	The earlier discussions on basin-scale precipitation verification were noted as an action for the JWGV. The group would propose guidance for cloud verification efforts to NWP centres. WGNE suggested that the Chair, JWGV reviews membership of the Verification group, and does not restrict the renewal of memberships to a minimum as this causes problems in the medium-term.	Chair, JWGV WGNE Members
4.9	**Progress with Metrics for climate models**	WGNE noted with some concern that the issue of metrics for climate models is still ongoing,, with at least a minimum set of metrics remaining to be defined. WGNE asked that the ad hoc working group proposed two years earlier be revived, (including a member from WGCM). This group should discuss and establish this minimum set of metrics for the climate modelling community. WGNE suggested that such a list should be proposed as part of a future AR5.	P. Gleckler
4.10	**Inter-comparison of typhoon track forecasts**	WGNE expressed satisfaction that this WGNE effort has evolved and progressed very well over the years and thanked the participants and particularly the JMA which has led this effort. WGNE urged that the data from this effort should be made more widely available to promote research.	Y. Takeuchi

Appendix C

AGENDA
WGNE-23 and GMPP-10, 22-26 October 2007
Shanghai Met Bureau

Monday 22 October

Agenda Item	Subject	Responsibility/ introductory speaker
0900-1045		
	Opening welcome and local arrangements, etc.	Chair, WGNE Chen Dehui
1.1	Adoption of Agenda	Chair, WGNE
1.2	WGNE and the last JSC-WCRP meeting	V. Satyan
	Other WGNE matters	Chair, WGNE
	Report on the WCRP observations and assimilation Panel (WOAP)	A. Lorenc
1.3	Report from the GEWEX Scientific Steering Group, including matters relevant to the development and status of the GMPP	C. Jakob
1045-1100	Coffee	
1100-1230		
1.4	Data assimilation activity within WCRP. Observing systems and results of OSEs, also CBS work.	A. Lorenc
1.5	Progress in climate simulation and numerical weather prediction in LASG/IAP and introduction of AMY08	B. Wang
1.6	Recent developments at operational forecasting Centres	Participants
1230-1330	**Lunch**	
1330-1530		
	Recent developments at operational forecasting Centres (continued)	Participants
1530-1545	**Coffee**	
1545-1730		
	Recent developments at operational forecasting Centres (continued)	Participants

Tuesday 23 October

Agenda Item	Subject	Responsibility/ introductory speaker
0900-1045		
2.1	Relevant activities under CAS auspices	G. Brunet
2.2	General report on WWRP and THORPEX	G. Brunet
2.3	TIGGE, IPY and other WG meetings	G. Brunet
2.4	CAS/AREP activities/interests in China	G. Brunet
1045-1100	**Coffee**	
1100-1230		
2.5	Introduction to DRR MHEWS project of WWRP/WMO	S. Tang
2.6	THORPEX Pacific-Asia Regional Campaign	P. Gauthier
2.7	Other THORPEX Regional plans	K. Puri and D. Majewski
2.8	THORPEX and WCRP	G. Brunet
1230-1330	**Lunch**	
1330-1530		
2.9	Tropical NWP development and operations At the Typhoon Research Institute	X. Liang
2.10	Forecast systems and the MJO	Participants
2.11	Year of tropical convection	C. Jakob and participant discussions
1530-1545	**Coffee**	
1545-1730		
2.12	An overview of recent developments/activities in monthly and seasonal forecasting including report the Barcelona meeting	M. Déqué and participants
2.13	AMIP, CMIP and a report on the Systematic Errors workshop	P. Gleckler

Wednesday 24 October

Agenda Item	Subject	Responsibility/ Introductory speaker
0900-1045		
3.1	GMPP: Progress and future activities	C. Jakob
3.2	GCSS: Progress report including new results and case studies and the GPCI	P. Siebesma
1045-1100	**Coffee**	
1100-1230		
3.3	GLASS and GABLS: progress reports	C. Jakob
3.4	A new GCSS collaboration with CFMIP2 and the possible involvement of WGNE members	P. Siebesma
1230-1330	**Lunch**	
1330-1530		
3.5	Land-surface parametrization and data assimilation: Future soil moisture data from space	P. van Oevelen
3.6	Land-surface parametrization and data assimilation: Status at the centres	Participants
3.7	Land-surface parametrization and data assimilation: Discussion	All
1530-1545	**Coffee**	
1545-1730		
3.8	Recent results from “field work” (CEOP, AMMA, TWP-ICE)	(C. Jakob can do some TWP-ICE)
3.9	Discussion on priorities in parametrization development for CAS and WCRP	Led by C. Jakob

Thursday 25 October

Agenda Item	Subject	Responsibility/ Introductory speaker
0900-1045		
4.1	Experience with convection-permitting models in NWP	M. Baldauf Participants
4.2	Other experiences, issues etc	Participants
4.3	Progress and plans in global ultra-high resolution modelling	Participants
4.4	New numerical developments and test cases	Participants
1045-1100	**Coffee**	
1100-1230		
4.5	Experience with EnKF and 4D-Var	P. Gauthier, A. Lorenc
4.6	Progress with Stretched-Grid Model Intercomparison Project (SGMIP)	M. Déqué
4.7	Regional Climate modelling and future workshop	C. Jones
1230-1330	**Lunch**	
1330-1530		
4.8	Report on the activities of the Joint Working Group on Verification including new ideas etc	B. Brown Participants
4.9	Progress with Metrics for climate models	P. Gleckler
4.10	Inter-comparison of typhoon track forecasts	Y. Takeuchi
1530-1545	**Coffee**	
1545-1730		
4.11	Trends in performances of the models of the main operational forecasting centres	M. Miller
4.12	Verification and comparison of precipitation forecasts at various centres	D. Majewski, M. Déqué, M. Iredell, K. Puri, Y .Takeuchi

Friday 26 October

Agenda Item	Subject	Responsibility/ introductory speaker
0900-1045		
5.1	Progress in reanalysis activities at NCEP, ECMWF, JMA and CPTEC	M. Iredell, M. Miller Y. Takeuchi, P. Silva Dias
5.2	Progress with SURFA	D. Majewski
5.3	"Transpose" AMIP: status of project	D. Williamson
5.4	Report on the APE (Aqua-planet Experiment)	D. Williamson
1045-1100	**Coffee**	
1100-1300		
5.5	Plans or results from national climate or global change modelling programmes, in particular updated reports on the "Earth Simulator Programme" in Japan; steps towards a unified weather prediction and climate simulation framework in the USA, PRISM, ESMF	Y. Takeuchi J. Hack K. Puri A. Lorenc and others as appropriate
5.6	Outstanding items and actions	Chair, WGNE V. Satyan
5.7	Arrangements for publication of the 2007 edition of "Research Activities in Atmospheric and Oceanic Modelling"	P. Gauthier
	WGNE Web page	V. Satyan
	Venue for WGNE 2008	Chair, WGNE
	Close of session	V. Satyan
1300	**Lunch**	

Appendix D

WGNE List of Operational Global Numerical Weather Prediction Systems (as of January 2008)

Forecast Centre (Country)	Computer (Peak in TFlop/s)	High resolution Model (FC Range in days)	Ensemble Model (FC Range in days)	Type of Data Assimilation
ECMWF (Europe)	IBM p575, 2x150 nodes (36.5)	T_L799 L91 (10)	T_L399 L62; (10) T_L255 L62 (+5)	4D-Var (T_L255)
Met Office (UK)	NEC SX6, 34 nodes NEC SX8 25 nodes (5)	~40km L50 (6)	~90km L38; M24 (3)	4D-Var (~120km)
Météo-France (France)	NEC SX8R (2x4.5)	T_L358 (C2.4) L46 (4)	T_L358(C2.4) L46; M11 (2.5)	4D-Var (T_L149)
DWD (Germany)	IBM p575; 2x52 nodes (2x3.1)	40 km L40 (7)	No global EPS	3D-OI
HMC (Russia)	Itanium 4x4; Xeon 2x4 (0.10; 0.028)	T85 L31 (10); 0.72°x0.9° L28 (10)	No global EPS	3D-OI
NCEP (USA)	IBM pSeries 5 575 (2x18)	T382 L64 (7.5) T190 L64 (16)	T126 L28; M88 (20/cycle) (16)	3D-Var (T382)
Navy/FNMOC/NRL (USA)	SGI and IBM (800 proc) (3.2)	T239 L30 (6)	T119 L30; M16 (10)	3D-Var
CMC (Canada)	IBM p575, 2X40 nodes (9.6)	~35 km L58 (10)	GEM (0.9°) L28; M20 (16)	Det: 4D-Var (T108) EPS: EnKF M96 (0.9°)
CPTEC/INPE (Brazil)	NEC SX6, 12 nodes (0.768) NEC/SUN 1100 Opteron Cluster (5.72)	T299L64 (7); T126L28 Coupled (30)	T126 L28; M15 (15)	3D-Var
JMA (Japan)	Hitachi SR11000-K1, 2*80 nodes (21.5)	T_L959 L60 (9)	T_L319L60; M51 (9)	4D-Var (T159)
CMA (China)	IBM p655/p690: 21 (SW1: 0.384)	T_L639 L60 (10)	T213 L31; M15 (10)	3D-VAR
KMA (Korea)	Cray X1E-8/1024-L (18.4)	T426 L40 (10)	T213 L40; M32 (17/cycle) (10)	3D-Var
NCMRWF (India)	Cray X1E-64 processor (1.1)	T254 L64 (7)	T80 L18; M8 (7)	3D-Var
BMRC (Australia)	NEC SX6, 28 nodes (1.792)	T_L239 **L60** (10)	T_L119 L19; M33 (10)	3D-OI

WGNE Overview of Plans at the NWP Centres with Global Forecasting Systems
Part I: Computer (Peak Performance in TFlop/s)
Note: Sustained performance is 6 – 15% of peak for RISC and 25 – 35% for vector computers

Forecast Centre (Country)	2008	2009	2010	2011	2012	2013
ECMWF (Europe)	2x18.2	2x145	2x145	2X245	2X245	tbd
Met Office (UK)	5	2*24	2*24	2*40	tbd	tbd
Météo-France (France)	9	9	28	28	tbd	tbd
DWD (Germany)	2x3.1	2x15	2x45	2x45	2x45	tbd
HMC (Russia)	11.6 (end of year)	11.6	11.6	11.6	11.6	tbd
NCEP (USA)	2x18	2x18	2x54	2x54	2x162	2x162
Navy/FNMOC/NRL (USA)	20	35	50	65	80	100
CMC (Canada)	2x4.8	2x9.6	2x14.4	tbd	tbd	tbd
CPTEC/INPE (Brazil)	20	20	40	40	40	tbd
JMA (Japan)	2x10.75	2x10.75	2x10.75	2 x 10.75	tbd	tbd
CMA (China)	IBM-21 SW1-0.384	IBM-21 SW2-50	IBM-21 SW2-50	IBM-21 SW2-50	IBM-21 SW2-50	tbd
KMA (Korea)	2x9.2	2x9.2 2x20	18.4 2x20	2x100	2x100	tbd
NCMRWF (India)	20	20	20	tbd	tbd	tbd
BMRC (Australia)	2x3(+) (sustained)	2x3(+) (sustained)	2x3(+) (sustained)	2x3(+) x 2(+) (sustained)	tbd	tbd

WGNE Overview of Plans at NWP Centres with Global Forecasting Systems

Part II: Global Modelling

a) Deterministic Model (Resolution and number of layers)

Forecast Centre (Country)	2008	2009	2010	2011	2012	2013
ECMWF (Europe)	T_L799 L91	T_L799 L91	T_L1279 L91	T_L1279 L130	T_L1279 L130	
Met Office (UK)	40 km L70	25 km L70	25 km L70	20 km L90	tbd	
Météo-France (France)	T538c2.4 L60	T538c2.4 L60	T799c2.4 L90	T799c2.4 L90	tbd	tbd
DWD (Germany)	40 km L40	20 km L60	20 km L60	15 km L70	15 km L70	tbd
HMC (Russia)	T85 L31; 0.72°x0.9° L28	T169 L31; 0.48°x0.56° L48	T339 L63; 0.48°x0.56° L48	T339L63; 0.24˚x28˚L60	tbd	tbd
NCEP (USA)	T382 L64 (7.5) T190 L64 (16)	T382 L64 (7.5) T190 L64 (16)	25 km L90	25 km L90	25 km L90	25 km L90
Navy/FNMOC/NRL (USA)	T239L30	T479 L60	T479 L60	T479 L60	T511 L64	T511 L64
CMC (Canada)	35 km L80	35 km L80	25 km L80	25 km L80	15 km L80	
CPTEC/INPE (Brazil)	30 km L96	20 km L96	20 km L96	10 km L96	10 km L96	
JMA (Japan)	T_L959 L60	T_L959 L60	T_L959 L60	T_L959 L60	tbd	tbd
CMA (China)	T_L639 L60 GRAPES 50 km L31	T_L639 L60 GRAPES 50 km L61	GRAPES 25 km L61	GRAPES 25 km L81	GRAPES 25 km L81	
KMA (Korea)	T426 L40	T426 L40	20km L70	20km L70	20km L70	20km L90
NCMRWF (India)	T254 L64	T382 L64	T382 L64	tbd	tbd	
BMRC (Australia)	Met Office UM 80km L50 or L70	Increased resolutions (tbd)	tbd	tbd	tbd	

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Part II: Global Modelling

b) Global Ensemble Prediction System (Resolution, number of layers, number of members, forecast range in days)

Forecast Centre (Country)	2008	2009	2010	2011	2012	2013
ECMWF (Europe)	T399/T255 L62; M 51; 15; change of res. at day 10	T399/T255 L62; M 51; 15; change of res. at day 10	T639L91?? Change of resolution to be determined	T639L91?? Change of resolution to be determined	tbd	
Met Office (UK)	~90 km L38; M24; 3	~60 km L70; M24; 3	~60 km L70; M24; 3	~60 km L90; M24; 3	tbd	
Météo-France (France)	T538c2.4 L55; M11; 3days	T538c2.4 L55; M40 3days	T799c2.4 L55; M40; 3days	T799c2.4 L55; M40; 3days	tbd	
DWD (Germany)	No EPS	No EPS	~40 km L40; M20; 1	~40 km L40; M20; 1	~40 km L40; M20; 1	
HMC (Russia)	T85 L31; M20; 10	T85 L31; M30; 10	(T85L31+ 0.72°x0.9°L28); M60; 10	(T85L31+ 0.72°x0.9°L28); M60; 10	tbd	Tbd
NCEP (USA)	T190 L28; M88; 20/cycle; 16 days	T190 L28; M88; 20/cycle; 16 days	50 km L45; M88; 16	50 km L45; M88; 16	50 km L45; M88; 16	50 km L45; M88; 16
Navy/FNMOC/NRL (USA)	T119 L30; M16; 10	T119 L30; M32; 15	T239 L30; M32; 15	T319 L40; M32; 15	T319L40: M32;15	T319L40: M64;15
CMC (Canada)	GEM (0.9°) L28 M20 16	GEM (0.9°) L45 M20 16	GEM 500x375 L45 M20 16	tbd	tbd	
CPTEC/INPE (Brazil)	60 km, L42, M25; 15	50 km, L42, M40; 15	50 km, L42, M50; 15	40 km, L64, M60; 15	40 km, L64, M60; 15	
JMA (Japan)	T_L319 L60; M51; 9	T_L319 L60; M51; 9	T_L319 L60; M51; 9	T_L319 L60; M51; 9	tbd	Tbd
CMA (China)	T213 L31; M15 (BGM, 10)	T213 L31; M30 (BGM, 10)	T213 L31; M30 (BGM, 10) GRAPES 50 km M15, (SV, 10)	GRAPES 50 km M30, (SV, 10)	GRAPES 50 km M30, (SV, 10)	
KMA (Korea)	T213 L40; M34; 17/cycle; 10	T213 L40; M34; 17/cycle; 10	40km L70; M34; 10	40km L70; M34; 10	40km L70; M34; 10	40km L90; M34; 10
NCMRWF (India)	T80 L18; 16; 8	T126 L64; 8; 7	T126 L64; 16; 7	tbd	Tbd	
BMRC (Australia)	TL119 L19; M33; 10	Met Office MOGREPS Resolution tbd	tbd	tbd	tbd	

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Part II: Global Modelling

c) Global Data Assimilation Scheme (Type, resolution, number of layers)

Forecast Centre (Country)	2008	2009	2010	2011	2012	2013
ECMWF (Europe)	4D-Var; T_L799 with T255 final inner loop; L91	4D-Var; T_L799 with T255 final inner loop; L91	4D-Var; T_L1279 with T_L399 final inner loop; L91?	4D-Var; T_L1279 with T_L399 final inner loop; L130?	4D-Var; T_L1279 with T_L399 final inner loop; L130?	
Met Office (UK)	4D-Var; 120 km; L70	4D-Var; 75 km; L70	4D-Var; 75 km; L70	4D-Var; 60 km; L90	tbd	
Météo-France (France)	4D-Var; T224; L60	4D-Var+ensemble; T224: L60	4D-Var+ensemble; T350; L90	4D-Var+ensemble; T350; L90	tbd	
DWD (Germany)	OI; 40 km; L40	3D-Var; 20 km; L60	3D-Var+ensemble; 20 km; L60	3D-Var+ensemble; 20 km; L60	3D-Var+ensemble; 20 km; L60	tbd
HMC (Russia)	OI; 0.72°x0.9°; L28	OI; 0.72°x0.9°L28	3D-Var; 0.48°x0.56°L48	tbd	tbd	tbd
NCEP (USA)	Advanced-Var; T382; L64	Advanced-Var; T382; L64	4D-Var; 25 km	4D-Var; 25 km	4D-Var; 25 km	4D-Var; 25 km
Navy/FNMOC/NRL (USA)	3D-Var; T239; L30	4D-Var T479L60 outer lp T119L60 inner lp	4D-Var T479L60 outer lp T119L60 inner lp	4D-Var T479L60 outer lp T159L60 inner lp	tbd	tbd
CMC (Canada)	4D-Var; T108, 35 km; L58	4D-Var T108, 35 km; L80	4D-Var T200, 35 km; L80	tbd	tbd	
CPTEC/INPE (Brazil)	LENKF; 40 km	LENKF; 40 km	LENKF; 40 km	LENKF; 20 km	LENKF; 20 km	
JMA (Japan)	4D-Var; T159; L60	4D-Var; T159; L60	4D-Var; T_L319; L60	4D-Var; T_L319; L60	tbd	tbd
CMA (China)	SSI GRAPES_3DVar 100 km; L31	SSI GRAPES_3DVar 100km; L31	GRAPES_4DVar 100km; L61	4DVAR/EnKF 100km;L61	4DVAR/EnKF 100km;L61	
KMA (Korea)	3D-Var; T106; L40	3D-Var; T106; L40	4D-Var; 60km; L70	4D-Var; 60km; L70	4D-Var; 60km; L70	Hybrid4dVar 60km; L90
NCMRWF (India)	3D-Var; T254; L64	3D-Var; T382; L64	3D-Var; T382; L64	tbd	tbd	
BMRC (Australia)	Met Office 4D-Var 120km L50 or L70	Increased resolutions (tbd)	tbd	tbd	tbd	

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Part III: Regional Modelling

a) Deterministic Model (Number of gridpoints, resolution, number of layers)

Forecast Centre (Country)	2008	2009	2010	2011	2012	2013
ECMWF (Europe)	-	-	-	-	-	-
Met Office (UK)	600*360; 12 km; L70 288*360; 4 km; L70	600*360; 12 km; L70 768*960; 1.5 km; L70	600*360; 12 km; L70 768*960; 1.5 km; L70	600*360; 12 km; L90 768*960; 1.5 km; L70	tbd	
Météo-France (France)	600x500; 2.5 km; L46	600x500; 2.5 km; L60	800x800; 2.5 km; L60	800x800; 2.5 km; L60	tbd	tbd
DWD (Germany)	665x657; 7 km; L40 421x461; 2.8 km; L50	665x657; 7 km; L40 421x461; 2.8 km; L50	665x657; 7 km; L40 421x461; 2.8 km; L50	local zooming 421x461; 2.8 km; L50	local zooming 421x461; 2.8 km; L50	tbd
HMC (Russia)	Var. Res.; 30 km over Russia; L28	600x347; 7 km; L40	600x347; 7 km; L40	tbd	tbd	
NCEP (USA)	726x1287; 12km; L60 720x1011; 4 km; L50	726x1287; 12km; L60 720x1011; 4 km; L50	726x1287; 12km; L64 863x1127 4 km; L64 525x751 4 km;L64 3 km; L55	726x1287; 12km; L64 863x1127 4 km; L64 525x751 4 km;L64 3 km; L55	966x1712; 9 km; L64 1148x1500 3 km; L64 698x999 3 km;L64 2 km; L64	966x1712; 9 km; L64 1148x1500 3 km; L64 698x999 3 km;L64 2 km; L64
Navy/FNMOC/NRL (USA)	27/9/3 km; L40	27/9/3 km; L60	9/3/1 km; L60	9/3/1 km; L60	9/3/1 km; L60	tbd
CMC (Canada)	15 km; L58 4 LAMs at 2.5°; L58	10 km; L58 4 LAMs at 2.5°; L58	10 km; L? 5 2.5°; L?	tbd	tbd	
CPTEC/INPE (Brazil)	1001x2101, 5 km; L60	1001x2101, 5 km; L80	1001x2101, 5 km; L80	2001x4201, 2.5 km; L80	2001x4201, 2.5 km; L80	
JMA (Japan)	721x577; 5 km; L50	721x577; 5 km; L50	721x577; 5 km; L50	721x577; 5 km; L50	tbd	tbd
CMA (China)	502x330, GRAPES-15kmL50	1200x800, GRAPES-5kmL50	2100x1300, GRAPES-2.5kmL60	2100x1300, GRAPES-2.5kmL60	2100x1300, GRAPES-2.5kmL60	
KMA (Korea)	513x573; 10 km; L40	513x573; 10 km; L40	5 km; L70 1.5 km; L70	5 km; L70 1.5 km; L70	5 km; L70 1.5 km; L70	5 km; L90 1.5 km; L90
NCMRWF (India	27km; L38	27km, L38 10km, L38	27km, L38 10km, L38	Tbd	tbd	
BMRC (Australia)	Met Office UM Resolutions similar to current operational systems	Increased resolutions (tbd)	tbd	tbd	tbd	

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Part III: Regional Modelling

b) Regional Ensemble Prediction System (Resolution, number of members, forecast range in days)

Forecast Centre (Country)	2008	2009	2010	2011	2012	2013
ECMWF (Europe)	-	-	-	-	-	-
Met Office (UK)	25 km; M24; 2	16 km; M24; 2	16 km; M24; 2	16 km; M24; 2 1.5 km; M6; 1	tbd	
Météo-France (France)	15km; M11; 2.5	15km; M40; 2.5	15 km; M40; 2.5	5 km; M40; 2.5	tbd	tbd
DWD (Germany)	No regional EPS	2.8 km; M20; 1	2.8 km; M20; 1	2.8 km; M40; 1	2.8 km; M40; 1	tbd
HMC (Russia)	No regional EPS	No regional EPS	No regional EPS	tbd	tbd	tbd
NCEP (USA)	32 km; M21; 3.625	32 km; M21; 3.625	26 km; M25; 3.625	26 km; M25; 3.625	20 km; M25; 4	20 km; M25; 4
Navy/FNMOC/NRL (USA)	No regional EPS	45/15 km; M10; 2	45/15 km; M20; 3	45/15 km; M30; 3	27/9 km; M30; 3	tbd
CMC (Canada)	No regional EPS	No regional EPS	No regional EPS	tbd	tbd	
CPTEC/INPE (Brazil)	15 km; M15; 5	15 km; M21; 5	15 km; M21; 5	10 km; M21; 5	10 km, M21, 5	
JMA (Japan)	T_L319 L60; M11; 4times/day; 5	T_L319 L60; M11; 4times/day; 5	T_L319 L60; M11; 4times/day; 5	T_L319 L60; M11; 4times/day; 5	tbd	tbd
CMA (China)	GRAPES-30 km, M15, 2.5	GRAPES-15 km, M17, 2.5	GRAPES-10 km, M17, 2.5	GRAPES-10 km, M21, 2.5	GRAPES-10 km, M21, 2.5	
KMA (Korea)	No regional EPS	No regional EPS	10 km; M20; 3	10 km; M20; 3	10 km; M20; 3	10 km; M20; 3
NCMRWF (India	No regional EPS	No regional EPS	No regional EPS	No regional EPS	No regional EPS	
BMRC (Australia)	No regional EPS	Met Office MOGREPS Resolution tbd	tbd	tbd	tbd	

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Part III: Regional Modelling

c) Regional Data Assimilation Scheme (Type and resolution)

Forecast Centre (Country)	2008	2009	2010	2011	2012	2013
ECMWF (Europe)	-	-	-	-	-	-
Met Office (UK)	4D-Var, 36 km 3D-Var + nudging, 4 km	4D-Var, 24 km 3D-Var + LH nudging, 1.5 km	4D-Var, 24 km 3D-Var + LH nudging, 1.5 km	4D-Var, 24 km 4D-Var, 4 km?	tbd	
Météo-France (France)	3D-Var; 2.5 km	3D-Var; 2.5 km	3D/4D-Var; 2.5 km	3D/4D-Var; 2.5 km	tbd	tbd
DWD (Germany)	nudging; 7 km nudging; 2.8 km	nudging; 7 km nudging; 2.8 km	Ensemble based	Ensemble based	Ensemble based	Ensemble based
HMC (Russia)			3D-Var	3D-Var	tbd	tbd
NCEP (USA)	Advanced-Var; 12 km	Advanced-Var; 12 km	4D-Var; 12/4 km	4D-Var; 12/4 km	4D-Var; 9/3 km	4D-Var; 9/3 km
Navy/FNMOC/NRL (USA)	3D-Var; 27/9/3 km	3D-Var; 27/9/3 km	4D-Var; 9/3/1 km	4D-Var / EnKF 9/3/1 km	tbd	tbd
CMC (Canada)	3D-Var; T108, 15 km; L58	3D-Var FGAT LAM 55 km; 15 km,L80	4D-Var FGAT LAM 55 km; 15 km,L80	4D-Var FGAT LAM 55 km; 15 km,L80	4D-Var FGAT LAM 55 km; 15 km,L80	
CPTEC/INPE (Brazil)	LENKF; 20 km	LENKF; 20 km	LENKF; 20 km	LENKF; 10 km	LENKF; 10 km	
JMA (Japan)	4D-Var, 15 km	4D-Var, 15 km	4D-Var, 15 km	4D-Var, 15 km	tbd	tbd
CMA (China)	GRAPES-4DVAR, 30 km	GRAPES-4DVAR, 20 km	GRAPES-4DVAR, 20 km or EnKF	GRAPES-4DVAR, 15 km or EnKF	GRAPES-4DVAR, 15 km or EnKF	
KMA (Korea)	3D-Var 10 km	3D-Var 10 km	4D-Var 15 km	4D-Var 15 km	4D-Var 15 km	4D-Var 15 km
NCMRWF (India	3D-Var	3D-Var	3D-Var	Tbd	tbd	
BMRC (Australia)	Met Office 4D-Var L50 or L70	Increased resolutions (tbd)	tbd	tbd	tbd	