

ACTIVITIES OF THE CAS/JSC WORKING GROUP ON NUMERICAL EXPERIMENTATION (WGNE)

1. Role of WGNE

The Working Group on Numerical Experimentation (WGNE), as a joint working group of the WCRP/ Joint Scientific Committee (JSC) and WMO/ Commission for Atmospheric Sciences (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. There is clearly a need for co-ordination between WGNE, Working Group on Coupled Modelling (WGCM) and Working Group on Seasonal to Interannual Prediction(WGSIP) and, currently, the Chairman of WGNE participates in an ex officio capacity in WGCM sessions. WGNE also works in close conjunction with the WCRP Global Energy and Water Cycle Experiment (GEWEX) in the development of atmospheric model parametrizations, and WGNE sessions are held jointly with those of the "GEWEX Modelling and Prediction Panel" (GMPP). The WGNE Chair is a member of WCRP Modelling Panel (WMP), and WGNE is represented on WCRP Observations and Assimilation Panel (WOAP) also.

WGNE is playing an active role in the planning and implementation of THORPEX, a Global Atmospheric Research Programme. WGNE now has specific THORPEX sessions at its meetings.

Beyond this, the close relationship that exists between WGNE and operational (NWP) centres underpins many of the activities by WGNE and it is the work of these centres that provides the major impetus for the refinement of atmospheric models. As usual, WGNE sessions include reviews of progress at operational centres in all aspects of NWP including data assimilation, numerical methods, physical parametrizations, ensemble predictions, seasonal prediction, verification of precipitation and tropical cyclone track forecasts. WGNE also follows progress in various relevant national initiatives such as the Frontier Research Center for Global Change in Japan. 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.

The following paragraphs briefly review the main activities of WGNE in support of WCRP/CAS objectives, emphasizing items arising at its twenty-first session which was kindly hosted by the Voeikov Main Geophysical Observatory, St Petersburg, Russia, 7 - 11 November 2005.

2. Studies and comparisons of atmospheric model simulations

Model intercomparison 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.

AMIP, CMIP, WGCM and a proposed Workshop on Model errors

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. WGNE congratulated PCMDI for undertaking and successfully completing the AMIP projects (AMIP-II is now complete), and for creating 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 were of particular note.

Acknowledging the lead role played by PCMDI and WGCM in this data management, WGNE felt that, in view of its own problems in this area, there was a need to widen this activity further. WGNE asked to be represented on the data oversight committee together with someone from the land surface modelling community.

AMIP-type studies will continue as a subset of Coupled Model Intercomparison Project (CMIP) in future and PCMDI has offered to receive high resolution NWP AMIP-type runs to complement their ongoing CMIP activities. WGNE thanked PCMDI for this suggestion and confirmed its interest in this. PCMDI have offered to be the local hosts for a pan-WCRP workshop on Model systematic errors in February 2007. This will be organized by PCMDI and WGNE with input from WGCM and GMPP.

"Transpose" AMIP

Transpose AMIP is 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 invaluable for weather prediction model development by applying climate models to weather forecasting. The method allows direct comparison of parametrized variables such as clouds and precipitation with synoptic observations, satellite and field programmes. Development of a complete analysis system is not needed. Initial conditions can be obtained from NWP reanalyses. The method allows direct comparison of parametrized variables such as clouds and precipitation with observations from field programs such as ARM, early in the forecast while the model state is still near that of the real atmosphere. This is in contrast to the more traditional climate model statistical analysis based on the model simulated climate balance. In that approach the parametrizations see the erroneous climate model state rather than the true observed state. This WGNE initiative was initially prototyped/developed jointly by NCAR and PCMDI. The goal of the intercomparison is to encourage climate modeling groups to implement this forecast strategy into their development process and to compare the characteristics of current models. The formal proposal for Transpose AMIP has been sent to climate modelling groups.

Aqua-Planet Experiments

WGNE continues to recognize the value of applying atmospheric models to simplified surface conditions for examining the behaviour of physical parametrizations and the interactions of parametrizations with the dynamical cores. In particular, "aqua-planet" experiments with a basic sea surface temperature distribution offer a useful vehicle in this regard. Thus WGNE had endorsed an intercomparison, the Aqua-Planet Experiment (APE), being led by staff from the University of Reading, NCAR and PCMDI. The details of the experiment and schedule are available at <http://www.met.reading.ac.uk/~mike/APE>.

The experiment is designed to provide a benchmark of current model behaviour and to stimulate research to understand differences arising from: (1) different subgrid-scale parametrization suites, (2) different dynamical cores, and (3) different methods of coupling model dynamics and parametrizations. A Workshop was held 20-22 April 2005 at the University of Reading, UK to discuss the results, summarize current model behaviour and produce a summary of research questions arising from the experiment.

Fourteen groups have now submitted their simulations to the APE database. Analysis of the APE experiments is continuing for another year. A second workshop is planned to discuss the more complete analyses in the fall of 2006 or spring of 2007 at the University of Tokyo.

The models show a wide range of behaviour with resolution and parameter changes, both within a single modelling environment, and across different models. The basic experiments are deliberately done at "climate model" resolutions but a few groups are examining convergence with resolution and more resolution work is needed. The discussions at the workshop led to plans for further diagnosis and journal papers to be developed before the next workshop.

Regional Climate Modelling

WGNE was presented with an overview of the potential uses of Regional Climate Models (RCMs) in areas such as: regional climate change projections, seasonal prediction and parametrization development. The GEWEX Transferability Working Group (TWG) was discussed. The aims of this group are to assess the global applicability of RCMs in regions remote from their home domain of development. Particular emphasis is being placed on the simulation of regional scale water and energy cycles in a wide variety of climatic regimes. TWG has sponsored the Inter Continental Scale Experiment Transferability Study (ICTS). In ICTS participating RCMs will run their model unchanged over 7 distinct regions around the globe, where each model domain is centred on a GEWEX Continental Scale Experiment site that is contributing data to the CEOP central archive. Presently 7 RCMs are contributing to ICTS and results will be archived at the CEOP central facility early in 2006.

WGNE also discussed results from SGMIP (Stretched Grid Model Intercomparison Project) noted that this was a very promising approach to higher resolution regional simulations. It will continue to monitor the developments in this area in its future sessions.

3. 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 depending on the intended applications. For NWP models the application is weather forecasts and seasonal forecasts. 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. Possible substitutes are to use the current climate, but there are no independent data sets for verification, or to use past climates, but these have insufficient data for a thorough evaluation. Therefore, for climate models, the processes creating the climate should also be evaluated, not just the climate itself.

NWP has a long history of forecast metrics such as the S1, RMS, and anomaly correlation skill scores. NWP generally assumes that errors in the verifying data are unimportant but this may not be the case with climate verification data.

The difficult aspect for climate models is not the definition of the metrics, but the definition of fields to be assessed. They should be standard and used during model development in the same way as NWP uses anomaly correlation. WGNE discussed the issue of climate model metrics at some length with many questions and issues resulting. As a way forward, WGNE requested PCMDI to liaise with WGCM and it was agreed to set up a sub group with a member from each of PCMDI, WGCM, WGNE, GEWEX modelling and prediction panel (GMPP) and the JWGV (Joint Working Group on Verification). This group will help define the climate model metrics and standard verification data sets. In due course WGNE would take this to WCRP, through WGCM, with the intention of asking WCRP to encourage usage of these metrics for climate models.

It was decided to have a session on climate model metrics in the February 2007 model

systematic errors workshop.

4. 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), and the progress of CEOP, are described in the reports of the GMPP and the GEWEX Scientific Steering Group to the JSC. 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 and this should lead to model intercomparisons during the CEOP period.

WGNE confirmed the value of the interaction with GMPP for parametrization work, particularly with GCSS. A pan-GCSS meeting was held in May 2005 in Athens. This addressed clouds in the climate system, methodologies and metrics in assessing models, the fundamental role of precipitation in cloud systems, and advances in the representation of clouds in large-scale models. 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. WGNE suggested that there might be a follow up exercise over land (e.g. the AMMA region), and noted that the study provides an excellent opportunity to bring together NWP and climate modellers.

In addition to the above, WGNE routinely reviews progress and outstanding issues in parametrization in general, and at the next meeting WGNE and GMPP will review what various Centres are doing in the area of land surface data assimilation and will consider having a joint workshop on this topic in the 2007/8 timeframe.

WGNE received the report on the Monsoon workshop, (Irvine, USA, 15-17 June 2005). WGNE noted with some disappointment the Monsoon community's apparent lack of interest/understanding of the important role of NWP in monsoon studies as evidenced by the workshop's programme. Many of the studies presented use models as 'black boxes' which can hinder progress.

The need for a specific action on 'convection'

Recognizing that convection is central to many problems in WCRP modelling research on almost all space and time scales, WGNE/GMPP are jointly proposing a high resolution modelling experiment specifically directed towards aiding and accelerating parametrization development. This effort would be part of a proposed coordinated WCRP's New Strategy effort on 'convection', an effort expected to benefit the entire WCRP community.

5. Numerical weather prediction

Reanalysis projects and data assimilation

The ERA-40 reanalysis at ECMWF is complete and an "interim reanalysis" has begun. This is running from 1989 onwards. It contains improvements that greatly alleviate deficiencies identified in ERA-40. The ERA-40 publication series now comprises more than 20 reports covering documentation of the data and of the data-assimilation system

and its performance, and results from users of the ERA-40 data. The reports are available on-line for outside users (<http://www.ecmwf.int/publications/library/do/references/list/192>).

A comprehensive atlas of the atmospheric general circulation as depicted by ERA-40 has been produced in collaboration with the Meteorology Department of the University of Reading.

The Japanese 25-year Reanalysis Project (JRA-25, 1979-2004) has now been completed. Comparison of JRA-25 with other completed reanalyses shows that the known problems of excessive tropical ocean precipitation seen in ERA-40 are not present. In general, precipitation in JRA-25 has much higher correlation with precipitation in CMAP than ERA-40 and NCEP reanalyses.

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. Regional reanalyses such as for N America and possibly Europe are also reviewed by WGNE.

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 demand cross-project liaison within WCRP and CAS.

Model developments

WGNE noted the substantial improvements in the resolution of global (40 km or less) and deep convection permitting forecast models (5 km or less) in progress or planned in the next few years. There exists a dichotomy of opinion regarding the use and interpretation of gridlengths 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 some concern to the group.

WGNE noted the plans for unified (coupled) forecast systems that will provide forecasts from days out to seasons, typically by progressively degrading the resolution with forecast range. Such developments 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.

Performance of the main global operational forecasting models

WGNE routinely reviews the skill of daily forecasts from a number of the main operational centres in terms of verification scores (such as anomaly correlation and root mean square error) for various fields at different lead times. For most centres, a distinct increase in skill is apparent over the last few years.

Model Verification

Scores such as rms errors and anomaly correlations provide good objective measures of large-scale model performance. However, with global models attaining much higher resolutions, and meso-scale models being routinely run at most operational centres, consideration is being given to additional skill scores 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 deterministic forecasts. These include the compilation of the standard skill scores, verification of quantitative precipitation forecasts(QPF), validation of tropical cyclone tracks and verification of stratospheric analysis and forecasts. A number of important issues and 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.

Following a request from the WGNE, the JWGV has prepared a set of recommendations for the verification and intercomparison of QPFs from operational NWP models. This first report focuses on deterministic forecasts; a future one will outline methods for probabilistic/ensemble forecasts. The JWGV is interested in collaborations with other WMO verification projects and groups.

Intercomparison of typhoon track forecasts

The intercomparison of forecasts of typhoon tracks in the western North Pacific has been an ongoing project that has been conducted by the Japan Meteorological Agency on behalf of WGNE for a number of years. The project has recently been extended to include all ocean basins. Relevant data from operational forecasts are now available from eight Centres. The overall gradually improving performance of these models in predicting cyclone tracks and intensity over the past few years has been maintained. A significant milestone was the opening of a web site for WGNE international tropical cyclone comparisons. 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).

Verification and intercomparison of precipitation forecasts

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.

Model-derived estimates of ocean-atmosphere fluxes

Evaluation and intercomparison of global surface flux products (over ocean and land) from the operational analyses of a number of the main NWP centres (the "SURFA" project) remains a priority for WGNE. The atmospheric and coupled modelling communities and oceanographers have very strong interests in advancing SURFA, which could provide a good opportunity for progress in estimating and determining the quality of surface fluxes. Efforts are continuing through liaison with the WCRP Working Group on Surface Fluxes (WGSF) to address the requirements of research, observations, analysis and modelling of surface fluxes within WCRP and closely-related programmes such as GODAE and GCOS. The importance of adhering to data

standards are noted with PCMDI and GODAE being active in this area. It is intended to have a session on this at the 2006 WGNE meeting.

6. THORPEX

At the 21st 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.

WGNE recognized that the THORPEX sub-structure of a) predictability and dynamics, b) observing systems, c) data assimilation and observing strategies, and d) societal and economic impacts, neatly encompassed much of the interests of WGNE, and it was agreed that WGNE will maintain a THORPEX session in its future meetings and would also make every effort to provide WGNE representation at the THORPEX workshop in March 2006 and the joint THORPEX/WCRP workshop on the MJO (also in March 2006)

WGNE discussed the results from THORPEX-related targeting and data denial forecast experiments. Both types of experiment focus on the 'value' or impact of observations in a specific region. WGNE felt that while these are stimulating experiments, THORPEX should nevertheless encourage more in-depth scientific investigations before promoting more (and expensive) experiments.

In the context of AMMA-THORPEX it was WGNE's advice not to attempt a targeting campaign as the scientific basis for such work was almost non-existent for this part of the world. However the extensive additional observations will provide excellent opportunities for impact studies of various kinds. The provision of targeting information for the driftsondes to be launched during the hurricane season later in the campaign, was however an interesting possibility.

The use of ensemble methods now forms a cornerstone of forecasting on all timescales. Recent years have seen progress in the application and use of ensemble prediction systems underpinned by the availability of supercomputer resources and rapid advances in the science of initial condition and model perturbations etc. However WGNE remained concerned at the rather slow progress being made at a number of operational NWP centres in the effective use of ensemble forecasting information, and hoped that THORPEX, and particularly the THORPEX Interactive Grand Global Ensemble (TIGGE) project, will help accelerate this. WGNE includes ensemble prediction as a regular discussion item at its meetings.

Finally WGNE noted that its preliminary plans for more coordinated action (probably within the WCRP's new framework) to address the wide-ranging difficulties in forecasting convection or in representing convection in GCMs were important to THORPEX, and that the proposed very high resolution (1 km) studies under consideration would be of particular relevance.

WGNE responded positively to the request that it should be represented at THORPEX Working Group meetings where possible. The planned THORPEX–WCRP meeting on the MJO, 13-17 March 2006, Trieste was welcomed.

7. African Monsoon Multidisciplinary Analyses (AMMA): progress and developments

WGNE welcomed and fully supported the proposal to prepare a Forecaster's Handbook. This included workshops in March and June-Sept 2006, reviews by editorial board, external review of all chapters and editing process, and publication by end 2008. WGNE

considered that the Forecasters handbook was a unique opportunity for capacity building. Furthermore, WGNE suggested that the possibility of a relevant WMO training programme for training should be explored. It also suggested that experts of the Nowcasting Workshops arranged by WMO/WWRP should be invited to the AMMA workshop.

8. Workshops and publications

- An International Workshop on " Aqua Planet Experiment" was held 20-22 April 2005 at the University of Reading, UK to discuss the results, summarize current model behaviour and produce a summary of research questions arising from the experiment.
- A joint WGNE/WWRP training workshop, organized by the JWGV is to be hosted at ECMWF, 29 January –2 February 2007.
- A THORPEX –WCRP meeting on the MJO, was held on 13-17 March 2006.
- A second International Workshop on " Aqua Planet Experiment" is planned to discuss the more complete analyses in the fall of 2006 or spring of 2007 at the University of Tokyo.
- A Pan-WCRP Workshop on model systematic errors will be held on 12 -16 February, 2007 in San Francisco, USA. (Local organizers are PCMDI)



Martin Miller (Chair of WGNE)