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REPORT OF THE TWENTY SECOND SESSION OF THE CAS/JSC WORKING GROUP ON NUMERICAL EXPERIMENTATION

(National Centre for Atmospheric Research, Boulder, USA, 25-27 October 2006)

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The twenty-second session of the CAS/JSC Working Group on Numerical Experimentation (WGNE), was kindly hosted by National Centre for Atmospheric Research, Boulder, USA, 25-27 October 2006. The session was opened at 0900 hours on 25 October by the Chair of WGNE, Dr M. Miller. There was ajoint session with the WCRP Modelling Panel (WMP) on 24 October. The list of participants in the session is given in the Appendix A.

Dr D.Williamson, the local host and former member of WGNE, welcomed the participants on behalf of Dr T. Kileen, Director, NCAR. On behalf of all participants, Dr Miller expressed his thanks to Dr Kileen, and Dr Williamson for hosting this session of WGNE and the excellent arrangements made. He expressed his appreciation also to the staff of National Centre for Atmospheric Research, for the efforts and time they had put into the organization of the session.

The Chair continued by extending his greetings to the participants in the session. He welcomed Dr M. Beland, President, Commission for Atmospheric Science (CAS). The Chair was pleased to welcome the invited experts.

ROLE OF WGNE IN SUPPORT OF WCRP AND CAS

WGNE, as a joint working group of the JSC and CAS, has the basic responsibility of fostering the development of atmospheric models for use in weather prediction and climate 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 WCRP Global Energy and Water Cycle Experiment (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 WMP, with WGNE represented on WOAP also. WGNE also has specific THORPEX sessions at its meetings. The close relationship that exists between WGNE and operational (NWP) centres underpins many of the activities of WGNE, and it is the work of these centres that provides much of the impetus for the development and refinement of the physics and dynamics of atmospheric models.

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

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

V. Satyan briefed the session on the relevant main recommendations from the twenty-seventh session of the JSC, Pune, India, 6-11 March 2006:

- JSC appreciated the continued progress by WGNE and reiterated its support to the Systematic Errors Workshop planned for February 2007 in San Francisco, USA.
- JSC strongly endorsed the WGNE/GCSS proposal on a coordinated effort on convection (and associated physics). JSC observed that convection is central to many problems in current modelling efforts on almost all space and time scales and that it cuts across most WCRP groups. As a next step, JSC suggested that a small group consisting of Chair of WGNE, Co Chairs of WGCM and Dr.T.Palmer should discuss this proposal.
- JSC supported WGNE's proposal to strengthen membership in ensemble prediction and /or coupled modelling.
- JSC expressed the view that the CLIVAR and GEWEX monsoon panels should work more closely together. CLIVAR and GEWEX (with SPARC and CliC) should establish focal points (with a JSC Representative) to define how to bring the monsoon studies into a more coordinated program for discussion at next JSC. WMP should coordinate the modelling parts of the two projects together with SPARC and CEOP. JSC strongly supported WGNE and THORPEX participation in these activities, particularly in the focus on the diurnal cycle.
- JSC urged CliC to take steps to provide inputs to modelling groups with a view to improving collaborations and the transfer of new modules to WGCM, WGNE, WGSIP, WMP and TFSP.
- JSC supported joint meeting of WGSF with WGNE on SURFA in Boulder (October 2006) and the joint meeting of WGSF representatives with SOLAS in Heidelberg (September 2006).

1.2 First session of the WCRP observations and assimilation Panel (WOAP)

A.Lorenc, WGNE representative on WOAP, reported on the WOAP meeting in Ispra, 28-30 August 2006. A summary is available from

http://copes.ipsl.jussieu.fr/Organization/COPESStructure/WGOA.htmlhttp://copes.ipsl.jussieu.fr/Organization/COPESStructure/WGOA.html

WOAP hopes that there will be increased attention on coupled data assimilation for climate studies in future, and requested WGNE's help in promoting this.

1.3 Report on the WGSIP meeting, 2006

M.Deque, WGNE representative on WGSIP, reported on a recent WGSIP meeting. The last WGSIP meeting took place in Wellington (NZ) in February 2006. A call for participation in the international reforecasting experiment has been sent by WCRP in summer 2006. The meeting to present the first results will take place in Barcelona in June 2007. There will be a WGNE presentation at this meeting with the results of the San Francisco meeting on Systematic Errors (M. Déqué and possibly T. Stockdale). The participation of seasonal forecast modellers in the Pacific cross-section intercomparison is encouraged by WGSIP.

1.4 Relevant Activities under Commission for Atmospheric Sciences (CAS)

M. Beland, the CAS President, made a presentation on CAS activities relevant to WGNE, including major outcomes of the Fourteenth Session of the WMO Commission for Atmospheric Sciences (CAS-XIV) held in Cape Town, South Africa, from 16 to 24 February 2006, and the major activities of WWRP-THORPEX in 2005/2006 as well as those related to research on nowcasting, mesoscale weather forecasting, tropical meteorology, verification and societal and economic applications of weather prediction, and WMO Sand and Dust Storm Early Warning System. The presentation was entitled "Improved High Impact Weather and Air Quality Forecasts, through Globally Coordinated Research: WMO WWRP-THORPEX".

In particular, the Group was informed that new Terms of Reference of the CAS identified main priorities in the implementation of Atmospheric Research and Environment Programme, which are GAW and the WWRP including THORPEX, with emphasis on the connection to climate research activities. The CAS-XIV adopted a new working structure and established two Open Programme Area Groups (OPAGs) on: (a) World Weather Research Programme (WWRP); and (b) Environmental Pollution and Atmospheric Chemistry (EPAC). It identified the main elements of the work programme within each OPAG and established working bodies.

The Group was particularly pleased with the progress made towards the development of the WWRP-THORPEX Interactive Grand Global Ensemble (TIGGE), which is a prototype for a multi-model ensemble forecast system that would guide the development of a possible Global Interactive Forecasting System (GIFS). In its first phase, TIGGE would provide to all WMO Members near-real-time access to ensemble forecast products for research purposes.

2. STUDIES AND COMPARISONS OF ATMOSPHERIC MODEL SIMULATIONS

2.1 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.

Atmospheric Model Intercomparison Project (AMIP)

The 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 has been the most important and far-reaching of the WGNE-sponsored intercomparisons.

P. Gleckler briefed the session on the developments at PCMDI. Regular updates of the overall status of AMIP, model integrations, diagnostic subprojects are posted on the AMIP home page http://www-pcmdi.llnl.gov/amip. Current priorities at PCMDI included evaluation of coupled models including WCRP Benchmark Intercomparisons CMIP, AMIP2, CAPT/Transpose AMIP, Climate Change Detection, and software development.

WGNE congratulated PCMDI for continuing to maintain and enhance a valuable infrastructure for processing model outputs at PCMDI and establishing efficient data formats etc for such exchanges of model simulations. The recent outstanding achievements in the context of the IPCC/AR4 are of particular note.

PCMDI has offered to receive high resolution NWP AMIP-type runs to complement their ongoing CMIP activities.

Systematic Errors Workshop

PCMDI is the local host for a pan-WCRP/CAS workshop on Model systematic errors in February 2007. This is being organized by PCMDI and WGNE with input from WGCM and GMPP, and the programme is structured by timescales to emphasis the 'seamlessness' of many model errors. See Appendix D for a report on the workshop.

Aqua-Planet Experiments (APE)

D.Williamson presented the report. WGNE continues to endorse the application of atmospheric models to very simplified surface conditions for the purpose of examining the behaviour of physical parameterizations and the interactions of parameterizations with the dynamical cores. In particular, "aqua-planet" experiments with a basic sea surface temperature distribution offer a useful vehicle in this regard. Thus one WGNE project is an intercomparison, the Aqua-Planet Experiment (APE), being led by staff from the University of Reading, NCAR and PCMDI. 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 session of the WGNE, a Workshop was held 20-22 April 2005 at the University of Reading, UK to discuss theresults, summarize current model behaviour 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.

Fourteen groups have now submitted their completed simulations to the APE database at the University of Reading. These data have been quality controlled, with minor problems corrected, and made available to the participating groups. Additional data are 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 is planned to be held in Choshi, Chiba, Japan in mid-November 2007. The workshop will review and discuss the diagnostic studies arising from the intercomparison and drafts of papers being prepared. 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. But any formal intercomparison will be considered a new project.

"Transpose" AMIP

Transpose AMIP is a WGNE proposal for the intercomparison of weather forecasts made by climate models being led by D. Williamson. 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. Development of a complete analysis system is not needed. Initial conditions can be obtained from NWP reanalyses. This WGNE initiative was initially prototyped/developed jointly by NCAR and PCMDI and is described in Phillips et al. (2004).

The formal announcement of Transpose AMIP and call for participation has been sent to a subset of the WCRP mailing lists. Six groups have declared their interest in participating. They are the Numerical Prediction Division, Japan Meteorological Agency; Department of Meteorology, Florida State University; the Climate Model Development and Evaluation group of the Hadley Centre; CSIRO, Australia; Experimental Climate Prediction Center, Scripps Institute of Oceanography; and NCAR.

Details of data exchange and schedule are being developed by the participants. The proposal is initially very modest and based on what can be realistically analyzed. 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 anticipated 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.

Any additional groups that are interested in participating should email David Williamson (wmson@ucar.ucar). It is not too late to join the effort.

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: 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: 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: JGR, Vol.110, D15S16, doi:10.1029/2004JD005109.

WGNE was pleased with the progress in the T-AMIP and to learn that the proposal had been sent to climate modelling groups and the model results are expected by March 2007 and reviewed at WGNE-23. WGNE asked its members to encourage participation by several more groups in the experiment.

2.2 Regional Climate Modelling

Proposal for a Regional Climate Modelling Workshop

C. Jones, Project Leader for the Canadian Regional Climate Modelling and Diagnostics Network and Regional Climate Modelling representative on the WGNE and GEWEX Modelling and Prediction Panel (GMPP), reported on a proposal to WMO and WCRP to sponsor a Regional Climate Modelling workshop, targeted to support and expand Regional Climate Modelling activities within developing nations.

In March 2004 WMO and WCRP sponsored a Workshop in Lund, Sweden titled: High-resolution climate modelling: Assessment, added value and applications. This workshop brought together many of the leading scientists in Regional Climate Modelling and explored a number of important issues in the field, including:

(i) Developing methods to better define the added-value offered by the increased resolution of Regional Climate Models (RCMs), relative to forcing Global Climate Models (GCMs).
(ii) Improving the performance of RCMs at the present and planned resolution of these models (~10-50km)
(iii) Identifying and supporting user-applications of RCMs in the fields of climate change impacts and adaptation and extended-range (seasonal) prediction.
(iv) Improving the dialogue between RCM groups and users of RCM results with a view to increasing the practical application of RCMs in the aforementioned fields.

This workshop was highly successful and helped define priority directions for RCM research and application over the following years. One outcome of this workshop was the creation of a WCRP-GEWEX Working Group: The Transferability Working Group. The remit of this group is to encourage the application and evaluation of RCMs in a variety of regions around the globe, with an aim to improve the overall performance and generality of RCMs outside of their native geographical regions.

Following the success of the Lund-2004 RCM meeting, the WGNE recommended that a follow up RCM workshop be organised. Initial discussions have taken place within the RCM community and with WCRP regarding the possible content and participation group of such a follow up workshop. *The views expressed in this* report *should be considered as preliminary in nature and may be modified as discussions with WMO, WCRP, WGNE, GEWEX and the wider RCM community continue.*

WCRP emphasised their wish that a follow-up RCM workshop engaged the existing and potential RCM science and user communities in developing nations. In particular, to investigate ways to support and expand RCM activities in developing nations and better identify and link with potential users of RCM simulations in these countries. This suggestion has received extremely strong support within the RCM community. Based on some preliminary discussions within this community 2 primary themes have been identified for such a follow up workshop:

1. Identify mechanisms by which the RCM science and user community can better support and expand Regional Modelling efforts in developing countries.
   This support should include:

   a. The provision of RCM simulations/predictions over specific developing nation areas to scientists in these countries for local evaluation and assessment.
   b. Practical support to scientists in developing nations to facilitate the use of RCMs directly within those countries, in order to build up a level of self-sufficiency in the field of regional climate modelling. Subsequent to this, ongoing collaboration around the use and development of RCMs should ensue.
   c. Assistance in identifying user groups requiring RCM simulations to support their efforts in regional climate impact assessment and adaptation. Furthermore, to provide practical experience in linking RCM simulations to the requirements of user groups in order to maximise the practical application of these simulations in local decision making.

2. RCM groups, in both developed and developing nations, should collaboratively work to evaluate and improve the performance of RCMs when applied over developing nations (mainly tropical and subtropical land regions) for the present and past climate.

   In doing this increased confidence will be gained in the application of these models for climate change projects and seasonal prediction. This activity fits with the aims of the GEWEX-Transferability Working Group (TWG) and would increase the practical use of research and development work made in the groups contributing to TWG. Furthermore, this activity would increase the critical mass of scientists with experience in running, diagnosing and improving RCMs in developing countries.

The RCM community felt that these 2 overarching goals were equally applicable both to regional climate change and extended-range (seasonal) prediction. Many of the key issues, pertaining to user needs and interaction, as well as model development are clearly common to both applications. Strong support for

this workshop has therefore come from RCM scientists engaged in both regional climate modelling and seasonal prediction.

A key element for such a workshop to succeed will be the active participation of a large number of scientists and members of the user community from developing nations. This will require strong financial support. Some preliminary discussions have taken place regarding the possible location and timing of this workshop. The first half of 2008 is suggested as a suitable date, allowing sufficient lead time to secure financial support and identify key persons and groups within developing nations that should be invited to such a workshop. A number of possible venues have also been suggested, with the Abdus Salam International Centre for Theoretical Physics (ICTP) being one centre that has offered to host this workshop. With its mandate to foster advanced research in developing countries, its wide experience in both supporting RCM usage in developing nations and in hosting such workshops, ICTP seems an ideal host and has received strong support in the RCM community.

The workshop proposal was discussed at the WGNE session. Subsequent to the support of this panel, WMO and WCRP, a more detailed plan will be developed in the fall of 2006.

WGNE thanked C.Jones for his presentation. WGNE welcomed the proposal for the follow up RCM Workshop in 2008 and strongly supported it. WGNE observed that the timing of the workshop was interesting as it would enable the scientists from the BARCA/LBA campaign (planned for early 2007) to contribute to the Workshop. WGNE appreciated the good tutorial part planned for the Workshop.

Stretched-Grid Model Intercomparison Project (SGMIP)

The Stretched-Grid Model Intercomparison Project (SGMIP) was presented by M.Deque.The SGMIP targets global atmospheric models with variable horizontal resolution used as an approach to regional climate modeling. It aims at comparing stretched-grid (SG) GCMs using different numerical techniques and producing an ensemble efficient regional downscaling to mesoscales over the US. The four participants are C-CAM from CSIRO (Australia), GEM GCM from RPN (Environment Canada), ARPEGE-climate from Météo-France and GEOS GCM from NASA/GSFC. Recently, the spectral-element CAM-SEAM (Baer, Tribbia, Taylor, Wang) from NCAR-UMD has joined the project.The first phase (SGMIP-1) has been completed in 2005. It consists of 12-year (1987-98) simulations with the SG models. A paper has been published with the results (Fox-Rabinovitz et al., JGR, 2006). The second phase (SGMIP-2) has started in 2006. It consists of 25-year (1979-2003) simulations with improved (i.e. more recent) versions of the SG model and two additional simulation with uniform grids (UG) of the respective models. The first one, intermediate UG, corresponds to the same number of grid points as the SG (~1°). As a consequence intermediate UG and SG have approximately the same computation cost. The second one, fine UG, corresponds to the maximum resolution of the SG (~0.5°). More information is available on the web site of SGMIP: http://essic.umd.edu/~foxrab/sgmip.html .

The preliminary conclusions of SGMIP-2, based on the available data (centralized at UMD) are:

- Comparison of SGMIP-1 and SGMIP-2 ensemble products: both global and regional errors and their maxima vs. observations or reanalyses are smaller for SGMIP-2 than for SGMIP-1
- Comparison of SG vs. intermediate UG ensemble mean GCM: over the U. S. region of interest, SG GCMs have smaller errors, calculated vs. observations or reanalyses, than intermediate UG GCMs; over the globe, both SG-GCMs and intermediate UG-GCMs produce high quality simulations with similar errors; SG-GCM errors are sometimes smaller
- Comparison of SG-GCM vs. Fine UG ensemble products: over the U. S. region of interest, SG GCMs and fine UG GCMs have similar errors vs. observations or reanalyses (sometimes SG better than UG). Over the globe, SG GCM and fine UG GCMs simulations are rather close, although the latter produce more mesoscale patterns outside the area of interest

The plans for the next phase (SGMIP-3) are to extend the SGMIP-2 protocol to future climate simulations and to compare the model responses on global scale to IPCC results from other GCMs and on the US to NARCCAP regional scenario. SGMIP-3 may be extended to other regions (e. g. Europe).

2.3 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. WGNE reiterated the value of the interaction with GMPP for parametrization work, particularly with GCSS. A joint WGNE/GCSS model intercomparison study of a Pacific cross section (GPCI) to evaluate physical parametrizations along the atmospheric cross section following the trade winds is in

progress, with excellent support from both NWP and climate modeling groups. The need for an expert group on parametrization to advise both WCRP and WWRP (and their Working Groups) was discussed, and further consideration will be given to this in consultation with the GMPP.

2.4 Overview of SURFA and WGSF

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.

There was a joint session at WGNE-22 with the WCRP Working Group on Surface Fluxes (WGSF). Representatives of the WGSF (C.Fairall, E.C.Kent, A.Bentamy, and H.Zhang) gave a series of talks at the WGNE meeting in Boulder to put SURFA into context. The purpose was to devejop a new proposal to initiate the SURFA project with an archive at NOAA National Climate Data Center (NCDC).

SURFA was originally conceived in 2000 as a WGNE project to improve NWP and GCM representations of surface fluxes by archiving operational NWP flux products and high-quality *in situ* observations for subsequent intercomparison and analysis. After the WGSF was formed in 2004, B. Weller and P.Gleckler led the initial discussions on SURFA held at the first WGSF meeting in Halifax. Progress continued in late 2005 and early 2006 with a dialogue between C.Fairall (WGSF chair) and M. Miller (WGNE chair). It was agreed that the WGSF would attend the WGNE meeting in Boulder and present a plan for SURFA. SURFA was the main topic of discussions at the second WGSF meeting (held in Heidelberg, Germany, in September 2006). Following Heidelberg, the WG approached NOAA NCDC about serving as the SURFA archive and they agreed.

At the WGNE meeting in Boulder WGSF members made three presentations (Fairall – background; E. Kent – in situ comparisons with NWP; Bentamy – satellite fluxes and NWP). Huai-Min Zhang of NCDC made a presentation on NWP and climate archiving activities at NCDC (including the new NOMAD system). The remainder of the afternoon was devoted to discussions of NWP variables to archive, grids, time resolution, and other related details, possibilities of sources of *in situ* data, and software within the NOMAD system for easy access to the data archives (in the interest of promoting research on SURFA issues). The WGSF talks are available at ftp://ftp.etl.noaa.gov/user/cfairall/wcrp_wgsf/surfa/WGNE_06_Boulder

The results of the meeting are as follows:

- A proposed list of NWP variables is available for comment.(Appendix E)
- It was agreed that the data frequency should be 3 hourly as this is the requirement for the study of diurnal cycle.
- A strategy was developed to initially begin archiving NWP flux products from NCEP and ECMWF as a pilot study of about one year duration to evaluate and streamline the process. After the initial problems are worked out, NCDC will begin accepting data from other NWP centers.
- D.Majeweski was appointed WGNE point of contact to arrange for archiving with the NWP centers. The WGSF will coordinate archiving the *in situ* data. See Appendix F for the list of variables for the SURFA project.
- Huai-Min Zhang returned to NCDC and began to investigate arrangements to set up the archive.

While there are still steps remaining before SURFA becomes a useful reality, it has been agreed to revitalize SURFA, and an agreed set of NWP fields etc will be routinely archived at the National Climate Data Centre from a number of NWP Centres in due course. WGNE was pleased to note that NCDC has kindly agreed to archive the flux data and expressed its thanks.

2.5 Plans or Results from 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 reported on the developments in climate modelling activities in 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.

Over the past year a Blueprint and Project Plan for ACCESS have been prepared that define the scope and components of ACCESS. A Science Advisory Group (SAG), whose main function is to provide support to the Science Leader by providing scientific advice on the development and implementation of ACCESS, including recommendations on priorities and options, has been formed and meets once a month.

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. 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 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 global and limited area runs of UM from downloaded Met Office global analyses; (ii) successful full forecast/assimilation cycle from Bureau data base using the ECMWF Observation Data Base (ODB); (iii) a 3-month run with the climate version of the model and plans for an AMIP-type climate run; (iv) ability to build and run locally a single column version of the model. 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 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.

Germany

D. Majewski reported on the joint development project ICON (Icosahedral Non-hydrostatic) of the DWD and Max Planck Institute for Meteorology (MPI-Met, which is the German Climate research centre). The goal of the ICON project is the development of a new global weather forecast and climate simulation model on the icosahedral-hexagonal grid and solving the fully compressible non-hydrostatic equations with a local zooming option. A shallow water prototype on a triangular C-grid where mass is defined at the centre of the triangles and normal wind components at the midpoints of the triangle edges underwent successfully the Williamson test suite. A 3D hydrostatic model version replacing the spectral dynamical core of the ECHAM5 climate model by the new grid point approach is being developed at MPI-Met as well as a 3D ocean version on the triangular grid. In 2007 work will begin on the 3D non-hydrostatic core based on the fully compressible Euler equations.

Japan

Y. Takeuchi reviewed some research projects on atmospheric-ocean study with Earth Simulator (ES) and the activities of Meteorological Research Institute (MRI) of JMA and Frontier Research Center for Global Change (FRCGC). MRI carried out: (i) global warming experiments with TL959 (20km) JMA-GSM for IPCC using time slice experiments and (ii) regional climate modeling for global warming climate with the JMA Non-hydrostatic Model (NHM) with resolutions of 1-5km. The 20km JMA-GSM is also a prototype of the next generation operational NWP model being developed by the Numerical Prediction Division (NPD/JMA) and is used to assess the effects of global warming on typhoons and Asia monsoon, while 5km JMA-NHM is used to assess the effects of global warming on heavy rains and it has been used as the operational NWP model (named as MSM) since March 2006. Takeuchi showed some simulation results such as rainfall amount related to Baiu front in future climate with regional cloud resolving model with 1km resolution.

FRCGC has been investigating global cloud resolving simulations using the Non-hydrostatic ICosahedral Atmospheric Model (NICAM) under a project named “A medium-range research project on global cloud resolving model simulations toward numerical weather forecasting in the tropics” for the period of October 2005 to March 2011.

Takeuchi briefly introduced the development and application of next-generation supercomputer project planned by MEXT (Ministry of Education, Culture, Sports, Science and Technology). Supercomputer was specified as “Key Technologies of National Importance” in Japan’s “3rd Science and Technology Basic Plan (JFY2006-JFY2010)” launched in April 2006. Of six goals of the Basic Plan two goals namely “Sustainable Development” and “Safe and Secure Nation” are related to simulation of climate change and natural disaster with very high resolution model. In January 2006 RIKEN Next Generation Supercomputer R & D Center (NSC) was established and the project organization started in August 2006.

USA

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. He described ongoing plans at the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) to create an Earth System Model (ESM), which by early 2009 is expected to include interactive atmospheric chemistry, improved treatment of convection, a medium resolution ocean component with biogeochemistry, and a land component with dynamic vegetation and vertically-resolved soil hydrology. Rosen highlighted a roadmap for the future development of the ESM at GFDL, based on the adoption of an Earth System Modeling Framework (ESMF). ESMF provides an infrastructure to enable model advances at research institutions like GFDL and NCAR to be readily transferred to operational use at the NOAA National Centers for Environmental Prediction (NCEP). NCEP is adopting ESMF and anticipates linking its various operational components to this framework.

2.6 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. A sub group with a member from each of PCMDI, WGCM, WGNE, GMPP and the JWGV (Joint Working Group on Verification) will define the climate model metrics and standard verification data sets with the intention of asking WCRP to encourage usage of these metrics for climate models. It was decided to ensure some emphasis on climate model metrics at the February 2007 model systematic errors workshop.

The need for good metrics for climate-type models is under discussion. WGNE will discuss this further also in the context of the new ‘unified’ prediction systems.

K. Taylor provided a perspective concerning the use of metrics in the evaluation of climate models. WGNE's longstanding practice of monitoring and comparing model skill in forecasting weather has convinced it of the benefits of using metrics to promote objective evaluation of model simulations. Historically, they have advocated the routine production of standard diagnostic products when new versions of climate models are proposed. In contrast to the abundant opportunities for verification of weather forecasts, climate simulations can only be assessed against a single set of observations, taken over recent decades. For this reason, metrics devised to measure the skill of weather forecast models do not easily transfer to climate models.

Metrics can be devised that focus on specific fields, specific time and space scales, and specific phenomena or processes. From this "basket" of metrics, one could select the ones that might have the most relevance to a specific application. Examples were given showing that climate metrics can be used to 1) monitor changes in performance as models evolve, 2) quantify the relative merits of different models, 3) aid model development and selection of a new model version, and 4) weight predictions from individual models to form a more accurate consensus climate prediction.

It was stressed that a single metric has limitations in that it focuses only a single aspect of model performance. Even with a collection of metrics, care must be exercised in interpretation. For example, very little is really known about the relationship between model skill in simulating present (observed) climate and its ability to predict future changes. Without rigorous scientific justification, it would be premature to rely on some index of model performance (perhaps based on a collection metrics). Although there is active research

ongoing in this area, the view was expressed that this does not yet justify using metrics as a quantitative measure of confidence in future projections.

The WCRP's interest in metrics is evident from WGNE's recent discussion concerning an ad-hoc panel to encourage research in this area and work toward a set of standard metrics for evaluating climate models. The GCSS is also working to establish a set of metrics useful for evaluating cloud and precipitation processes in climate models. Finally, the WCRP CMIP3 multi-model dataset has fostered metric development by those outside the climate modeling research centers. The Systematic Errors Workshop planned for February 2007 promises to lead to even further interest in this area.

3. DATA ASSIMILATION AND ANALYSIS

3.1 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 presented the work on reanalysis at ECMWF. Reanalysis activities have been concentrated on finalising the data-assimilation system, including the monitoring environment, for the ERA-Interim reanalysis. The system will provide a major upgrade of ERA-40 from 1989 onwards and will address the main deficiencies of ERA-40 for this period. Adaptive bias correction techniques will, for the first time in the reanalysis context, be used for satellite radiances. ERA-Interim will be continued in near-real time as a Climate Data Assimilation System. It will be an evolutionary step between ERA-40 and the next major ECMWF reanalysis.

A preliminary ERA-Interim reanalysis run was started, as planned, in December 2005 using T255L60 model resolution and 12 hour 4D-Var. Results showed substantial improvements over ERA-40, consistent with earlier experiments. The assimilation was continued until February 1991. The reanalysis system has now been upgraded to IFS cycle 31r1, and ERA-Interim has been restarted from 1989.

Configuration of the ERA-Interim data assimilation system

The ERA-Interim system uses IFS Cycle 31r1, with model resolution T255L60. In addition to the increased spatial resolution and improvements in the model physics, the main differences with respect to ERA-40 are:

- use of 4D-Var with a 12-hour time window (instead of 6-hourly 3D-Var FGAT)
- complete reformulation of the humidity analysis
- rain assimilation using 1D retrievals of rain-affected SSM/I radiances
- adaptive bias correction of all directly assimilated radiance data
- adaptive bias correction of SHIP and SYNOP surface pressure data
- use of a homogenised radiosonde temperature dataset and improved bias correction tables
- use of reprocessed Meteosat winds

The general quality of the new analyses has been assessed through validating medium-range forecasts run from them. These show a substantial improvement of the preliminary ERA-Interim analyses over ERA-40, which in turn showed improvements over ERA-15 and ECMWF operations for 1989 and 1990.

Japan Meteorological Agency (JMA)

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 CDAS after 2005.

Positive features of JRA-25 against ERA-40 and NCEP reanalysis, include 1) better performance of 6-hour precipitation due to better use of SSM/I data and TOVS data, 2) better performance of low level cloud along subtropical western coasts, 3) better tropical cyclone analysis by using Fiorino's TC wind data, 4) better snow analysis by using SSM/I snow data and Chinese surface snow data, and 5) better meridional circulation such as Hadley circulation and B-D circulation. On the other hand, some negative features such as temperature bias in the stratosphere due to model bias in the analysis and unstable ozone density due to

the lack of TOMS data from May 1993 to July 1996. An experimental hindcast for the period from 1979 to 2004 shows the forecast score based on JRA-25 is much better than that of operational forecast of that time.

The JRA-25 official data from 1979 to 2004 are released in July 2006 followed by release of the single variable and single level data in September 2006. The 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.

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

WGNE reiterated its strong support for the reanalysis work, the desirability of maintaining a core of experts without excessive duplication of effort and ensuring efficient phasing of these efforts.

3.2 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 assimilation such as the GEMS (Global and regional Earth-system Monitoring using Satellite and in-situ data) project will increasingly demand cross-project liaison within WCRP and CAS.

3.3 Observing System Requirements

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.

4. NUMERICAL WEATHER PREDICTION TOPICS

4.1 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.

Presentaions at the session included (i) General report on THORPEX: including TIGGE, IPY and other WG meetings by D. Burridge and Y. Takeuchi, (ii) THORPEX Pacific-Asia Regional Campaign by D. Parsons, (iii) THORPEX and WCRP by G. Brunet, and (iv) THORPEX Regional plans by D. Burridge and K. Puri.

THORPEX PACIFIC-ASIA Regional Campaign

WGNE 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 and not after the campaign.

THORPEX Regional Plans

Y.Takeuchi presented the TIGGE related activities in Japan.JMA is planning to host a THORPEX verification web site the design of which is the same as the WMO/GDPFS EPS verification site at JMA. The WMO/GDPFS EPS verification site is operated by JMA as the lead centre for verification of EPS under the CBS framework. Each NWP centre participating in TIGGE as a data provider will be requested to send JMA the verification measures defined at the Attachment II.7, Table F, Section III of the Manual on the GDPFS <http://www.wmo.int/web/www/DPS/ Manual _GDPFS.html>.

WGNE discussed the importance of cloud physics research and providing these inputs to WWRP. The relevance of this topic to WGNE is obvious. The WGNE-GCSS link provides WWRP the link to cloud physics. Of late, with the WGNE-GMPP joint sessions being held in alternate years, this has not been adequate.WGNE would work more closely with GCSS to provide the inputs to WWRP-THORPEX. THORPEX with its present concern to address the ‘’second week forecast’’ problem would like to work closely with the GCSS through WGNE. WGNE would appreciate additional support from WWRP to reestablish annual joint meetings with GMPP in this regard.

4.2 THORPEX and WCRP

THORPEX/WCRP White Paper1

G. Brunet gave an overview of the THORPEX/WCRP White Paper1 entitled: A Collaborative Effort between the WMO Programs THORPEX and WCRP.The international THORPEX and WCRP communities both have the obligation to help the development of relevant scientific knowledge and a science infrastructure to provide policy- and decision-makers

- More accurate, and from a socio-economic prospective more useful, prediction of high-impact weather and environmental events.
- Information needed for the reduction of emerging and existing global and regional social, economic and environmental vulnerabilities caused by the combined effects of a changing environment and increasing economic development.

As the appreciation of the complexity of the underlying science issues grows, investigations not only must become more and more multidisciplinary in nature, necessitating a more holistic and team approach to modeling of the Earth System, but also will require a concerted international effort. Climate, air quality, water, environmental and weather modeling and prediction systems will become more integrated, move to increasingly finer space-time scales, and rely on complex systems for blending information from observations and models. There will be a tremendous increase in the variety and quality of environmental data, and in the variety and scope of weather and environmental predictions on scales from minutes to decades and beyond, as well as a broadening of prediction paradigms (deterministic as well as probabilistic). These changes will greatly enhance the capacity to meet a range of prediction challenges to increase safety and security, regionally and globally, and to provide information in support of the development of policies and services by better adapting to the constantly changing environment. As these weather and climate science issues become more global and complex, they cannot be addressed in isolation. An international and multi-disciplinary research program is essential.

A white paper (G. Brunet, Environment Canada; B. Hoskins, University of Reading; R. Morss, NCAR, J. Slingo, University of Reading; I. Szunyogh, University of Maryland; D. Waliser, NASA) is prepared in consultation with the international community for the next WMO conference of the Commission for Atmospheric Science. The white paper will propose specific means of collaboration between THORPEX and WCRP to achieve the following main scientific objectives:

- Global climate simulations that correctly represent the variability associated with transient weather events, such as tropical and extra-tropical cyclones.
- Extended range weather predictions that take advantage of the assumed predictability (e.g., MJO) in the intra-seasonal (10- to 90-days) forecast range.

The proposed collaboration is timely because of the unprecedented advances of the last few decades in High Performance Computing (HPC), high-speed telecommunication, ground-, space- and aircraft-based measurement technologies, systematic observations, remote sensing, field and laboratory

process studies, data assimilation techniques, and in highly performing coupled numerical models of weather and climate prediction. Weather and climate research has produced numerical prediction and data assimilation systems that can efficiently exploit these technological improvements. The challenge today is to further improve the existing forecast and diagnostic products, to increase their economic and societal values and to broaden their suite of applications through the development of a seamless prediction process that eliminates the long existing separation of the weather and climate forecast processes.

The white paper will then introduce a series of high priority THORPEX/WCRP collaborative issues on numerical prediction and modelling, data assimilation and observational requirements from weeks to seasons. More specifically, they are:

1. Organization and maintenance of tropical convection (Madden-Julian Oscillation, intra-seasonal variability of monsoons, equatorial waves ...)
2. Tropical-extratropical interaction (Rossby wave train, extra-tropical transition, cold frontal/winter monsoon surge …)
3. Seamless prediction with multi-model ensembles (TFSP, TIGGE …)
4. Data assimilation as a prediction and validation tool for the climate and weather research communities (SPARC …), and a design tool for observation networks (GEO …)
5. High-impact weather in observations and models (including Regional Climate Models)
6. Societal and Economical Research Applications (SERA)

4.3 PAN-WCRP YEAR of Tropical Convection in the THORPEX context

A Year of Tropical Convection (YOTC)

D. Waliser presented an overview of the proposal for 'A Year of Tropical Convection' (YOTC). WCRP and 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, 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 we propose this activity as one of its initial projects.

WGNE discussed the proposal for YOTC which, as currently envisaged, is aiming to assemble a dataset that will enable focussed research on many aspects of tropical convection, which in turn should lead to significant/important advances in our NWP abilities on all timescales currently labelled under 'seamless' prediction. The discussions strongly supported the idea but felt that it was less clear how the aims of the YOTC would be achieved. Some concern was also expressed that the proposed timescales were somewhat too tight.

As this YOTC dataset will be a judicious combination of many existing datasets in a variety of forms and repositories, questions were asked as to whether this is an opportunity to harness the powers of the new WMO Information System (WIS), and what was the YOTC relationship to other planned 'global' activities such as IPY and a possible Monsoon' focus. It was suggested that WWRP and WCRP should consider these questions and the efficacy of having a working group and/or a workshop in 2007.

Recognizing that convection is central to many problems in WCRP modelling research on almost all space and time scales, WGNE/GMPP were already jointly considering a high resolution modelling experiment specifically directed towards aiding and accelerating parametrization development. This could be part of a coordinated effort to benefit the entire WCRP community.

WGNE welcomed the proposal by D. Waliser and discussed it at length. WGNE sees merit in the proposal, in its potential to improve monthly weather and seasonal forecasts by addressing the poorly understood MJO and tropical convection phenomena. The proposal aims to achieve this by creating a

broader data base on tropical convection. Therefore WGNE strongly supports the proposal. However, the proposal as it stands needs to be strengthened particularly with regard to its implementation, and the modelling component should be highlighted. The final proposal should consider the ongoing/ planned efforts in CEOP, avoid overlaps, and the fact that WMO has admitted this proposal under its WIS.

4.4 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. There exists a dichotomy of opinion regarding the use and interpretation of grid-lengths of several kms for forecasting. These resolutions will become affordable for GCM use in the coming years, and 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.

Trends in performances 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. 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. Virtually all Centres show some continuing improvements

Inter-comparison 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 and CMA 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. Eight NWP centers except for CMA participated in the 2005 intercomparison.

Many results related to typhoon track forecast including a multi-model ensemble are presented on the web site: 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. NCEP also shows small forecast errors in North Atlantic area. The trends of typhoon track forecast error by a multi-model ensemble composed of ECMWF, JMA and UKMO for the last 15 years are also shown. Takeuchi remarked that four day forecast with the multi-model ensemble in 2005 reached about 300km in 2005, which is almost the same score as two day forecast in 1995, for western North Pacific area.

The overall gradually improving performance of these models in predicting cyclone tracks over the past few years has been maintained. In future statistics will be gathered to assess the skill in intensity forecasts and forecasts of cyclone genesis.

4.5 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 (JWGC) 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

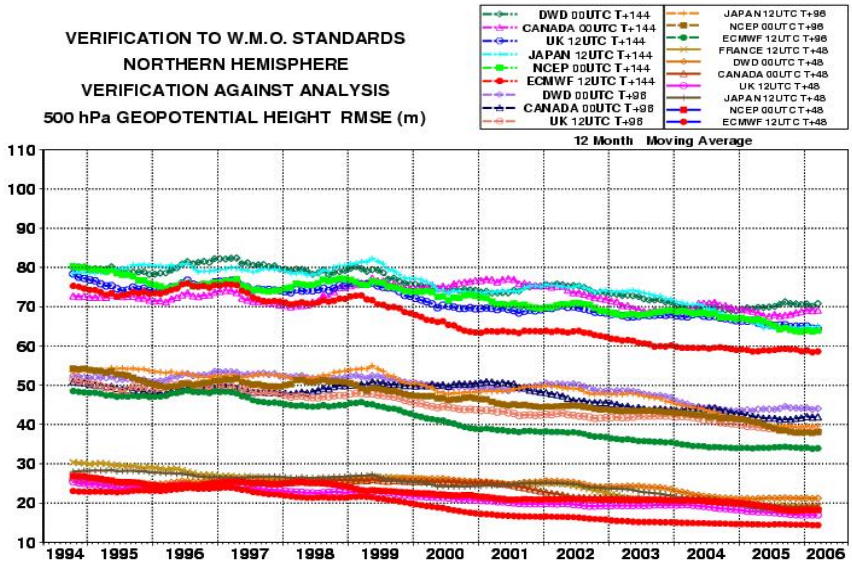

Figure 1.

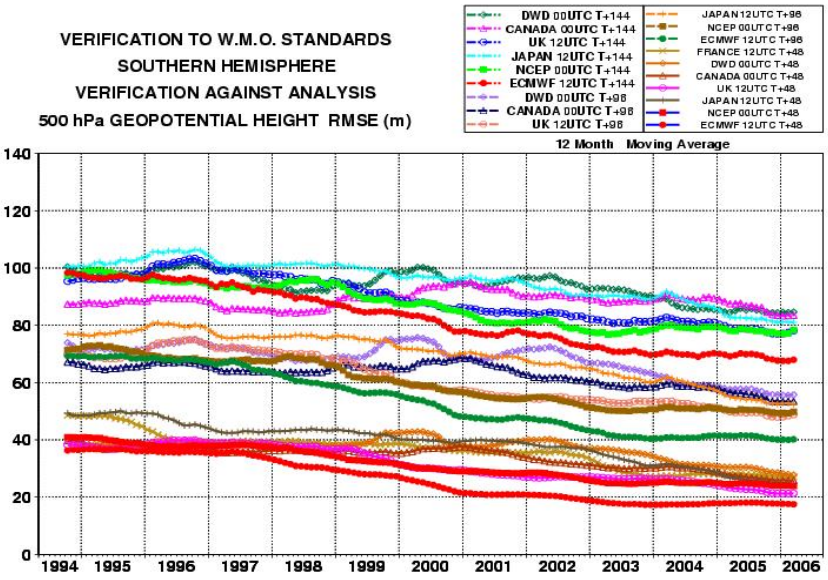

Figure 2.

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.

As Chair, B. Brown reported on the activities of the WWRP/WGNE joint Working Group on Verification (JWGV) during the past year. A number of WGNE projects focus on verification of forecasts from numerical weather prediction (NWP) models. These projects include the compilation of the so-called WMO scores, verification of quantitative precipitation forecasts, evaluation of tropical cyclone tracks and evaluation of stratospheric analyses and forecasts. In addition, the modelling and verification communities have recognized that there is an urgent need to move forward from the traditional measures-based verification methods toward methods that are more diagnostic and represent meaningful forecast performance characteristics. In addition to addressing activities of the JWGV, Brown also described community progress in development of these new methods.

Membership in the JWGV includes F. Atger (Météo-France); H. Brooks (NSSL, USA); B. Brown (Chair; NCAR, Boulder, USA); B. Casati (MSC, Canada); U. Damrath (DWD, Germany); E. Ebert (BMRC, Australia); A. Ghelli (ECMWF, UK); P. Nurmi (FMI, Finland); D. Stephenson (U. Exeter, UK); C. Wilson (UKMO, UK); and L. Wilson (MSC, Canada).

The JWGV held one formal coordination meeting in Boulder, Colorado, USA, in June 2006 in association with the 2nd International Symposium on Quantitative Precipitation Forecasting and Hydrometeorology. This meeting helped facilitate planning for the 3rd International Workshop on Verification Methods, scheduled for 29 January through 2 February 2007 in Reading, U.K. as well as other JWGV activities.

Activities of the JWGV in the past year included participation in specific projects, research on verification methods, education and outreach, and initial investigation of methods for cloud verification that could be applied by WGNE members.

One of the specific projects is the Mesoscale Alpine Project Forecast Demonstration (MAP D-Phase); the JWGV's role in this project has primarily been advisory. In addition, 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. H. Brooks, B. Brown, B. Casati, and L. Wilson also participated in planning for the North American THORPEX SERA program; currently all THORPEX verification activities are contained within the SERA program.

Several members of the JWGV are also closely involved in activities associated with the Forecast and Research Demonstration Projects for the Beijing Olympics (B08FDP and B08RDP, respectively). B. Brown and L. Wilson are both members of the B08 Steering Committee, and E. Ebert and others are developing a Real-Time Forecast Verification (RTFV) system in coordination with the Beijing Meteorological Bureau. The RTFV will primarily be used to evaluate nowcasts provided by the nowcasting systems as part of the B08FDP. This effort will provide an opportunity to demonstrate the use of new verification methods, as well as the use of a real-time verification system. L. Wilson is providing guidance for verification of high-resolution mesoscale ensemble forecasts as part of the B08RDP; verification of the forecasts for this program will primarily be undertaken by the groups providing forecasts and the China Meteorological Administration (CMA). B. Brown participated in the 2nd workshop on the B08 RDP and FDP in late August 2006 and provided guidance on verification activities for both the FDP and RDP.

Recent research on verification methods has led to advances in many areas, including improved methods for evaluation of spatial forecasts, ensemble forecasts and forecasts of extremes, as well as new diagnostic approaches and user-focused verification. Examples include entity- and object-based approaches, "fuzzy" or neighbourhood methods, composite approaches, and methods that apply the statistical theory of extremes. The capabilities of many of these methods are being compared in an intercomparison project that is sponsored by and includes participants from the JWGV (http://www.rap.ucar.edu/projects/icp/index.html; this web site also includes references for many of the new methods).

The JWGV's current outreach activities include continued support for the verification web page (http://www.bom.gov.au/bmrc/wefor/staff/eee/verif/verif_web_page.html) and a verification discussion group. In addition, L. Wilson and P. Nurmi prepared an online tutorial for EUMETCAL (the "European Virtual Organisation for Meteorological Training"). This on-line training course is available at http://www.eumetcal.org/-Learning-Modules-. The 3rd Workshop on Verification Methods will also include a