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

The JSC/CAS Working Group on Numerical Experimentation (WGNE) has the central responsibility in the WCRP for the development of the atmospheric component of climate models and, together with the Working Group on Coupled Modelling (WGCM), lies at the core of the climate modelling effort in WCRP. Close co-ordination is duly maintained between WGNE and WGCM. Furthermore, WGNE works in conjunction with the WCRP Global Energy and Water Cycle Experiment (GEWEX) in the development of atmospheric model parameterizations and, in this respect, WGNE sessions are held jointly with the "GEWEX Modelling and Prediction Panel". Liaison is also maintained with the SPARC "GRIPS" project (focussed on the intercomparison of model stratospheric simulations) and will be developed with the new SPARC initiative on stratospheric data assimilation.

WGNE additionally has an important role in support of the WMO Commission for Atmospheric Sciences (CAS) in reviewing the development of atmospheric models for use in weather prediction on all timescales. The close relationship between WGNE and operational (NWP) centres by virtue of the CAS connection underpins many aspects of WGNE work and provides a strong impetus for the refinement of the atmospheric component of climate models. WGNE sessions duly include reviews of progress at operational centres in topics such as data assimilation, numerics, physical parameterizations, ensemble predictions, seasonal prediction, forecasting tropical cyclone tracks, and the verification of precipitation forecasts. A particularly strong area of collaboration is in the planning and development of THORPEX: A Global Atmospheric Research Programme.

The following paragraphs review the main activities of WGNE in support of WCRP objectives, including especially items of interest and recommendations arising at the nineteenth session of the group kindly hosted by the Centro de Previsão de Tempo e Estudos Climáticos (CPTEC), Salvador, Brazil, 10 to 14 November 2003.

1. MODEL INTERCOMPARISON PROJECTS

A key element in meeting the WGNE basic objective to identify errors in atmospheric models, their courses, and how they may be eliminated or reduced, is a series of model intercomparison exercises.

Atmospheric Model Intercomparison Project

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. The second phase of AMIP (AMIP-II) had more than twenty-three modelling groups submitting simulations and much of the data from these runs are available for a wide range of diagnostic sub-projects. Climatological comparisons are available for nearly every standard AMIP model output field, and probably represent the most comprehensive source of the climatologies of atmospheric circulation models. AMIP research is structured round a series of diagnostic sub-projects and a clear view of how models have evolved since AMIP began nearly a decade ago has emerged. Overall, there has been a general improvement both in terms of the "median" model as well as for many of the individual models. The simulation of interannual variability and performance in specific geographical regions, as measured by global climatological statistics, also appear to be more realistic. 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**.

On the technical side, PCMDI has now completed an open source software system which enables much more efficient management of the voluminous AMIP data sets. An automatic system has been put in place to organize the simulations, perform extensive quality control, and make the data accessible (via FTP) to interested users, and modellers are provided rapidly with a "quick-look" summary of the performance of submitted runs.

In its review of AMIP, WGNE was briefed by Dr. P. Gleckler about the recent developments at PCMDI and possible future directions of AMIP. AMIP continues to provide an ongoing benchmark diagnostic for WCRP modelling activities. PCMDI's diagnostic strategy will be towards coordinating WCRP modelling activities. Evaluation of CMIP models will be an overarching theme for PCMDI, but AMIP will continue to be supported as a complimentary diagnostic to CMIP. WGNE expressed the view that it would be very useful for the CMIP and AMIP panels to meet jointly in the near future to discuss how this could be achieved.

WGNE noted that the AMIP had become a well-defined and useful experimental protocol for testing and intercomparing global atmospheric circulation models. WGNE also noted that AMIP, in view of the powerful capabilities of PCMDI, provides a good infrastructure for handling model integrations, and so effectively facilitating the diagnosis and display of many characteristics of the results. As such WGNE continues to strongly support the continuation of AMIP. However any future planning depends strongly on the level of PCMDI support for the project. WGNE expressed the hope that the official position of PCMDI would be clarified in the near future.

"Transpose" AMIP

Results were presented from the work at NCAR and PCMDI which has grown out of the earlier WGNE proposal for a transpose AMIP. The NCAR/PCMDI project has been labelled CAPT, the 'CCPP-ARM Parameterization Testbed'. The goal is to obtain the benefits for climate model development and evaluation that have been realized in weather prediction by applying climate models to weather forecasting, but without the huge costs of developing a complete NWP system. An important point is that the climate models are applied at their relatively low application resolutions and are not expected to make the best weather forecast. The method allows direct comparison of parameterized 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 atmosphere. This is in contrast to the more traditional climate model statistical analysis based on the model simulated climate balance. In that approach the parameterizations see the erroneous climate model state rather than the true observed state.

To avoid developing a complete NWP system based on the climate model the Transpose AMIP/CAPT approach maps NWP analyses or reanalyses to the climate model grid and orography using methods developed in NWP such as that in IFS FULL-POS. Not basing the approach on a native analysis system has the added benefit of allowing use of atmospheric analyses from several different NWP centres to provide some information about the uncertainty or sensitivity of the parameterizations to particular analyses since the each is influenced to some extent by its system model. When the parameterization errors are the same in forecasts based on different analyses one has more confidence that they are actual errors as opposed to differences between model parameterizations. Of course, there is also benefit in having the climate model itself embedded in a complete NWP system but that requires a much larger investment.

Initialization of the land variables is more problematical than initialization of the atmospheric state variables. It is difficult to map discrete/discontinuous land variables between different resolutions, there may be different dominant land types in the two systems involved in the mapping, and there is no uniform definition of land model state variables. To date the Transpose AMIP/CAPT project has applied two procedures to spin-up land and atmospheric parameterized variables. Both involve letting the land model (and parameterizations) interact with and respond to the forcing from the atmospheric model while the atmospheric model is constrained to evolve following the observed atmosphere. One approach involves updating atmospheric state variables with the interpolated analyses periodically (e.g. 6 hourly) and letting the coupled land/atmosphere system evolve until the next update time. The other involves adding terms to the atmospheric model to relax predicted state variables toward analyses with some time scale, say 6 hours. The two produce similar initial land states.

Results were presented from forecast experiments with the Community Atmospheric Model (CAM) resident at NCAR. The land was spun up from January 1, 1997 by interacting with CAM2.0 in which the atmospheric state variables were replaced with ERA40 interpolated variables every six hours. In fact the initial land moisture at ARM CART site is better than expected because two significant errors cancelled each other: the atmosphere rains too much and the land dries too fast. After the land spinup, the forecast latent and sensible heat fluxes are in reasonable agreement with ARM. At least their errors seem second order compared to other errors arising in the forecasts.

Two series of 5-day forecasts with CAM 2.0 from ERA40 initial conditions were presented. One from the June/July 1997 ARM IOP, and the other from the April 1997 ARM IOP at the ARM CART site in Central Oklahoma. Examination of traditional Skill scores of the forecasts indicate that in both seasons CAM produces reasonable forecast of large scale atmosphere. Thus the parameterizations are being driven by realistic fields in the forecasts. Analysis of the summer forecasts indicates that the convective parameterization is invoked too frequently and when it is invoked the model does not maintain the observed atmospheric state. In the April case the CAM forecasts the timing of precipitation events accurately, however, again when the convective parameterization is invoked it does not produce the observed atmospheric state.

These early experiments indicate that the application of climate models to weather forecasts is very useful to gain insight into model parameterization errors. The current methods for initializing the land are useful for this application because the model parameterization errors are relatively large. However, as these errors are reduced better land initialization methods will be needed.

Comparisons of stratospheric analyses and predictive skill in the stratosphere

In the past few years, there has been growing interest in the representation of and prediction in the stratosphere and several major global operational centres have significantly increased the vertical extent and resolution of their models and associated data assimilation and predictions in the stratosphere and into the mesosphere. WGNE is thus undertaking an intercomparison of stratospheric analyses and forecasts in the stratosphere from a number of operational models. One expects better skill in the stratosphere because its flow is dominated by a quasi-stationary polar vortex rather than in the troposphere where the flow is influenced by transient, synoptic scale waves. The best test would be when the polar vortex is undergoing strong changes -sudden warmings. These dramatic changes to the polar vortex occur over short time scales and provide an excellent test for short-term forecasting systems operating in the stratosphere.

Analyses for the period from 15 September - 15 October 2002 (Days 0-30 in this study) and forecasts from 20 September - 3 October 2002 (Days 5-18) during the southern hemisphere major sudden warming of 2002 from five current NWP models (the Australian BMRC Atmospheric Model, BAM; the ECMWF IFS; the NCEP MRF; the NRL NOGAPS and the UKMO model) are compared. These models provided forecasts out to 8, 10, 10, 5 and 10 days, respectively. TOMS plots indicate that the vortex started to deform on 20 September, split in two by 24 September and had a single vortex centre again by 30 September. Comparisons of the 30 hPa temperature RMSE between the model 5-10 day forecasts and their respective analyses show that for forecasts initiated on 20-25 September, when the vortex was in the process of splitting, all the models have almost continuously increasing RMSE for any given forecast day. Thus, for example, the error in the 48 hour forecasts initialized on these days gets worse from the 20th to the 25th of September. This implies that over this period there is a steady reduction of forecast skill and that this is an increasingly difficult period for all the models. From initialization days 25-27 September the skill in all the models is seen to improve dramatically. This is found to be true for other fields (geopotential height, zonal and meridional winds) and other levels above 200 hPa, with this characteristic being larger the higher in the upper levels.

Can these RMSE difficulties be related to particular days? If this is true then there should be a strong dependence of the RMSE on the verification day. All the models show that the periods 27-28 September and 2 October are dynamical situations which they have difficulty with forecasting. These are periods when the split vortex is decaying and when the reformed vortex is moving westward, respectively. All the models show that these errors are generally due to the models creating a final forecast vortex which is smaller, more circular, more poleward and more westerly displaced and with a more easterly orientation, though the latter is not as obvious in the ECMWF model. The creation of a smaller, more circular and more polewardlydisplaced vortex indicates that all the models are trying to create weaker and less disturbed vortices.

The analyses from all five systems are well correlated over the period of the study when the vortex is quasi-stationary; however these analyses are seen to have larger RMSE differences and become less correlated when the polar vortex is undergoing rapid changes. Also during these active periods the model analyses correlations with TOMS total column ozone decreases dramatically from the very high values found when the vortex is quiescent.

The next phase in this study is to carry out a similar analysis for the northern hemisphere polar vortex and compare the stratospheric forecasting ability of these NWP models in the two hemispheres. The northern hemisphere target period has been selected as 15 Jan. - 15 Feb. 2000 and was chosen because of a developing planetary wave three in the lower stratosphere associated with tropospheric blocking, cold temperatures and a developing warming.

International Climate of the Twentieth Century Project (C20C)

The objective of the International Climate of the Twentieth Century Project, developed under the leadership of the Centre for Ocean-Land Atmosphere Studies (COLA) and the UK Met Office Hadley Centre for Climate Prediction and Research, is to assess the extent to which climate variations over the past 130 years can be simulated by atmospheric general circulation models given the observed sea surface temperature fields and sea-ice distributions and other relevant forcings such as land-surface conditions, greenhouse gas concentrations and aerosol loadings.

WGNE was informed that C20C became a formal CLIVAR project at the beginning of 2003. The groups participating in C20C will expand by two to include the Voeikov Main Geophysical Observatory in Russia and the National Climate Centre of the China Meteorological Administration.

The Third Workshop of the C20C project will take place in Trieste, Italy on 19-23 April 2004, at which the participating C20C groups will report on progress to date. The workshop will include a discussion of future plans, to which representatives from WGCM, WGSIP, AMIP, and WGNE will be invited. The existing phase of C20C will probably not be completed until early 2005. A key aim of the workshop, which will be of value across CLIVAR, is to work towards an agreed set of forcings or ways of dealing with them. This will lead to a new, expanded phase of C20C. Another key element will be to determine the value and the methodology of running CGCMs and AGCMs with various and all forcings from about 1850-present; these runs could be useful for several aspects of CLIVAR research such as seasonal prediction to decadal prediction, climate variability, climate change detection and aspects of climate change projection. It is hoped that AGCMs at that time will be run with more than one SST and sea ice extent analysis and the coupled models would be validated against data sets that would include these different SST analyses. It is also planned to use the new global historical International Sea Level Pressure Data Set currently under development under the auspices of the GCOS Atmospheric Observing Panel for Climate (AOPC).

2. STANDARD CLIMATE MODEL DIAGNOSTICS

Over the past six or so years WGNE has developed two lists of standard diagnostics, one of the mean climate and one of variability. The lists were based on responses from the modelling community to queries concerning what diagnostics they would find useful, and from the diagnostic community as to which diagnostics were appropriate for standard application. The WGNE Standard Diagnostics of the Mean Climate are described at http://www-pcmdi.llnl.gov/amip/OUTPUT/ and the WGNE Standard Diagnostics of Variability are described at http://www.cgd.ucar.edu/cms/mstevens/variability/AMWG/variab.html

These diagnostics were intended to: (1) provide a comprehensive set of diagnostics that the community agrees is useful to characterize a climate model, (2) provide a concise, complete summary of a model's simulation characteristics, (3) provide an indication of the suitability of a model for a variety of applications, and (4) provide information about the simulated state and about the processes maintaining that state. They were also intended to be diagnostics whose utility has been demonstrated and which can be calculated by each group. It was hoped that many modelling groups would adopt such diagnostics for routine model processing so that groups could easily compare the properties of their models with each other during the development phase, rather than waiting for frozen models and formal intercomparisons.

To date the diagnostics have not received wide application. Admittedly, it is nontrivial to implement the complete lists. They have been used as the basis for Community Climate System Model (CCSM) Atmospheric Model Working Group (AMWG) model comparison for selecting atmospheric model components for future versions of CCSM, and they are a component of the “quick-look“ diagnostics provided to modelling groups upon submission of their simulations to PCMDI.

Given the lack of wide acceptance, WGNE was asked to decide how to proceed in the future. Several paths are possible. One is to do nothing for a few years and see if their application becomes more common and routine. Another is to more actively promote their use for examining models. A third is to simply consider them a part of the AMIP processing at PCMDI. It was noted that the development of diagnostics of the mean climate presented no problem. However, it is not easy to develop a standard list of diagnostics for the variability and other statistics as there is no standard way. WGNE felt it is necessary to move forward in the matter. PCMDI has accepted to develop a list of diagnostics for the Madden Julian Oscillation

3. DEVELOPMENTS IN NUMERICAL APPROXIMATIONS

At past meetings WGNE has recognised the value in stripped down versions of atmospheric models with very simplified surface conditions for 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 WGNE has 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-pcmdi.llnl.gov/amip/ape/ and http://www.met.reading.ac.uk/~mike/APE/ape_home.html

The experiment is designed to provide a benchmark of current model behaviour and to stimulate research to understand of differences arising from: (1) different models, (2) different subgrid-scale parameterization suites, (3) different dynamical cores, and (4) different methods of coupling. Concerning the schedule, the experiment details were announced early in 2003. Experiment results were to be submitted to PCMDI at the end of September, although that deadline is not being enforced. A Workshop to discuss and summarize the results is scheduled for June 9-11, 2004 at the University of Reading, U.K. The organizers hope that in Spring 2004 analyses will be exchanged between participants for consideration before the Workshop.

4. REGIONAL CLIMATE MODELLING

The Chairman of the WGNE/WGCM RCM panel, Prof. R. Laprise, presented an overview of the regional climate modelling initiatives underway in Europe, USA and Canada. These included 'The Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate (PRUDENCE)' and 'Providing Regional Climates for Impacts Studies http://www.meto.gov.uk/research/hadleycentre/ (PRECIS)' in Europe, 'Climate-Change Science Program (CCSP)' in USA and 'Canada's Consortium OURANOS' and 'Big Brother Experiment (BBE)' in Canada. PRUDENCE activities that relate directly to WGNE and WGCM include the coordinated use of several climate models to assess, in a controlled manner, a number of numerical modelling uncertainties associated with climate-change projections. These include the use of several low resolution coupled GCMs (CGCM), atmosphere only GCMs (AGCM) and nested RCMs. AGCMs are usually run at medium resolutions, as time slices of high resolution uniform resolution models, or as variable resolution AGCMs. These models are driven with sea states based on recent climate analyses to which are added the climate change from CGCM simulations. RCMs are usually nested in AGCM simulated atmospheric states rather than CGCM atmospheric fields in order to reduce systematic biases. Prof.R.Laprise reported on the highlights of the Workshop in Wengen, 29 Sep. - 3 Oct. 2003 which dealt with the sources of uncertainty over Europe using results from 20 model climate-change experiments.

The Hadley Centre has developed an RCM that can be run on a PC and can be applied easily to any area of the globe to generate detailed climate-change predictions. The intention is to make this modelling system (PRECIS), freely available to groups of developing countries so that they can develop climate-change scenarios at national centres of expertise. WGNE reiterated the need to provide the necessary information to users in order to avoid the indiscriminate use of such models.

Experimentation continues at the University of Quebec at Montreal (UQAM) following the so-called BBE perfect model protocol to assess the ability of nested regional climate models to reproduce with fidelity fine scales features. Earlier work using BBE focussed on the winter season over an eastern North American region where surface forcing is not dominant (Denis et al., 2002 and 2003). Further experiments have been carried out over a western North American region where there is a strong forcing exerted by orography (Antic et al., 2003), and for the summer season when surface processes exert a significant influence (Dimitrijevic et al., 2003). The overall conclusions of these perfect model experiments are as follows. One-way nesting RCMs can simulate quite accurately climate in terms of both large and fine scale components of stationary and transient eddies, when driven by large scale information in midlatitude winter. The results are improved by the presence of strong surface orographic forcing. The RCMs' ability to reproduce accurately fine scale features is substantially reduced in summer, due to less effective large-scale control by lateral boundary nesting. Additional findings of these studies concern the acceptable jump in spatial resolution between the driving and nested models and the acceptable time interval for providing lateral boundary conditions. For a 45-km grid RCM, it appears that a maximum jump of 6 (or possibly 12) is acceptable, which corresponds to an equivalent GCM spectral resolution of T60 (or possibly T30). The maximum acceptable update interval of the lateral boundary conditions for the nesting of a 45-km grid RCM appears to be around 6 hours. It is noteworthy that the maximum acceptable values of resolution jump and boundary update interval are mutually dependent.

WGNE was briefed about the organisation of the joint WGNE/WGCM international Workshop, aiming at promoting better knowledge of the potential and limitations of RCM. The Workshop entitled "High-resolution climate modelling: Assessment, added value and applications" will be held in Lund, March 29 April 2, 2004 (https://dvsun2.gkss.de/domino/html/Lund.nsf). The event is held jointly with a meeting of the PRUDENCE WG1 and 2. The focus of the Workshop is on comparing the merits and limitations of various approaches to climate modelling at regional scale, including limited-area nested models, variable-resolution or stretched-grid global models, and uniform high-resolution global models. Contributions are invited on topics such as the role of resolution beyond physiographic details, and on the best strategy to achieve progress in regional-scale climate modelling. While the focus of the Workshop will be on climate time scales, some contributions on non-climate applications will also be considered, e.g. Numerical Weather Prediction (NWP), Seasonal to Inter-seasonal Prediction (SIP), and intermediate time scales (e.g. PIRCS). The organising committee is composed of the following members: René Laprise (UQÀM; Chair), Lars Barring (Lund U.), Filippo Giorgi (ICTP; Lead co-author on Chap. 10 of IPCC TAR), Jens Hesselbjerg Christensen (DMI; Coordinator of PRUDENCE project), Richard Jones (the Met Office), Ben Kirtman (COLA; Member of WGSIP), Harry Lankreijer (Lund U.), Anders Lindroth (Lund U.), Markku Rummukainen (SMHI), Hans von

Storch (GKSS), Werner Wergen (DWD; former member of WGNE).

WGNE was pleased with the progress towards the planning of the Workshop and stressed that the Workshop should air the concerns of WGNE including indiscriminate use of RCMs and the work of PRUDENCE bringing out errors and uncertainties in the approach.

5. MODEL-DERIVED ESTIMATES OF OCEAN-ATMOSPHERE FLUXES AND PRECIPITATION

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 high priority for WGNE. The atmospheric and coupled modelling communities and oceanographers have very strong interest in advancing SURFA, which could provide a good opportunity for real progress in estimating and determining surface fluxes. Some NWP fluxes had already been accumulated at PCMDI; however no further work has been conducted over the past year because of changing priorities at PCMDI. Unfortunately, a committed funding source has yet to be identified for SURFA. Given the importance of this effort for a variety of research communities, efforts are continuing in order to resolve the issue in the near future.

In its twenty fourth session the JSC recommended the formation of a limited-term (three years) WCRP Working Group on Surface Fluxes (WGSF) to address all the requirements of research, observations, analysis and modelling of surface fluxes within WCRP and WCRP's interests in closely-related programmes (e.g. GODAE, GCOS). All relevant WCRP projects and activities, including specifically WGNE and SOLAS, will be represented on the new WGSF. WGSF will work closely with the new Modelling and Observational Councils of WCRP since their interests will overlap with those of WGSF. WGNE has nominated Dr. P. Gleckler to serve on this committee.

6. ATMOSPHERIC MODEL PARAMETERIZATIONS AND CO-ORDINATED ENHANCED OBSERVING PERIOD (CEOP)

The GEWEX "modelling and prediction" thrust, with which WGNE works in close association, is devoting efforts to the refinement of atmospheric model parameterizations, notably those of cloud and radiation, land surface processes and soil moisture, and the atmospheric boundary layer.

GEWEX Cloud System Study (GCSS)

The goal of GCSS is to improve the parameterization of cloud systems in global climate and NWP models through improved physical understanding of cloud system processes. The main tool of GCSS is the cloud-resolving model (CRM), which is a numerical model that resolves cloud-scale (and mesoscale) circulations in either two or three spatial dimensions. The large-eddy simulation (LES) model is closely related to the 3D CRM, but resolves the large turbulent eddies. The primary approach of GCSS is to use single-column models (SCMs), which contain the physics parameterizations of GCMs and NWP models, in conjunction with CRMs, LES models, and integrated, high-quality observational datasets, to evaluate and improve cloud system parameterizations. Integrated, high-quality observational datasets are required to run the models and to evaluate their results. GCSS and collaborating programs (such as DOE ARM) produce these valuable datasets, which are available from GCSS-DIME (Data Integration for Model Evaluation) (http://gcss-dime.giss.nasa.gov). In addition, GCSS has recently begun to lead diagnostic studies of the representation of cloud processes in GCMs.

Meetings held for GCSS this past year include: 1) June 2003: ARCMIP (WG 5) met in Potsdam, Germany, and 2) 27-30 Oct 2003: WGs 1, 3, 4 held workshops in Broomfield, CO, USA, in conjunction with the DOE ARM Cloud Parameterization and Modeling WG and Cloud Property WG. The GCSS Science Panel also met.

GEWEX Global Land-Atmosphere Study (GLASS)

The GLASS project is progressing through the various actions which were defined in the implementation plan. Within GLASS, PILPS(Project for Intercomparison of Land Surface Parameterization Schemes) operates the off-line intercomparisons. The goal of PILPS is to contribute improved understanding of continental surface and near-surface processes through international intercomparison of current state of the art parameterizations employed in coupled climate, atmospheric and earth system models. Since the early 1990s PILPS has evaluated the parameterization of energy and water fluxes to/from the land-atmosphere interface. In 2002 carbon fluxes were included in this land-surface MIP (Viovy, 2002). In 2004/5 it is planned to incorporate stable water isotopes in a new phase of PILPS -“IPILPS”. Two rare but naturally occurring isotopes of water, 1H218O and 1H2H16O, will be exploited in IPILPS as part of the overall GEWEX push into the use of isotopes in modelling and monitoring the global water cycle.

Progress for this past year includes: 1) Completed Arctic basin study – ACSYS/PILPS completed and generating publications (17 papers in a Special Issue of Global and Planetary Change 2003), 2) Continued tropical forest study, PILPS 1(c) completed and still generating publications (Henderson-Sellers et al., 2002a.; Henderson-Sellers & Pitman 2002), 3) More on frozen soil and snow–PILPS 2(d) still generating publications (Luo et al., 2003, Pitman et al., 2003; Lettenmaier and Bowling., 2002), 4) Coupled comparisons continue, PILPS 3 (AMIPII DSP 12) generating publications as results from AGCMs released through PCMDI (Henderson-Sellers et al. 2002b & 2003a and 2003b; Irannejad et al., 2003), 5) Carbon fluxes, PILPS C1 progressing well, http://www.pilpsc1.cnrs-gif.fr/ (14 LSSs participating; all runs completed and preliminary analysis done), a workshop to evaluate results held in May 2003 in Gif-sur-Yvette, 6) Launched arid environments, PILPS San Pedro workshop in Tucson in August 2003 (Bastidas, L.A., Gupta, H., V., Nijssen, B., Emmerich, W. & Small, E., 2002, the PILPS San Pedra-Sevilleta Experiments Model Comparison over Semi-Arid Areas), and 7) Isotopes in PILPS - IPILPS draft proposal approved by the GLASS Science Panel Aug 2003 Henderson-Sellers et al., 2004, Henderson-Sellers & McGuffie, 2004.

The Global Soil Wetness Project 2 (GSWP-2)

A 13½ year meteorological forcing data set (global 1° resolution, 3-hourly interval) was prepared for GSWP-2. It is based on the NCEP/DOE reanalysis data set prepared by COLA for the ISLSCP Initiative II data set. Additionally, land surface characteristics from ISLSCP Initiative II (soil, hydrology, topography and vegetation properties) were prepared for GSWP-2 through conversion to NetCDF and the ALMA data standard (http://www.lmd.jussieu.fr/ALMA/).

Baseline land surface model simulations have been completed by research groups on four continents, and results sent to the GSWP-2 Inter-Comparison Centre (ICC) at the University of Tokyo. Analysis and validation will be a distributed effort, centred on University of Tokyo and COLA. For simulation of brightness temperatures associated with soil wetness, the L-MEB (L-band Microwave Emission of the Biosphere) model from INRA (France) was chosen to couple with the LSSs. This model is based on the ‘state-of-the-art’ knowledge of passive microwave emission from various land covers (herbaceous and woody vegetation, frozen and unfrozen bare soil, snow, etc). In preparation for the analysis phase of GSWP-2, and to establish a baseline of existing global land surface data sets for climate applications, the existing global data sets of soil wetness have been compiled and assessed that span at least the period 1980-1999 for model-based products, or at least 1992-1999 for satellite-based products.

GEWEX Atmospheric Boundary Layer Study (GABLS)

The objective of GABLS is to improve the representation of the atmospheric boundary layer in regional and large-scale models. The first focus of GABLS is on stable boundary layers (SBLs) over land. On the basis of previous discussions and meetings, a benchmark case was selected to discus the state of the art and to compare the skills of single column (1D) models and Large-Eddy Simulation (LES) models for the Stable Boundary Layer. The case is based on the results presented in a study by Kosovic and Curry (2000) for a shear-driven and stable case. As such the boundary layer is driven by an imposed, uniform geostrophic wind, with a specified surface-cooling rate over ice, which attains a quasi-steady state SBL (after about 9 hours). More than 10 groups participated in the comparison for the LES models and more than 15 groups for the 1D models (including the models from the large operational weather and climate centres).

The findings were presented at a workshop at the University of the Balearic Islands in Mallorca, September 22-26, 2003. Results indicate that the models show quite significant differences for the mean temperature and wind profiles as well as the turbulent fluxes and other model outputs for the same initial conditions and forcing conditions. At the workshop several options were explored for future activities, including comparisons with models with more elaborated data sets for cases with stronger cooling over different type of surfaces and increasing complexity. In addition, suggestions were made to explore existing observations over the Baltic Sea and at Antarctica (notably Halley). It is foreseen that the outcome of the Mallorca workshop will be presented in a number of journal papers as well as a meeting.

Co-ordinated Enhanced Observing Period(CEOP)

To aid in the development of various hydroclimatological datasets, CEOP has requested the WGNE community to provide comprehensive gridded output from global data assimilation systems. This requested output includes not only standard meteorological output but also output allowing study and analysis of water and energy processes in the atmosphere and land surface. In particular, detailed Model Output Location Time Series (MOLTS) have been requested at 41 international locations, where there are extensive in situ measurements and where extensive satellite products are being developed. This small data set will be complemented by more comprehensive 3 dimensional globally gridded data. Minimum output will include analysis variables, every 6 hours, as well as variables every 3 hours from a 6 hour forecast made every 6 hours as part of the analysis cycle. Every day at 1200 UTC, a corresponding 36 hour forecast is also requested, since this will provide some measure of how the models are adjusting (spinning up) to the initial state. This model output data should be sent to MPI, which is developing a comprehensive model output archive. NWP Centres are only being asked for comprehensive analysis and forecast output for the period July 1, 2001 - December 31, 2004.

In his presentation, Dr. J. Roads noted that CEOP had made substantial progress since the last WGNE meeting. WGNE has previously stated that the model output data would be useful because: (1) CEOP brings atmospheric and land model fluxes together with observations, and potentially this would be an important combination if good contact points can be made with each of the field experiments; experience has shown real progress can be achieved when the field scientist works closely with the modeller (and vice-versa); (2) if there is a central archive of CEOP reference data, which is readily available and an easy to read format then NWP centres could make good use of it. Dr. Roads observed that besides helping to document water and energy processes during CEOP, there are a number of reasons why this output will be useful: for example, there have previously been a number of extensive model intercomparisons (AMIP, CMIP, SMIP, PIRCS, PILPS) that have revealed systematic errors in models. By contrast there has not been any systematic comparison made for analyses. It is not known what the error in comparison to observations is as well as what the differences in the modelled hydroclimatological processes are between various models. Given its focus on high-resolution temporal sampling of a comprehensive number of hydrometeorological processes and variables from observations and NWP analyses, CEOP is well positioned to begin to coordinate efforts with modelling groups on observing and modelling the global hydrologic cycle on diurnal to seasonal time scales. Understanding and improving current model deficiencies of various hydrometeorological processes should aid in efforts to improve model simulations and predictions on longer times scales.

7. REANALYSES

ECMWF

Dr. M. Miller reported on the ERA project.The ERA project was completed in April 2003: ERA-40 has provided analyses for a 45-year period from 1 September 1957 to 31 August 2002. A comprehensive set of 2.5^{o}-grid single-level and pressure-level analysis or six-hour forecast fields from ERA-40 can be downloaded from the Centre's new data server http://data.ecmwf.intdata. This server also offers data from the DEMETER project and ERA-15. Data are downloadable in either GRIB or NetCDF data formats; plots of individual fields may also be produced and downloaded. A measure of the accuracy of analyses is provided by the skill of the medium-range forecasts run from them. It is seen that anomaly correlations of 500 hPa height as a function of forecast range for ERA-40 forecasts for all eleven years which span 1958 to 2001, for Europe (and also for other northern hemisphere regions) remain above 60% on average for well over five days for all years, indicating good synoptic accuracy of the analyses throughout the period. In contrast, forecasts for Australia/New Zealand are very much poorer prior to the major improvement to the observing system that was introduced for the Global Weather Experiment in 1979. The ERA-40 analyses for the southern hemisphere before 1979 must be used with more caution than either their counterparts for the northern hemisphere or the later analyses for the southern hemisphere. Basic global-mean temperature trends and low frequency variability are captured well over much of the troposphere and lower stratosphere. ERA-40 analyses reproduce both the well-documented warming that has occurred at the surface since the mid 1970s, which is especially marked over land, and the cooling that has occurred in the lower stratosphere. Interannual variability in the lower stratospheric analyses is stronger in ERA-40 than ERA-15, and more in accord with observations. The warm periods following the volcanic eruptions of Agung in 1963, El Chichon in 1982 and Pinatubo in 1991 are also clearly seen. Compared with estimates from the Global Precipitation Climate Project (GPCP) for 1979 onwards, ERA-40 precipitation is substantially too large only in the tropics, especially over the oceans. Patterns of precipitation appear realistic, but rainfall amounts in precipitating tropical oceanic areas are much higher than GPCP values, and the discrepancy is larger than can be ascribed to uncertainties in the GPCP estimates. ERA-40 precipitation is in much better agreement with GPCP in the extratropics, not only with respect to the climatological means but also with respect to the interannual variability of monthly totals.

Current activities include preparation of documentation (including production of an atlas jointly with the University of Reading), observation related studies and reprocessing, diagnosis of analysis, completion and diagnosis of twice-daily 10-day forecasts, and diagnosis of an " AMIP-style" run using ERA-40 model.

NCEP

Dr. R. Petersen reviewed the status of the reanalysis activities at NCEP.The preparation of a regional reanalysis (RR) over the USA for the period 1979-2003 provides a long-term consistent data set for the North American domain, superior to the NCEP/NCAR global reanalysis in both resolution and accuracy. The regional reanalysis is based on the Eta model and the Eta data assimilation system (with the global reanalysis used as boundary conditions). Important features include direct assimilation of radiances and assimilation of precipitation (over the USA), as well as recent Eta model developments (refined convective and land-surface parameterizations). A range of data (including all those used in the global reanalysis, various precipitation data sets, TOVS-1B radiances for certain periods, profiler measurements, and lake surface data) has been assembled. Many pilot experiments have been done at 80km resolution. The production resolution is 32 km with 45 layers. The domain covers Greenland, North-eastern Siberia, oceanic areas west of Hawaii and east of Barbados, Central America and the Northern tip of South America. Precipitation data for the Continental U.S., Canada, Mexico and oceanic areas have been gathered. Fits of wind and temperature observations to the analysis and guess fields are generally superior to those of the NCEP/NCAR Global Reanalysis (GR). Biases of 2m temperature and 10m wind speed are also improved over the GR. Precipitation patterns from the analysis cycle, averaged monthly, agree well with observed ones in pilot studies carried out so far. The RR production began in February 2003 and was completed by September 2003 when the computer was removed from service.

Results for upper troposphere, comparing both GR and RR show that (i) root-mean-square (RMS) analysis fits significantly better for temperatures and vector wind speeds for RR, (ii) wind speed improvement is greatest in the upper troposphere, especially in winter, (iii) first guess (3-hr forecast, pre-3DVAR) temperatures are not always as favourable for RR compared to GR, and (iv) relative humidity is improved for RR for both analysis and first guess. Near surface, results show improvements in RMS errors of surface temperature and winds of RR over GR. For precipitation, the pattern looks very much like the observed precipitation pattern in both summer and winter. Comparison of summer precipitation of extreme years (draught of 1988 and flood of 1993) reveals the success of precipitation assimilation even for drought and flood years. Ongoing activities include moving towards the creation of the real-time R-CDAS system, verification and monitoring of RR system, and distribution of RR results.

Japan Meteorological Agency (JMA)

Dr. K. Saito reported on the ongoing reanalysis activities in Japan, namely the planning of a 25-year reanalysis by JMA (JRA-25) for the period 1979-2004. This will form the basis for a dynamical seasonal prediction project and global warming study, for advanced operational climate monitoring services at JMA, and for various activities in climate-system studies. The reanalysis is a five-year joint initiative of JMA, which is providing the data assimilation expertise and forecast system, and the Central Research Institute of the Electric Power Industry, a private foundation, furnishing the computer resources. A 3DVAR system (operational since September 2001) with a model of resolution of at least T106 and 40 levels in the vertical will be employed. As well as data archived at JMA from 1975 to the present, the NCEP/NCAR data set used in the NCEP reanalysis and the merged ECMWF/NCEP data sets in ERA-40, a range of satellite observations (including reprocessed GMS cloud motion wind data) will be assimilated. The project is expected to be completed by 2005, with the products available to scientific groups contributing to the evaluation of the reanalyses and who provide feedback on improvements that could be made. Dr. Saito presented results of intercomparison of time series of snow cover over north America and the global, northern hemisphere, tropics, southern hemisphere means of 100hpa temperature for the period October 1988 to September 1989 derived from the reanalysis data from JRA-25, ERA-15, ERA-40, NCEP/NCAR Reanalyses I and II.

WGNE reiterated its strong support to the reanalysis efforts and reiterated the desirability of setting up a dedicated 'Reanalysis Centre' at a major NWP operational centre. WGNE recommended that the concept should be built into the new initiative 'COPE' and that the JSC should secure funding for this ' Reanalysis centre.'

8. THORPEX: A GLOBAL ATMOSPHERIC RESEARCH PROGRAMME

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 on Atmospheric Sciences (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.

The core research objectives of THORPEX are to:

- Contribute to the design and demonstration of interactive forecast systems that allow information to flow interactively between forecast users, numerical forecast models, data-assimilation systems and observations. Interactive forecast systems include the concept of targeted observations.
- Advance the knowledge of global-to-regional influences on the initiation, evolution, and predictability of high-impact weather.
- Collaborate with numerical forecast centres in the development of advanced data-assimilation and forecast model systems. Research will include: i) improving the assimilation of existing and experimental observations, including observations of physical processes and atmospheric composition; ii) developing adaptive data-assimilation and targeted-observing strategies; iii) incorporating model uncertainty into data-assimilation systems and in the design of ensembles.
- Develop and apply new methods to enhance the utility of improved weather forecasts. This research will identify and assess the societal/economic costs and benefits of THORPEX recommendations for implementing interactive forecast systems and improvements in the global observing system.
- Perform THORPEX Observing-System Tests (TOSTs) and THORPEX Regional field Campaigns (TReCs).
- Demonstrate the full potential of THORPEX research results for improving operational forecasts of high-impact weather on time-scales out to two weeks.

At the WGNE session, Prof. A. Thorpe (co-Chair ISSC) and Dr. M. Beland (Chair ISSC) made presentations on THORPEX. WGNE was informed of the THORPEX response to last year's resolution and an update on THORPEX developments over the year. The International Science Plan was also presented and discussed. WGNE reiterated its support for THORPEX as a collaborative WWRP/WGNE experiment. A draft of the joint WWRP/WGNE THORPEX Resolution was discussed. The draft joint Resolution, in accepting the Science Plan, commends the co-Chairs of the ISSC at the steady progress made in the past year and views the development of a succinct and visionary THORPEX Science Plan as a positive step forward. It further notes and approves THORPEX's aspiration to become a Global Atmospheric Research Programme, encompassing a wide range of research to accelerate improvements in the accuracy of 1 to 14-day high-impact weather forecasts for the benefit of society and the economy. The Resolution notes that the stage has now been reached where a detailed THORPEX Implementation Plan needs to be developed to set up procedures for selection of projects and experiments to be managed within the THORPEX programme, and establish linkages to enable input from THORPEX into existing programmes and structures.

WGNE was also briefed about the developments in the Asian THORPEX by Dr. D. Chen. At the first meeting of the THORPEX International Core Steering Committee (ICSC) held in Oslo, Norway in October 2002, representatives from Asian countries, China, India, Japan, Republic of Korea and Russia reached an agreement that they, together with USA, will establish the Asian THORPEX community in which they will collaborate to promote THORPEX aims by targeting the high impact weather events in Asia. A planning meeting of the Asian THORPEX community was held in February 2003 at the Japan Meteorological Agency,Tokyo, to discuss research targets and possibility of international collaboration.

9. MODEL VERIFICATION

There are a number of WGNE projects involved with the validation of deterministic forecasts. These include the compilation of the so-called WMO scores, verification of quantitative precipitation forecasts, validation of tropical cyclone tracks and verification of stratospheric analysis and forecasts. There has also been the recognition that with models attaining increasing resolutions there is urgent need to move forward from the gross validation methods that have been used so far. Accordingly, WGNE has prepared a position paper on verification (see " The WGNE survey of verification methods for numerical prediction of weather elements and severe weather events", by P. Bougeault, CAS/JSC WGNE Report No. 18, Appendix C, WMO/TD-NO. 1173,2003).

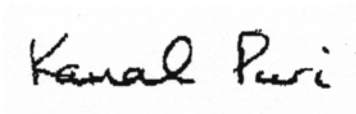
Verification is of considerable importance for both WGNE and WWRP projects. It has therefore been decided to form a joint Working Group (JWG) on verification. It was recognised that a joint working group will be valuable to coordinate efforts and share ideas and results, and that the JWG will allow the formation of unified approaches to solve common verification problems. Proposed members of the JWG are: Barbara

Brown (chair; NCAR); Frederic Atger (MeteoFrance); Harold Brooks (NSSL); Barbara Casati (U. Reading); Ulrich Damrath (DWD); Beth Ebert (BMRC); Anna Ghelli (ECMWF); Glenn Greed (UKMO); Pertti Nurmi (FMI); David Stephenson (U. Reading); and Laurence Wilson (MSC).

The JWG has identified a number of specific goals, including the following:

- Encourage greater cooperation between users and verifiers of forecasts, to ensure the relevance and integrity of the practice of forecast verification; this includes development of useful, meaningful and statistically sound verification measures, as well as working with both forecast users and developers;
- Encourage the development and application of improved diagnostic verification methods to assess and enable the improvement of the quality of weather forecasts, including forecasts of weather elements and forecasts from numerical weather prediction and climate models; some of the issues that are of concern include partitioning error according to scale, verification of forecasts of probability distributions, spatial forecast verification, assessing uncertainty in verification statistics, and the use and processing of high resolution remotely sensed observation data for verification;
- Encourage the sharing of observational data for verification purposes;
- Encourage greater awareness in the research community of the importance of verification as a vital part of numerical and field experiments; and
- Encourage collaboration among scientists conducting research on various aspects of forecast verification, and with model developers and forecast providers.

WGNE welcomed Dr.B.Brown, Chair, JWG on Verification who made a presentation on the proposed JWG. WGNE formally approved the formation of the JWG and suggested that Dr.P.Bougeault's review paper on Verification could serve as a good starting point for the JWG as most of the points of interest are contained there. WGNE pointed out that ensemble prediction verification is of great interest to the scientific community and should be included in the JWGs plans. A joint WWRP/ WGNE International Workshop on Verification is planned to be held in Montreal, 13-17 September, 2004



(Kamal Puri)

Chairman, WGNE