ANNUAL REVIEW OF THE

WORLD CLIMATE RESEARCH PROGRAMME

AND

REPORT OF THE TWENTY-FOURTH SESSION OF

THE JOINT SCIENTIFIC COMMITTEE

(Reading, United Kingdom, 17-21 March 2003)

FEBRUARY 2004

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ANNUAL REVIEW OF THE WORLD CLIMATE RESEARCH PROGRAMME

AND

REPORT OF THE TWENTY-FOURTH SESSION OF THE JOINT SCIENTIFIC COMMITTEE (Reading, UK, 17-21 March 2003)

1. ANNUAL SESSION OF THE JOINT SCIENTIFIC COMMITTEE FOR THE WORLD CLIMATE RESEARCH PROGRAMME

The principal task of the annual session of the WMO/ICSU/IOC Joint Scientific Committee (JSC) for the World Climate Research Programme (WCRP) is to review the scientific progress in the programme during the preceding year. At the kind invitation of Professor B.J. Hoskins, Department of Meteorology, University of Reading, the 2003 session of the JSC, the twenty-fourth, took place at the Department of Agriculture, University of Reading, UK from 17-21 March. The session was called to order by the Chairman of the JSC, Professor P. Lemke, at 0830 hours on 17 March 2003. The list of participants is given in Appendix A. This report summarizes the information presented to the JSC on the progress in the WCRP during the preceding year and records the recommendations by the JSC for the further development of the programme (these recommendations are compiled for convenience in Appendix B).

The session was formally opened by the Mr. Peter D. Ewins, Chief Executive, Met Office, UK, who extended a warm welcome to Reading to all participants and expressed his pleasure that the JSC was meeting in Reading. He observed that the venue was very appropriate since the University of Reading through its strong relationship with the Met Office was playing an increasingly significant role in the international effort to measure and identify the causes of climate change. He also stressed the UK's involvement in climate change issues, the effects of climate change on humans in the long term, its impact on water resources and other major challenges posed by climate change. Mr. Ewins pointed out that with the new supercomputing facility at the Met Office, it should be possible to use ensemble forecasting methods for climate change. Mr. Ewins further underlined the important responsibility of the WCRP in developing an understanding of the extent of human influence on climate and the major potential socio-economic benefits that would result from an improved capacity to forecast climate fluctuations.

On behalf of the UK agencies sponsoring the JSC session, Professor B.J. Hoskins added his welcome to participants and hoped that all would have an enjoyable time. He noted that the agenda for the session included many challenging questions, and looked forward to working through these and arriving at recommendations that would allow WCRP to move forward, both in its own studies of the physical climate system, and, in conjunction with its partner programmes, the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP) and DIVERSITAS, in the overall study of Earth system science and global change. Professor Hoskins observed that atmospheric and climate sciences were healthy in the Department of Meteorology, Reading, and in the UK in general. He called attention to the challenges in forecasting, especially in western Europe, and gave the example of blocking highs which tend to be 'underpredicted' in both weather and climate models. Professor Hoskins expressed gratitude for the support he had received from the sponsoring agencies for the JSC session, namely the University of Reading, the Met Office, the Royal Society and the Natural Environment Research Council, as well as to all those who had assisted in the local organization.

The Chairman of the JSC thanked the Chief Executive of the Met Office for his welcome and his highly appropriate and inspiring remarks. It was for all a pleasure and privilege to be in Reading and have the opportunity to acknowledge the outstanding contribution of the UK to the WCRP. The Chairman also expressed deep gratitude to all the agencies who had sponsored the organization of the session. He personally thanked Professor B.J. Hoskins and all the others who had made such substantial efforts in making the arrangements for the session. The Chairman noted especially the excellent facilities provided and the extensive hospitality being offered.

The Chairman continued by extending his greetings to the participants in the session, particularly to members of the Committee attending for the first time, namely Professor T. Yasunari (Hydrospheric Atmospheric Research Center, Nagoya University, Japan) and Dr V. Ramaswamy (NOAA Geophysical Fluid Dynamics Laboratory, Princeton University, USA). The Chairman noted with regret that three JSC members, Dr J. Church (Officer), Professor P. Cornejo and Dr K. Trenberth (Officer), could not be present.

The Chairman was pleased to welcome the representatives of the UK agencies sponsoring the JSC session. These were Mr Peter D. Ewins, Chief Executive, Met Office, UK, Professor B.J.Hoskins, University of Reading as well as The Royal Society, and Professor A.J.Thorpe, the Natural Environment Research Council (representing as well the THORPEX International Scientific Steering Committee). The Chairman further acknowledged with appreciation the participation of observers on behalf of the organizations sponsoring WCRP: Dr M. Hood, IOC; Dr L. Goldfarb, ICSU; Dr D. Carson (as well as Director of the WCRP), WMO. The Chairman also noted with pleasure the attendance of the Chair of the Scientific Committee for IGBP, Professor G. Brasseur. In view of the increasing interactions between WCRP and IGBP in many areas (see section 9), Professor Lemke emphasized that he regarded participation by WCRP and IGBP in the sessions of the main scientific committee meeting of the other as an essential duty. The Chairman was also pleased to welcome, Professor C.H. Vogel, Chair, Scientific Committee of the IHDP, Professor W.L. Gates, Past Chair, JSC, and Dr A.H. Hollingsworth, Head of Research Department, ECMWF.

The Chairman voiced his gratitude for the customary participation of the chairs or representatives of WCRP steering or working groups who would brief the JSC on activities in their respective fields and advise on future actions to be taken. These included: Dr A. Busalacchi and Professor J. Willebrand, Co-chairs of the CLIVAR Scientific Steering Group; Dr B. Goodison, Chair of the ACSYS/CliC Scientific Steering Group, Professors A. O'Neill and A.R. Ravishankara, Co-chairs of the SPARC Scientific Steering Group; Dr J.F.B. Mitchell, Chair of the JSC/CLIVAR Working Group on Coupled Modelling (WGCM); Dr K. Puri, Chair of the CAS/JSC Working Group on Numerical Experimentation (WGNE); Professor S. Sorooshian, Chair of the GEWEX Scientific Steering Group; Dr J. Roads, Chair, GEWEX Hydrometeorology Panel; Dr J. Polcher, Chair, GEWEX Modelling and Prediction Panel; Professor P. Liss, Chair, SOLAS Scientific Steering Committee; Dr R.E. Dickinson, Co-chair of the Scientific Steering Committee for the Global Carbon Project.

The Chairman was further pleased to note the attendance of Project Office Directors: Dr C. Dick, ACSYS/CliC International Project Office; Dr H. Cattle, International CLIVAR Project Office; Dr R. Schiffer, Acting Director, International GEWEX Project Office; Dr J. Ingram, Executive Officer, GECAFS International Project Office; Dr M. Manning, Director, IPCC Working Group I, Support Unit. The Chairman was gratified by the interest manifested by GCOS with the attendance of Professor P. Mason, Chair of the GCOS Steering Committee (also representing the WMO Commission for Atmospheric Sciences (CAS)), as well as Dr D.E. Harrison Chair of the Ocean Observations Panel for Climate (jointly sponsored by WCRP, GCOS and the Global Ocean Observing System, GOOS), and Professor Sulochana Gadgil, the new Co-chair of the joint WCRP/IGBP/IHDP Global Change System for Analysis, Research and Training (START). The Chairman observed with satisfaction the attendance of Dr U. Svedin, Chair, International Group of Funding Agencies for Global Change Research.

Finally, the Chairman looked forward with anticipation to the scientific lectures by two leading UK scientists that had been arranged, namely "Climate Processes" by Professor J. Slingo (Director of the NERC Centre for Global Atmospheric Modelling (CGAM), Department of Meteorology, University of Reading) and "Climate Modelling" by Professor J.F.B. Mitchell (Chief Scientist, Met Office, UK and Chair of the JSC/CLIVAR Working Group on Coupled Modelling (WGCM)).

2. MAIN DEVELOPMENTS AND EVENTS SINCE THE TWENTY-THIRD SESSION OF THE JSC

The overall progress in the various components of the WCRP over the past year, and the issues on which the advice and guidance of the JSC were required, are summarized in detail at the appropriate parts of this report. At this point, only a few of the major highlights are reviewed.

In the Global Energy and Water Cycle Experiment (GEWEX), the past year was the first full year of GEWEX Phase II and most projects underwent orientation changes following JSC-22 guidelines resulting in an increased interaction between the various projects for a more global and a more interdisciplinary approach. GEWEX highlights for 2002 included: (i) the beginning of the build-up phase of the Co-ordinated Enhanced Observing Period (CEOP), with the joint commitment of the continental scale experiments, the space agencies and the global modelling community; (ii) advances in closing regional water budgets; (iii) the reorganisation of global data sets under a common umbrella; and, (iv) the start of new modelling activities in close co-ordination with the global climate modelling community.

As the panels and working groups of the Climate Variability and Predictability (CLIVAR) study grow in maturity, links and common activities between them are beginning to emerge. This is particularly noticeable in terms of observational activities but is also reflected in continual progress in modelling of the coupled climate system. WOCE has formally ended leaving an important legacy of observational techniques, of improved models and understanding of physical processes and, for the first time, a quantitative

assessment of the ocean circulation's role in climate. The final WOCE Conference, entitled "WOCE and Beyond", was held in San Antonio, Texas, USA in November 2002, and provided a fitting overview of WOCE achievements and a look to the future. Ocean reanalysis and data assimilation have been identified as high-priority topics which would contribute significantly to the global integration of CLIVAR activities. A workshop on ocean reanalysis has been scheduled tentatively for February 2004 in La Jolla, CA. CLIVAR regional initiatives on the Variability of the African Climate System (VACS), the Variability of the American Monsoon System (VAMOS) and the Asian-Australian monsoon (CLIVAR-AA) continued to progress. Planning for the first International CLIVAR Science Conference to be held from 21-25 June 2004 in Baltimore, USA was now well advanced. The conference will provide, in particular, an overall review of progress in CLIVAR to date, as well as providing the impetus for an assessment of the overall direction of the programme.

With the Arctic Climate System Study (ACSYS) in its final year, and the Climate and Cryosphere (CliC) project under way, issues during the year involved mostly work towards the successful conclusion of ACSYS and the spin-up of CliC activities. These included completion of ACSYS observational programmes and studies and summarising of the results with the goal of improving representation of the Arctic region and corresponding processes in global climate models. This will be accomplished, in part, by the ACSYS Final Science Conference scheduled to be held at the Arctic and Antarctic Research Institute (AARI), St Petersburg, Russia, from 11-14 November 2003. The conference will celebrate ten years of progress in WCRP research on the Arctic Climate System and its role in global climate. Also addressed were the smooth and full transition of all relevant ACSYS activities to CliC, and refining of the CliC Implementation Strategy document. The first CliC Science and Implementation conference was being planned to be held in 2005 with the objectives of presenting CliC science objectives and activities to funding, research and operational agencies, and of discussing national and agency priorities and efforts to address CliC goals.

During the past year, the study of Stratospheric Processes and their Role in Climate (SPARC) had continued its efforts in the detection of stratospheric trends, which indicate climate change or can affect climate. This included assessments of trends in stratospheric temperature and vertical distribution of ozone, upper tropospheric and stratospheric water vapour. Work was now under way on a stratospheric aerosol climatology; an updated stratospheric reference climatology had been finalised; and the SPARC data centre, established in June 1999, was being used extensively. SPARC studies in the dynamics and transport in the lower stratosphere and upper troposphere had demonstrated convincingly the existence of additional predictive potential associated with stratospheric observations and the inclusion of stratospheric layers in general circulation models of the atmosphere. The tenth session of the SPARC Scientific Steering Group was preceded by an "International Symposium on Stratospheric Variations and Climate", in Fukuoka, Japan, on 12-15 November 2002. The first ten years of SPARC research had been capped by the awarding of the Norbert Gerbier-MUMM International Award for 2003 to an international team of 17 SPARC scientists (Drs Ramaswamy, Chanin, Angell, Barnett, Gaffen, Gelman, Keckhut, Koshelkov, Labitzke, Lin, O'Neill, Nash, Randel, Rood, Shine, Shiotani and Swinbank) for their paper, 'Stratospheric temperature trends: observations and model simulations', published in Reviews of Geophysics in 2001.

In the area of climate modelling, particular attention was being given to the future development of the two principal intercomparison projects, the Atmospheric Model Intercomparison Project (AMIP) overseen by the JSC/CAS Working Group on Numerical Experimentation (WGNE), and the Coupled Model Intercomparison Project (CMIP) overseen by the JSC/CLIVAR Working Group on Coupled Modelling (WGCM). An International AMIP Workshop had been held in Toulouse from 12-15 November 2002 with a focus on innovative climate model diagnostics and with strong representation from the observational communities. The WGNE session immediately following the AMIP Conference had discussed future directions for AMIP. Additionally, WGNE has the responsibility and leadership in WCRP for fostering the atmospheric reanalyses so important for many WCRP activities. It was gratifying to note the good progress being made in the comprehensive 40-year reanalysis project at ECMWF (ERA-40) and in the 25-year reanalysis project (1979-2004) at the Japan Meteorological Agency. WGNE was also closely involved, jointly with the CAS World Weather Research Programme (WWRP), in reviewing and finalising the draft resolution concerning the current status and the next steps in the development of "The Observing System Research and Predictability Experiment" (THORPEX) which would be likely to have significant implications and benefits for a number of WCRP projects. WGCM had continued in its endeavour to maintain a broad overview of modelling activities in the WCRP and in its basic task of building up comprehensive climate models. A Coupled Model Intercomparison Project (CMIP) Workshop was planned back to back with the WGCM/GAIM Conference on Earth System Modelling in Hamburg, 22-24 September 2003. WGCM was considering the possibility of regarding CMIP as an overarching Model Intercomparison Project (MIP) guiding and coordinating the activities of other MIPs. A Joint WGNE/WGCM/IPCC Regional Climate Modelling Workshop was planned for early 2004 in close collaboration with START. The Workshop will consider optimal ways to use Regional Climate Models (RCMs) in different regions for climate change applications. In its continuing efforts to foster cooperation with the Global Analysis Interpretation and Modelling (GAIM)

element of IGBP, WGCM would be involved in GAIM's Earth System Atlas effort. WGCM is well versed in data management through its Programme for Climate Model Diagnosis and Intercomparison (PCMDI) activities, and could contribute significantly to the atlas effort.

3. MATTERS RELATING TO THE WCRP SPONSORING AGENCIES, WMO, IOC AND ICSU

3.1 Fifty-fourth session of the WMO Executive Council

At its fifty-fourth session (Geneva, June 2002) the WMO Executive Council had expressed its appreciation of the achievements of, and advances being made in, WCRP. In particular it had acknowledged the importance of the results of WCRP in laying the basis for operational climate prediction services by National Meteorological and Hydrological Services (NMHSs) and in underpinning scientific assessments of climate change, in turn feeding into scientific advice that could be offered by NMHSs on climate change issues. The Council stressed that the continuing development of WCRP and the co-sponsorship by WMO were thus of the utmost importance.

The Council noted the progress in WCRP core activities. Of particular interest were the regional studies being undertaken in CLIVAR focused on African climate variability, the Variability of the American Monsoon System (VAMOS), and the Asian-Australian monsoon. The Council stressed that attention should also be given to the applications and applicability of CLIVAR scientific results.

Another initiative of interest was the Co-ordinated Enhanced Observing Period (CEOP) of GEWEX. CEOP, in conjunction with other components of the WCRP, would enable progress in assessing the influence of continental heat and moisture sources and sinks on the global climate system and its anomalies. The Council noted that the Fourth International GEWEX Scientific Conference had been held in Paris in September 2001, focusing on themes central to GEWEX including the microphysics of clouds and cloud/aerosol interactions, the global water cycle and its sensitivity to climate change, and remote sensing and land-surface processes.

In the area of polar research, the Council noted that an initial implementation plan was being drawn up for CliC, in preparation for an international commitments conference (to be held in 2005). The Council encouraged all WMO Members having interests in the Arctic, Antarctic and Southern Ocean to support and participate in CliC to the limit of available resources. In the meantime, ACSYS, with the more restricted objective of assessing the role of the Arctic in global climate, was proceeding as planned with extensive new data sets on the Arctic Ocean circulation, temperatures and salinity, sea-ice, and exchange of water masses with the North Atlantic being collected.

The Council particularly recognized the achievements of the World Ocean Circulation Experiment (WOCE), which was now well into the final stage of synthesizing the measurements collected during the field programme (1990-1998) into a dynamically consistent view of the ocean circulation in the 1990s. WOCE had stimulated major advances in techniques of observing the oceans (e.g. automated floats, satellite sensors for precise ocean topography) and the understanding of the deep ocean structure and circulation had been greatly expanded. A substantial book on the ocean circulation and climate based on WOCE findings had been published and the latest version of the WOCE data set distributed on CD-ROMs. Work had begun on preparing a series of large-format atlases of the physical and chemical properties of the global ocean based on WOCE observations.

The Council was encouraged by the continuing active development of WCRP modelling and related activities. In particular, it was pleased to hear that good progress was being made in the new comprehensive 40-year reanalysis at ECMWF (ERA-40) and that the Japan Meteorological Agency was undertaking a 25-year reanalysis (1979-2004) (JRA-25) expected to be completed in 2005.

The Council was briefed on the status of the work of the WCRP Task Team on Climate Research for Arid and Desert Regions. The Team considered that, before realistic assessments of the implications of future climate conditions in arid regions could be made, the variability of past and present local climates had to be adequately characterized. However, there were only sparse long-term observational records in these regions, whose representativeness was uncertain and only few studies of impacts of past climate changes. Simulations of climate models in desert regions had also not been adequately verified. The appropriate development of climate observing and data management systems able to serve many applications ranging from climate research to policy issues was required as well as efforts to reconstruct past climates and elaboration of suitable regional climate models. It was planned to organize a multi-disciplinary workshop to frame strategies to meet these goals and to begin to answer the scientific questions involved. The Council

stressed the importance of arranging this event and making progress in the study of climate conditions in arid regions as urgently as possible. The Council recalled that a successful workshop on regional climate change indices (sponsored jointly by CLIVAR and the WMO Commission for Climatology) had taken place in Morocco in February 2001. The results obtained were highly relevant to arid region studies and it was suggested that this approach should also be pursued.

The Council welcomed the developing cooperation between WCRP and the other global environmental change programmes (IGBP, IHDP, and now also DIVERSITAS (an international programme of biodiversity science)). A particular highlight of this collaboration in the past year had been the Global Change Open Science Conference, *Challenges of a Changing Earth*, held in Amsterdam, The Netherlands, 10-13 July 2001. In this context, the Council urged that all relevant WMO Programmes should be fully involved in the planning of the new joint projects on the global carbon cycle, food systems, and the global water system, being developed by WCRP, IGBP, IHDP and DIVERSITAS.

The JSC recognized the continuing need to make some significant progress with the request from the WMO Executive Council to consider additional research needed for improved understanding of climate processes and potential effects of climate change in arid and desert regions. In particular, the JSC supported the proposal to hold an expert workshop on this topic in conjunction with the GEWEX Scientific Steering Group session, to be held in Morocco in January 2004.

3.2 Intergovernmental Oceanographic Commission (IOC)

At the fifty-fourth session of the WMO Executive Council (Geneva, June 2002), the representative of the IOC emphasised that the Commission would continue to play an active role as co-sponsor of the WCRP, in particular by maintaining the same level of financial support. In particular, IOC recognized the great value of the results of WOCE, which was now nearing its conclusion. Additionally, it was foreseen that CLIVAR would lead to understanding of and forecasting climate change on decadal time-scales. Support to this important CLIVAR research would be provided by the IOC/WMO/UNEP/ICSU Global Ocean Observing System (GOOS). The representative of IOC further noted that, jointly with GOOS and the Global Climate Observing System (GCOS), WCRP was a key sponsor of the Ocean Observations Panel for Climate, which has instigated the Global Ocean Data Assimilation Experiment (GODAE) and global profiling float programme, ARGO. Excellent progress was being made in these initiatives.

A new structure for the IOC Ocean Science Section was adopted at the twenty-first session of the IOC Assembly (Resolution XXI-6) (Paris, July 2001), since when the programmes of the Ocean Science Section of IOC have consisted of the following three interactive lines of work:

- Oceans and Climate

- Science for Ocean Ecosystems and Marine Environmental Protection

- Marine Science for Integrated Coastal Area Management.

At its thirty-fifth session (Paris, June 2002) the IOC Executive Council discussed the terms of reference for the programme elements of the IOC's Ocean Science Section and instructed the IOC Executive Secretary to prepare a revised version to be circulated to the IOC Member States for further comments. The final version of the document will become the guiding instrument for the implementation of the IOC Ocean Science Programme, and it will be made available for the twenty-second session of the IOC Assembly (Paris, June 2003).

3.3 International Council for Science (ICSU)

The ICSU General Assembly (September 2002) approved a proposal by the ICSU Committee on Scientific Planning and Review (CSPR) to develop ICSU Priority Area Assessments (PAA), initially in three areas, Environment and its Relation to Sustainable Development, Capacity Building, and Data and Information, and starting with the one on Environment. There are several reasons why ICSU had chosen to review its environmental activities at this stage, not least of which are the challenges for ICSU arising from the World Summit on Sustainable Development (WSSD, Johannesburg, August/September 2002). In particular, the United Nations invited ICSU (and a few other organizations) to represent the Scientific and Technological community at the WSSD. The challenge now is to develop research that integrates the environmental, social and economic pillars of sustainable development. ICSU has therefore decided that it is necessary to take stock of its environmental activities to assess how it is suited to address emerging problems and to provide the basis of good science for good governance.

The goal of the PAA process is to strengthen ICSU's overall capability in addressing priority scientific issues that are of emerging importance to science and society at large. The ICSU CSPR had appointed an *ad hoc* Panel for a PAA on Environment and its Relation to Sustainable Development, which was chaired by Dr R.T. Watson, World Bank. In this context, WCRP was requested to complete and submit a comprehensive questionnaire, by 31 January 2003. This written exercise was followed by a request to participate in a 'dialogue' between the PAA Panel and representatives of ICSU's environmental activities, which was held at ICSU, Paris, 21-22 February 2003. The Director of the WCRP participated in this meeting. The final report would be available on the ICSU website (www.icsu.org) by the end of January 2004.

4. SCIENTIFIC DIRECTION, STRUCTURE AND PRIORITIES OF WCRP

4.1 Report of the Task Force for the WCRP Predictability Assessment of the Climate System

4.1.1 Introduction

Professor B. Hoskins, Chair, presented the report of the task force on "Predictability Assessment of the Climate System", which had involved JSC members and representatives nominated by the projects and overarching activities.

The task force noted that much has already been achieved by scientists working through WCRP in the area encompassed by the WCRP's two main aims viz., (i) to determine to what extent climate can be predicted, and (ii) to determine the extent of human influence on climate. Outstanding successes like the completed Tropical Ocean-Global Atmosphere (TOGA) project and World Ocean Circulation Experiment (WOCE), and progress in the currently ongoing activities of CLIVAR, GEWEX, SPARC, ACSYS/CliC and modelling demonstrate this. The essence of WCRP science is understanding, observation, quantification, prediction and projection of the climate system which underlie its two aims. The re-emphasis by WCRP of its original aims is consistent with the vision of a seamless prediction problem, from weeks through decades to the projection of climate change. Variability on all shorter times scales, including those associated with the weather, is important both for its impact on the longer time-scale behaviour and because its statistical behaviour is a crucial part of the longer time-scale prediction. Increasingly climate projection also will become an initial value problem. Biogeochemical cycles are increasingly seen as part of the area of observational interest of WCRP and as interactive components in WCRP climate system models. This will continue and develop in close partnership with IGBP. The human dimension dictates the relevance of the two aims. The challenge to use the results of WCRP science in support of sustainable development necessitates a closer relationship with IHDP and with START, and more generally for WCRP to play its full role within the Earth System Science Partnership (ESSP). The ESSP joint projects on water, carbon, food and health are important aspects of this.

It may be appropriate and useful under the two WCRP aims to have a small number of specific objectives that can be achieved on specified time-scales. These should be widely debated in WCRP. Potential candidates are:

- determination of the extent to which seasonal prediction is possible
- development of well-tested procedures for the ensemble prediction of climate variability and change
- realistic simulations of an Ice Age Cycle using full GCMs (with IGBP-PAGES)
- development of well-tested, detailed, climate-chemistry prediction and projection models and procedures (with IGBP-IGAC)
- in collaboration with IPCC Working Group 1, to enable the science that it will review in its Fourth Assessment Report.

4.1.2 Requirements to meet WCRP aims and objectives

Research components

WCRP tries to achieve its aims through climate modelling, climate observations and climate process research. In addition, more complete exploitation of observations and improvement of models require climate system data assimilation. This is an important period in climate modelling. Computing resources available now and in the near future give the possibility of climate models run at very high resolution, large ensembles of runs to describe the uncertainty, the addition of more interactive chemistry and biology and also the

cryosphere, and very long simulations of, for example, an Ice Age cycle. The emerging discipline of seasonal to decadal forecasting continuously challenges models. New and future satellite instrumentation will be giving very large quantities of new, more detailed and better quality information on the usual meteorological and oceanographic state variables, on processes occurring in them, on aspects of the land surface and on atmospheric composition. At the same time the in situ observational capability is increasing in its possibilities, but not necessarily in its execution. The ARGO initiative will routinely provide a large increase in the detailed information about the ocean. During this decade the WWRP project, 'THORPEX: a global atmospheric research programme' will focus on the possibility that targeting the observational system, both satellite and in situ, using prediction-model information may give enhanced ability to predict high impact weather. It also aspires to investigate how such ability depends on larger space- and time-scales, and the predictability in week two. THORPEX will culminate in a global weather experiment around 2010. Given the importance in longer-term predictions of the statistics of severe weather as well as the feedback of such weather onto the longer time-scale, and also the complementary predictability time-scales, this project is clearly of interest to WCRP. Another clearly essential requirement is for research focused on the various components of the climate system, atmosphere, ocean, land and cryosphere and on the pair-wise interactions between them. Equally, the expertise in physical processes must increasingly be complemented by those in chemistry and biology and in the interdisciplinary areas. Added to this is the interaction also with the human dimension. Arising from the science or from requests from others, there is sometimes a need to be able to focus effort onto a particular problem. A current example for WCRP is the cloud-radiation problem.

Requirements for ability to link with other activities

Increasingly, the ability of WCRP to liaise with the other global change programmes in the ESSP and with their projects is becoming essential. In particular the linkage with IGBP in many areas, such as biogeochemical cycles in models, climate system and Earth system models, the coupled chemistry-climate problem and palaeoclimates, will become a larger aspect of WCRP activity.

In climate change a working link with IPCC is vital. On the observational front, linkages with GCOS and with the satellite agencies must work well so that WCRP needs and products are appreciated and used. There is a continuing and generally good relationship between WCRP and the National Meteorological and Hydrological Services: the atmospheric component of climate models generally derives from NWP models and experience, and the products of WCRP science feed back to their operational activities.

4.1.3 Implications for the structure and activities of WCRP

One way to approach the future would be to totally revise the structure of WCRP. An alternative would be to change rather little but try to focus more on the aims. Here a course somewhere between the turmoil generated by revolution and the inertia of little change is proposed.

The responsibility for the WCRP aims and objectives

Clearly, the overall responsibility for WCRP must lie with the JSC. Such a responsibility implies that the JSC members play a more active role in the programme of WCRP with specific members attached to its projects and activities, whose role is to pay particular attention to the fulfilling of the aims and objectives of WCRP. JSC meetings should then become much more focused on progress towards these aims and objectives.

The projects and activities may have to evolve their scientific programmes and structures so as to enable them to make their proper contribution toward the aims and objectives. With such a concentration, any concerns over boundaries and overlaps between projects should be reduced. At JSC meetings the inputs of projects and activities would become much more oriented towards input to the discussion on the progress towards the WCRP aims and objectives.

Modelling activity in WCRP

All WCRP projects have modelling working groups. The need for liaison between them, and also WGNE and WGCM, has sometimes been tackled by cross-attendance or even meeting together. It has also led at one time in the past to two JSC members being tasked with providing some coordination.

Because WGCM was seen as providing a lead on what is here described as the second WCRP aim, it was given a JSC status as well as its original CLIVAR parentage. If the JSC takes the leadership for both aims then this dual reporting line would no longer be necessary. However the central role to be played by modelling in WCRP and the over-riding need for coordination of this activity would be enabled by the setting

up of a WCRP Modelling Council. This should have as its members the chairs of WGNE, WGCM and the project modelling groups, also a representative of IGBP/GAIM, and perhaps two JSC members. This Modelling Council would:

- between JSC meetings carry the responsibility in the prediction and projection aspects of the WCRP aims and objectives
- coordinate modelling activities across WCRP and facilitate collaborations where appropriate
- formulate and oversee overarching modelling activities such as carbon/climate models
- act as the contact point with modelling in IGBP and elsewhere
- act as the link to IPCC, establishing common forcing scenarios and coordinating the execution of consistent and comparable climate change projections for use in impact assessments.

WGCM should then revert to its CLIVAR status and role. The last three responsibilities listed for the Council would probably be performed mainly through WGCM as is now the case. The evaluation and development of climate system models would be one of WGCM's major roles. Its position in CLIVAR, alongside the Working Group on Seasonal-to-Interannual Prediction (WGSIP) and the Working Group on Ocean Model Development (WGOMD) would recognize that climate variability and change are intimately connected. In order to cover the range of WCRP interests, it is proposed that WGSIP extend its period of interest to cover the periods from weeks to decades. WGNE would retain its joint JSC/CAS status and its current role, in particular providing the link with the NWP centres.

Observation Council

The arguments given for a Modelling Council based on the previous discussion appear to apply with almost equal weight to the observational aspect of WCRP's activities. If set up, a WCRP Observational Council would:

- between JSC meetings carry the responsibility for observational aspects of WCRP aims and objectives
- coordinate observational activities across WCRP, and in particular ensure that any major activities proposed by one project are discussed by all and, if they occur, become WCRP campaigns with the synergy that this implies
- take responsibility for any decade long observational programme if this is decided upon
- act as the contact point with GCOS and the satellite agencies, developing the WCRP observational requirement
- link with IPCC on observational aspects of the detection and attribution problems
- oversee data management in WCRP.

There is clearly a danger in having separate Modelling and Observation Councils. However, the danger should be limited because modelling and observations must come together in each of the WCRP projects and in the JSC in the pursuance of the WCRP aims and objectives.

The staffing implication of setting up the two Councils would also need careful consideration.

Other modes of working

In order to work on topics of the moment or stimulate or coordinate activity in particular areas it is proposed that WCRP should make much greater use of focused task forces/limited-life working groups and also workshops. The cloud radiation problem is already starting to be tackled in this manner. Systematic errors in models and how to reduce them may be another suitable topic.

One aspect highlighted earlier was the vital role that will be played in the future by climate system data assimilation. Given the new satellite instrumentation and the broadening of climate system interest in

WCRP, the need to stimulate and coordinate this activity is urgent. It would be appropriate for WCRP to organise a workshop in this area as soon as possible. Subsequently the continuing role of overseeing and coordination may be appropriate to give to one of the Councils.

An observational experiment?

As stated before, a persuasive argument has been made that WCRP should, both for its science and for its credibility, exploit fully the new observational data that are becoming available. By doing so it would put itself in a position to argue for the climate observational system that will be needed in a decade's time. Further, if this is depicted as a Climate Experiment, in which it is closely linked with the WCRP aims and objectives, it may provide an extra stimulus for the science as the First GARP Global Experiment (FGGE) did. One proposal is that the decade 2005-15 be designated the Climate System Predictability Decade (CSPD). CEOP could then be viewed as the start-up activity for the CSPD. This would have to be extremely well thought out so that it is clear that it is driven by progress towards the WCRP aims in general and towards specific objectives in particular.

Because of the importance of severe weather in the climate problem and the complementary time-scales of interest, and because there could be a real synergy between the continuing observational component of CSPD and THORPEX, there is a strong argument for considering a linkage with the 'THORPEX Prediction Experiment" near 2010 (perhaps the Global Climate and Weather Experiment). The advantages to both of these would have to be considered but appear to be real. There is also a suggestion from some in the polar community that about 50 years after the 1957 International Geophysical Year there should be another dedicated year of observations. Liaison between any WCRP observational initiative and the development of any such proposal will be very important. If it is decided to go ahead with a CSPD or similar idea there will be an urgent need to develop the concept and to start the planning process. A task force would appear to be appropriate in the short term. In the longer term it would become a major responsibility for the proposed Observation Council.

4.1.4 Discussion and decisions

The JSC thanked the task force for the report. Throughout the session, the JSC thoroughly debated the proposal produced by the task force for a new WCRP-wide "Predictability Assessment of the Climate System" with the aim of major steps forward in climate prediction. The JSC decided on the following for the future scientific direction and structure of WCRP:

WCRP objectives

The major objectives of the WCRP should continue, as they have always been, namely, to determine to what extent climate can be predicted and the extent of human influence on climate, together with the research priorities agreed at the WCRP Conference, 1997, namely:

- assessing the nature and predictability of seasonal to interdecadal variations of the climate system at global and regional scales, and providing the scientific basis for operational predictions of these variations for use in climate services in support of sustainable development;
- detecting climate change, attributing causes and projecting the magnitude and rate of human-induced climate change, regional variations, and related sea-level rise (as needed for input to the IPCC, the United Nations Framework Convention on Climate Change (UNFCCC) and other conventions).

Climate system Observation and Prediction Experiment (COPE)

To recognise the renewed emphasis of WCRP on its prediction aims and the observational activity that is needed to fulfil them it was decided to develop a major overarching and integrating initiative, tentatively called the "Climate system Observation and Prediction Experiment (COPE)", to be conducted over a decade up to about 2015. It is intended that the proposed focus on the aims of WCRP, setting objectives and viewing them in the context of COPE will provide a new stimulus for the science of WCRP, and widen the recognition of its relevance and importance for a globally-sustainable future.

Role of the JSC

The JSC will be responsible for guiding and assessing the development and implementation of COPE, in the context of the WCRP's overall objectives and research priorities. JSC members will need to

play a more direct and active role in WCRP, with specific members accepting responsibilities for liaison between JSC and WCRP activities, and JSC sessions should become more focused on assessment of progress towards the main WCRP objectives.

New "Councils"

Two new coordinating bodies, the Modelling Council and the Observation Council, should be established, their prime role being to coordinate and integrate modelling and observational activities across WCRP, with the purpose of meeting the WCRP objectives.

The Modelling Council should consist of specified JSC members, Chairs of WGNE, WGCM and project modelling groups. It will: coordinate modelling activities across WCRP and facilitate collaboration where appropriate; focus on the prediction and projection aspects of COPE; oversee data management in WCRP modelling activities.

The Observation Council should consist of specified JSC members and representatives of project observational activities. It will: coordinate observational activities across WCRP and facilitate collaboration where appropriate; focus on the observational aspects of COPE; act as the contact point with GCOS and the satellite agencies, developing the WCRP observational requirement; link with IPCC on observational aspects of the detection and attribution problems; oversee data management in WCRP observational activities. The Observation Council should also address the need for a pan-WCRP Precipitation Panel.

WCRP Data Management Group

A new "WCRP Data Management Group" should be formed to take care of all data needs across WCRP. Data issues are important to both the Modelling and Observation Councils. This group will interact closely and collaborate with the two Councils and also with project groups and working groups to evolve a comprehensive data policy for WCRP including mechanisms and structures necessary for data management, climate system data assimilation/ synthesis/reanalysis and model initialization.

Specific WCRP objectives

WCRP should set itself a number of specific objectives with associated time-scales for completion. At the end of the time-period for each objective, a publication, synthesizing the scientific status and understanding of the topic should be produced. Such objectives should be widely debated in the WCRP community and stakeholders should be asked for their comments.

The projects and activities should play an essential role in proposing objectives for WCRP. Scientific programmes and structures may have to evolve to enable full and proper contributions towards WCRP objectives, and to COPE. At JSC sessions the contributions of projects and activities will focus more on progress towards WCRP objectives, and highlighting topics for future objectives.

"Sunset dates" for WCRP projects

All projects should consider and propose their "sunset dates" in the period before 2015 with an outline of what is expected to be achieved by that date (to be reported to the next session of the JSC).

Seasonal prediction

Recognising the importance of seasonal prediction as a specific objective under COPE, it was recommended that a limited-term Task Force on Seasonal Prediction (TFSP) be established. This should be led by WGSIP, drawing on expertise in all WCRP projects, WGNE and WGCM, and with a progress report to the next JSC session. Terms of Reference (ToR) should be drawn from WGSIP and elsewhere: a prime aim will be to determine the extent to which seasonal prediction is possible and useful in all regions with currently available models and data.

Recognising that variability on time-scales of both weeks and decades is important for WCRP but not clearly expressed in the ToR of any modelling group, it was proposed that WGSIP should broaden its time-scales of interest to cover the range from weeks to decades, possibly changing its name to make this clear. WGSIP should interact more closely with the modelling working groups of WCRP projects.

4.2 THORPEX: a global atmospheric research programme

Professor A.J. Thorpe made a presentation of the THORPEX. A detailed description of THORPEX themes is given in section 8. The themes proposed are of major interest to WGNE, and the studies of predictability and observing system issues being taken up will have benefits throughout the WCRP. The international coordination of THORPEX is under the auspices of the WMO, WWRP and WGNE. The THORPEX International Science Steering Committee (ISSC) defines the core research objectives with guidance from the THORPEX International Core Steering Committee (ICSC) whose members are selected by national permanent representatives to the WMO. WGNE has reiterated its support for THORPEX as a collaborative WWRP/WGNE experiment. At the 18th session of WGNE, a joint WWRP/WGNE draft resolution concerning the current status and the next steps in the development of THORPEX was reviewed and finalised in consultation with the Chair of the WWRP, Dr R. Carbone. The committees agreed that the essential next step is the development and submission of the detailed THORPEX Science Plan for review and consideration by WWRP and WGNE.

The JSC welcomed the presentation on progress of THORPEX, by Professor A.J. Thorpe. Recognizing its importance in the context of the evolving concept of COPE and given the importance in longer-term predictions of the statistics of severe weather as well as the feedback of such weather onto longer time-scales, the JSC noted that this joint WWRP/WGNE experiment was clearly of interest to WCRP. The JSC acknowledged that it should provide the basis for design of a dynamical, interactive observing system for the global atmospheric system and that it had potential for a seamless integration of methodologies for weather forecasting and climate prediction. The JSC stressed that effort should be made to generate evidence for the predictability of high-impact weather events and also the need to generate their statistics using low-resolution models. The JSC noted that THORPEX would culminate in a "global weather experiment" around 2010 and expressed that coordination and collaboration with THORPEX should be explored further, especially with respect to the development and implementation of the observational component of COPE.

5. CLIMATE VARIABILITY AND PREDICTABILITY (CLIVAR)

Dr A. Busalacchi, Co-chair of the CLIVAR Scientific Steering Group, and Dr H. Cattle, Director of the International CLIVAR Project Office (ICPO), presented a comprehensive account of the status of CLIVAR. The past year has shown continued marked progress towards the implementation of CLIVAR. As its panels and working groups grow in maturity, links and common activities between them are beginning to emerge. This is particularly noticeable in terms of observational activities but is also reflected in continual progress in modelling of the coupled climate system. Activities related to applications of CLIVAR science are also being encouraged and this is reflected in the text below. CLIVAR is conscious of the importance of continuing to develop a global synthesis of its regional activities and a global perspective.

5.1 Ocean Observations

5.1.1 The outcome of the final WOCE Conference

WOCE has provided CLIVAR with an extensive and key inheritance of ocean observations and a community dedicated to implementation and analysis of global ocean observations for understanding the role of the oceans in climate and climate variability. The final WOCE Conference, entitled "WOCE and Beyond", was held in San Antonio, Texas, USA in November 2002, and provided a fitting overview of WOCE achievements and a look to the future.

While WOCE has formally ended it leaves an important legacy of observational techniques, of improved models and understanding of physical processes and, for the first time, a quantitative assessment of the ocean circulation's role in climate. Within four years of the last data being collected, the WOCE data resource (amounting to some 20 Gbytes) has already been quality controlled and freely distributed both at the conference itself on DVDs and via the www. WOCE results are documented in almost 1800 refereed publications. Many elements of the data system developed by WOCE will continue to operate enabling the WOCE data resource to be expanded. CLIVAR has recently taken action to ensure this continuity is maintained through its mandate to the WOCE Data Assembly Centres. Much remains to be done, in the exploitation of WOCE observations and in the further development of schemes to assimilate data into models to permit ocean state estimation at increasingly higher resolution. It is within CLIVAR that the advances made by WOCE will be sustained and further expanded.

The JSC acknowledged the success of final WOCE Conference in providing a fitting overview of WOCE achievements and in looking to the future. It expressed great satisfaction at the successful conclusion

of WOCE and the important legacy it has left of observational techniques, improved models and understanding of physical processes and, for the first time, a quantitative assessment of the ocean circulation's role in climate. The JSC recommended that WOCE observations be fully exploited and development of data assimilation schemes continued for ocean-state estimation.

In further discussion, the JSC supported the notion that a task force should be established to review and report to the next JSC session on WCRP interests and activities dealing with sea-level rise. In the meantime, projects were asked to identify any contributions being made to the study of sea-level rise.

5.1.2 Global hydrography and interactions with biochemistry and carbon

The required integration of physical and biogeochemical ocean observations started between WOCE and IGBP's Joint Global Ocean Flux Study (JGOFS) must also continue to be expanded through closer collaboration between WCRP and IGBP. CLIVAR is actively working towards this integration.

Coordination with repeat WOCE hydrographic cruises will be an essential component of the total activity and the ICPO is working with IOC to produce a linked CLIVAR-International Ocean Carbon Coordination Project (OCCP) interactive website actively seeking to document plans and carbon and hydrographic datasets as they become available. Links have also been established with the IGBP OCEANS transition team with CLIVAR input being provided by Dr A. Busalacchi, Co-chair, CLIVAR SSG.

5.1.3 CLIVAR Ocean Observations Panel

Implementation of ocean observations in support of CLIVAR has been progressing steadily and a detailed summary of the status of the sustained network of ocean observations was provided in the CLIVAR report to JSC XXIII. More recently an unprecedented number of satellites with ocean observing missions have been launched, including Jason (radar altimetry), GRACE (gravity), ENVISAT (altimetry, ocean colour, radiometry), Aqua (microwave radiometry and ocean colour), ADEOS II (microwave radiometry and scatterometry) and WindSAT (microwave radiometry). In addition, two new missions with ocean relevance have been selected for further development: GOCE to improve the geoid and gravity measurements and Aquarius for sea surface salinity. In situ networks have been making some progress, most notably Argo which had 620 active floats as of January 2003 and for which current commitments indicate a near complete global array will be possible. Certain technical difficulties have been overcome and deployments are now increasing rapidly. Data are publicly available from two data centres. An Argo symposium will be held in November 2003 to review scientific and operational use of the data.

The CLIVAR SSG at its last meeting (Xian, China, May 2002) identified ocean reanalysis and data assimilation as high priority topics which would contribute significantly to the global integration of CLIVAR activities. The CLIVAR Ocean Observations Panel, COOP, has been asked to organize a workshop on ocean reanalysis, which is tentatively scheduled for 2004 in La Jolla, CA. The workshop aims to develop plans for sustained ocean synthesis efforts in support of CLIVAR, and to review the ocean observing strategy with respect to synthesis needs.

Almost all activities under the COOP banner are of interest to the marine applications and climate user communities. Operational ocean observing systems depend almost exclusively on the research community to develop new techniques and products (e.g. TAO moorings, Argo floats). Ocean data assimilation and synthesis are key elements for improved climate predictions.

The JSC supported the CLIVAR-sponsored workshop on Ocean Reanalysis. It also recommended the inclusion of appropriate aspects of the Global Ocean Data Assimilation Experiment (GODAE).

5.1.4 Tropical moored buoy implementation panel (TIP)

TAO/TRITON data underpin much of CLIVAR research on ENSO and related variability in the tropical Pacific. In calendar year 2002, 43 refereed publications used TAO-TRITON data to improve the description of tropical Pacific phenomena, to diagnose variability on seasonal to interannual timescales, to validate and improve climate models and data assimilation methods, and to validate satellite products (see http://www.pmel.noaa.gov/tao/proj_over/pubs/taopubsr.shtml for a full list of TAO/TRITON publications).

TAO/TRITON data have been used widely for monitoring the evolution of the current El Niño event and for initialising ENSO forecast models at operational weather and climate centres around the world. PIRATA data are used less extensively in seasonal forecasting, though they have found limited application

for forecasting purposes in Brazil and South Africa. Both PIRATA and TAO/TRITON data are among the data streams assembled for GODAE servers which support operational ocean data assimilation and data product development.

5.2 The major ocean basins

5.2.1 Atlantic

CLIVAR implementation in the Atlantic sector focuses primarily on issues of tropical Atlantic variability (TAV), the meridional overturning circulation (MOC) and basin-wide implementation of sustained observations. The MOC was the particular focus of the last panel meeting that took place in Bermuda in April 2002. With regard to TAV, two particular initiatives have emerged following the workshop held in Paris in August 2001:

- a programme on Dynamics and Predictability of the Atlantic ITCZ (inter-tropical convergence zone) and its Regional Climate Influences. The primary focus is the determination of the variability of the ITCZ position and intensity and the related effects on transient tropical disturbances, precipitation, and the impacts of associated atmospheric circulation changes on oceanic circulation. This is a US-led initiative that seeks collaboration with other interested nations. An international workshop is scheduled for 2004, possibly in the UK;
- a programme on the effect of atmospheric forcing, upper ocean teleconnections and feedbacks on tropical sea surface temperature (SST) variability, based on the hypothesis that the oceanic sub tropical cells are a significant contributor to the variability of tropical Atlantic thermocline structure and of SSTs on long time-scales. An enhanced observation period and related data assimilation efforts and modelling studies are planned. This initiative is an international effort with main contributions from Germany, France, Brazil and the USA.

In addition, linkages and possible joint field work with the emerging AMMA experiment (see under CLIVAR-VACS, section 5.3.3 below) are being explored.

The MOC provided the focus of the last Atlantic panel meeting to which inputs were also made by invited experts from WGCM and WGOMD. Key points emerging included:

- on interannual and shorter timescales, wind-driven Ekman cells dominate variability; longer time-scale variability is dominated by thermohaline driving. The mixture of the two poses significant challenges for sustained observations;
- GCM projections of greenhouse gas induced climate change indicate a weakened MOC over the next century. Observations reveal consistent evidence of long-term changes in the properties of overflows and the convectively-renewed water masses of the Labrador Sea; the present observational network seems inadequate, however, to directly determine whether the strength of the circulation is changing;
- since the initial dynamical adjustment of the thermohaline circulation occurs via Kelvin and Rossby waves (timescales months to decades) but thermodynamic equilibrium is approached over several centuries, a mixture of eddy-resolving and coarse resolution models needs to be employed in studies of the MOC and its response to changing greenhouse gas forcing, though conclusions from both types need treating with caution;
- a critical issue is to improve understanding of how the coupled ocean-atmosphere system responds to changes in the MOC. Modelling studies are providing new insights here whilst empirical studies suggest a link between Atlantic multidecadal fluctuations in SST and hurricane activity.

A substantial portfolio of observations targeting the Atlantic MOC is now taking shape (http://www.clivar.org/organisation/atlantic/IMPL/proc-stud.html#moc). This includes contributions from ongoing national CLIVAR programmes in Canada, Norway, France, Germany, and the USA as well as two thematic programmes:

- the Arctic-Sub-Arctic Ocean Fluxes Study (ASOF – http://asof.npolar.no);
- the UK RAPID Climate Change programme (http://www.nerc.ac.uk/funding/thematics/rcc/).

A basin-wide synthesis will be needed, the details of which have yet to be worked out. Collaborations with the WGOMD and WGCM for developing experiments to explore MOC responses and sensitivity have been initiated. A workshop on Atlantic thermohaline variability with emphasis on synthesis has been proposed for September 2004.

A key new activity is the encouragement of sustained observations in the South Atlantic. The current status of implementation of CLIVAR-relevant sustained observations for the Atlantic is summarised at http://clivar.org/organisation/atlantic/IMPL/. In particular, the North and equatorial Atlantic are at the forefront of initial Argo implementation and the South Atlantic will be one of the next targeted regions. At present, however, the South Atlantic is a region with scarce sustained observations and only a few studies at basin scale. In recognition of this the South Atlantic Climate Observing System Workshop (Angra dos Ries, Brazil, 6-8 February 2003) was organised. The workshop brought together 70 scientists from South America, Africa, Europe and North America and was intended as a spur for the identification of new elements for the South Atlantic observing system, community development and identification of joint actions and partners. Follow-up over the coming months will be crucial.

5.2.2 Pacific

Two events have dominated the Pacific sector in 2002. The first is the 2002/3 ENSO event, early indications of which were picked up by the TAO-TRITON array. The second is a continuation since 1998/99 of anomalously high SSTs in the central and eastern subtropical gyre and cooler waters along the North American seaboard. Some have speculated that there was an abrupt shift in 1998/99 of the large-scale structure of the North Pacific atmosphere and ocean associated with the Pacific Decadal Oscillation, but this will only be established with hindsight.

The Pacific panel is developing plans for process studies focused on sub-tropical cells, bifurcations and equatorial mixing, western and low-level boundary currents, the role of marginal seas and ocean-atmosphere exchange. Planning is advanced for the Kuroshio Extension System Study (KESS), the VAMOS extension of the Eastern Pacific Investigation of Climate (EPIC), and the Pacific Upwelling and Mixing Project (PUMP) which is investigating mixing and water mass transformations that control the properties of water supplied to the upper ocean in the equatorial Pacific.

The paucity of observations, both broad-scale and for process studies, in the South Pacific continues to be of concern. The issue will be a topic at the forthcoming Pacific panel meeting in July 2003. There will also be discussions with the Southern Ocean panel to seek ways of investigating the connection between the two oceans. The panel remains conscious of its need to maintain strong links with other relevant CLIVAR panels, including WGSIP and WGCM in relation to decadal variability of ENSO, the AAMP and VACS with regard to ENSO links to monsoons and African climate, and with the Southern Ocean panel. It is also seeking to strengthen its links to the carbon community and a greater balance of atmospheric representation.

5.2.3 Southern Ocean

The Southern Ocean (SO) panel held its first meeting in March 2002 in Hobart, Tasmania, in conjunction with the Argo Science Team. Argo is particularly important in the Southern Ocean (SO) region, as autonomous floats represent the only realistic means of obtaining regular repeated in situ measurements of temperature, salinity and water velocity in such a remote and hostile region.

Largely as a result of discussions initiated in the first panel meeting there is a new initiative (GOODHOPE) to cover the important “choke point” section south of Africa. This initiative will use a variety of hydrographic, float, atmospheric and satellite data to:

- obtain a better understanding of Indo-Atlantic inter-ocean exchanges and their impact on the global thermohaline circulation and present day climate;
- study the impact of inter-ocean exchanges on the local climate of the African continent;
- monitor the variability of the Southern Ocean frontal systems;
- study the local air-sea heat exchanges and their role in the global heat budget.

An important challenge will be to find resources to establish time series sites in the Southern Ocean. These will be critical in a number of science areas (e.g. carbon cycle, air-sea interaction and water mass formation, as reference sites for air-sea fluxes and to document variability). Resource and logistic challenges are large. A white paper is being produced by the panel for the OOPC/CLIVAR Science Team for Global Eulerian Observatories.

An issue deserving increased attention over the coming year concerns the various approaches for estimating air-sea gas exchange over the Southern Ocean. Investigations over the past year have revealed that there continues to be significant disagreement between the low uptake estimates suggested by atmospheric inversions, the higher uptake estimates from direct measurements and those from inversions of

ocean hydrographic data which lie in between these. There are clear links to the Surface Ocean-Lower Atmosphere Study (SOLAS) here. A plan to box in the Adelie Land source with repeat hydrography, in coordination with the US Carbon sections, is under negotiation.

The JSC noted the continuing sparsity of Southern Ocean observations and stressed that efforts should be continued to develop the observing system in this region.

5.3 Studies of Monsoons and Regional Climate Variability

The regional foci for the seasonal-to-interannual elements of CLIVAR are the Americas, areas influenced by the Asian-Australian monsoon and Africa. The last two are closely related and there is collaboration between all three on monsoon modelling issues. CLIVAR has science oversight panels for each of these areas. Plans for a global monsoon observational and modelling effort, jointly with GEWEX and CEOP, are being laid. A proposed WCRP Workshop on Modelling Monsoon Environments will be aimed at developing this concept further, with participation from WGSIP, WGCM and WGNE as well as from CLIVAR, GEWEX, CEOP and CliC.

5.3.1 The Variability of the American Monsoon System (VAMOS)

VAMOS is made up of a number of projects, each of which has reached a different state of implementation. To improve warm season prediction over the Americas, the North American Monsoon Experiment (NAME), and the Monsoon Experiment in South America (MESA), focus on the northern and southern components of the American monsoon system respectively. They are collaborative with GEWEX and perform modelling and empirical studies and enhance the monitoring infrastructure through multinational scientific collaboration. Deliverables include fine-resolution precipitation products, as well as an improved understanding of orographic and land surface processes, and of the regional water budgets.

VAMOS presents a number of challenges. In particular, although it is conceived as a unified project, there is a large discrepancy in the means of communicating needs and obtaining funding for the plans of its North American component (NAME) and the South American component (MESA). It is felt that the programme could split if a special effort is not made to keep these components together. Nevertheless, many coordinated group meetings are taking place and during the year a VAMOS International Project Office was established for support of its field programmes overall. Starting with the planning and field implementation of the SALLJ experiment (see below), the Project Office will continue with implementing the field phase of the NAME project.

5.3.1.1 Monsoon Experiment in South America (MESA)

The VAMOS activities in South America are organised in sequential stages. The first focuses on the moisture corridor east of the Andes and the US-led Eastern Pacific Investigation of Climate (EPIC) which had its intensive observational period from September-October 2001. A VAMOS extension (VEPIC) is being planned. PLATIN is aimed at studies of the climatology and hydrology of the La Platin Basin in South America.

The South American Low Level Jet (SALLJ) project

The focus for studies of the moisture corridor east of the Andes is the South American Low Level Jet (SALLJ) project, part of a broader programme on American LLJs. The SALLJ field campaign (SALLJEX) was performed with great success between 15 November 2002 and 15 February 2003 in Bolivia, Paraguay, central and northern Argentina and western Brazil. Scientists, collaborators, students and local volunteers from Argentina, Brazil, Bolivia, Paraguay, Chile, Uruguay and USA participated in SALLJEX activities. SALLJEX had three major components:

i) enhanced upper air observations: The main objective of this component is to reduce the uncertainty in estimating the daily (and longer time-scale) intensity and other characteristics of the tropospheric flow over a large region currently without a dense sounding network.

ii) enhanced raingauge daily observations: SALLJEX raingauge network activities over Argentina, Bolivia, Paraguay, Peru and Uruguay were concentrated in enhancing the very sparse operational network existing there. This network not only included the new SALLJEX raingauge stations but also raingauge networks owned by local cooperatives and institutions that kindly accepted to participate in the experiment. Efforts will be made during 2003 to promote the continuation of such an integrated raingauge network which will be extremely

useful for long-term monitoring in the region as well as for other VAMOS activities like PLATIN.

iii) NOAA/P-3 aircraft missions. The main objective of the aircraft missions was to provide a detailed representation of the structure and variability of the LLJ east of the Andes and of the relationship between mesoscale convective complexes over northern Argentina or western Paraguay and the LLJ.

During the experiment the SALLJEX modelling group provided a diversity of forecast products from several numerical models not only running at operational centres but also at the research institutions involved in SALLJEX. Information about all these products as well as about the reports of the activities and preliminary results are currently available at the SALLJEX field catalogue. Full information about SALLJEX is available at http://www.salljex.at.fcen.uba.ar/. SALLJEX observations provide a unique opportunity for validation of numerical simulation sensitivity studies that attempt to reproduce the structure of the jet and its variability as well as the related precipitation. An international SALLJEX workshop will be held in the second half of 2003 in order to carry out preliminary evaluation of the experiment. Application of SALLJEX experience has already been made in the classroom. One elementary and one high school teacher (from the US and Argentina) participated in SALLJEX through the NOAA programme "Teachers in the Field". The programme promotes awareness of the need to understand and protect the world's environment. The teachers and SALLJEX scientists attended a reception on Capitol Hill (March 13) and presented VAMOS to members of US Congress as well as NSF and NOAA administrators.

VAMOS extension of EPIC (VEPIC)

Early results from EPIC were submitted for publication in the Bulletin of the American Meteorological Society and the Journal of Atmospheric Sciences. In the South Pacific stratocumulus, abundant drizzle dramatically affects the characteristics of the planetary boundary layer, although very little reaches the surface. The diurnal cycle of heating over South America has also been found to heavily modulate the diurnal cycle of subsidence and stratocumulus evolution.

VEPIC is working to develop an intensive new short-term field programme, but the definition of such a programme and entrainment of interested oceanographers have, to date, proved challenging. Nevertheless, the Woods Hole Oceanographic Institute buoy at 20^{o}S, 85^{o}W has completed a second successful year of data gathering for VEPIC-related research. Plans are also under way for routine ship-based cloud remote sensing and turbulence measurements on a variety of buoy maintenance cruises across the Pacific. A ceilometer has been installed at San Felix Island (26^{o}S, 77^{o}W) where a profiler will also be installed to detect precipitation from stratocumulus cloud. Finally, modelling efforts encouraged by VEPIC are resulting in improvement of the representation of planetary boundary layer clouds in GCMs and further understanding of their feedbacks on the climate system.

Climatology and hydrology of the La Plata basin (PLATIN)

PLATIN is a newly involving VAMOS initiative to study the climatology and hydrography of the La Plata river basin and a numerical model of the climate and hydrology of the Plata basin is under development. PLATIN scientists are participating in a project "Interactions of Natural and Human Systems in the Rio La Plata Basin: Impacts of Land Use/Land Cover Change on Watershed Ecosystem Function". A proposal for funding was submitted to NSF's Biocomplexity Program in November 2002. A request for $1.4M was made to the Global Environment Facility of the United Nations Development Programme, the Organisation of American States and the Intergovernmental Committee for the Plata Basin to fund a framework programme for the climate and hydrography of the basin, including its impacts on economies and populations. PLATIN has been identified as the responsible body for the science component. If successful the next step will be the design of a $25M project.

5.3.1.2 North American Monsoon Experiment (NAME)

The NAME Science Working Group has developed proposals and plans for the NAME 2004 enhanced observations field programme and for NAME modelling and diagnostic studies. A NAME Forecast Operations Centre has been established jointly by US and Mexican National Weather Services to support NAME 2004 and longer-term efforts. The applications community has also been participating in NAME meetings to foster collaborative investigations in order to develop new climate information products for stakeholders.

5.3.2 Asian-Australasian Monsoon

The meeting on Indian Ocean GOOS (IOGOOS) was a significant step towards the development of a sustained ocean observation system in the Indian Ocean. The meeting discussed plans for and the implementation status of an enhanced Indian Ocean network to monitor the basin-wide structure of temperature, salinity and currents by combining satellite data with in situ measurements by Argo floats, moored buoys, XBTs and other instruments.

The most recent meeting of the Asian-Australian Monsoon Panel (AAMP-5, Atlanta, USA, 25-27 February 2003) discussed the implementation of the IOGOOS plans, including consideration of observation simulation experiments aimed at providing guidance on how best to deploy Argo floats in order to monitor intra-seasonal variations in the tropical Indian Ocean and to link to the coastal community for applications.

There has been considerable progress in the planning of the joint GEWEX/CLIVAR CEOP Inter-monsoon Model Study (CIMS). The aims of CIMS are:

- to better understand the fundamental physical processes underpinning the diurnal and annual cycles and intraseasonal oscillations in monsoon land and adjacent oceanic regions; and
- to demonstrate the synergy and utility of CEOP integrated satellite data, in situ observations and assimilated data in providing a new pathway for model physics evaluation and improvement.

A major effort will be devoted to defining the data requirements and modelling strategy for validating model physics. Validation data will be derived from CEOP reference sites, including GEWEX continental scale experiments (CSE) and planned CLIVAR field campaign sites under, e.g., NAME, MESA and AMMA. Additional key CLIVAR input will come from the development of a database of ocean observations covering the CEOP period. Numerical experiments will be designed using, where appropriate, combinations of AGCM, CGCM, regional climate models, as well as cloud resolving models to target the simulation of fundamental physical processes in monsoon regions, leading to identification of model errors and pathways for improvement.

AAMP-5 also considered advances in monsoon modeling studies. The AAMP has encouraged the simulation of fundamental processes in monsoon regions in order to identify model errors and pathways for improvement. In particular, recent progress in simulating intraseasonal variability was reviewed. Intraseasonal oscillations dominate tropical variability at 15-70 day timescales. Their simulation proves to be a critical test of a model's ability to simulate the tropics. Recent analyses indicate that though atmosphere-only models typically fail to represent the intra-seasonal dominance of the large-scale circulation, ocean-atmosphere coupling leads to an improved propagating structure. In addition a recently-developed physically-based empirical prediction forecasting method exhibits very encouraging results in providing up to 20 day rainfall forecasts in Indian monsoon regions.

Discussions at the AAMP-5 meeting resulted in a critical recommendation that WCRP should support a 3-day workshop to develop a pan-WCRP monsoon modelling strategy, based on the GEWEX/CLIVAR joint initiative of CIMS. The workshop should involve all relevant CLIVAR panels and other WCRP modelling groups to define priorities and plans for follow-up workshops. AAMP-5 also discussed the issue of a proposed Indian Ocean panel for CLIVAR to help drive forward the implementation of ocean observations in the region. The AAMP were strongly supportive of the establishment of such a panel which they recommended be set up jointly with IOC in the framework of the recently established IOGOOS.

In terms of coordination with other organizations, regional networks such as the Asia-Pacific Network (APN) and START Regional Centres play active roles in the monsoon regions and attract national funding to progress activities. One example is the Integrated Regional Study (IRS) for Monsoon Asia, which is to be carried out by START under the umbrella of the Earth System Science Partnership (i.e. IGBP, WCRP, IHDP and DIVERSITAS), and which aims to study vulnerability and impacts due to environmental/climate changes in the monsoon regions. The issues here are how best to coordinate AAMP with such activities and attracting the needed resources for greater involvement.

Improved methods of monsoon prediction are crucial for society in the Asian and Australian region. The panel is keen to develop the link to applications in the region. One avenue is through an organisation called Climate Forecasting Applications in Bangladesh (CFAB), which one of the panel Chairs (P. Webster) helped to set up and which aims to make forecasts available to agricultural and other government officials in Bangladesh. Applications to flood prediction are also being planned.

5.3.3 Variability of the African Climate System (VACS)

The African Monsoon Multidisciplinary Analysis (AMMA) project has continued to develop during 2002/2003. An international science plan is nearly completed. In West Africa a network of scientists, called AMMANET, has formed to encourage scientific collaborations that will contribute to AMMA. This includes scientists in universities and NMHSs. FIRMA, a meteorological research initiation fund for Africa set up at ACMAD with the support of the French Ministry of Cooperation, has already helped to initiate several research projects in Africa aimed at contributing to AMMA. In Europe, efforts are under way to help mobilize European Union funding as well as national funding in France, Germany and the UK. In the US a scientific steering group that represents US interests in AMMA has been formed and a US science plan is being prepared. AMMA is clearly viewed by its participants as a joint CLIVAR-GEWEX project. AMMA has the endorsement of both CLIVAR and GEWEX SSGs.

A working group has been established to oversee the production of an Atlas of African Climate Variability. The atlas is currently being developed on the web but plans are also being made to make this available in hard copy. A major goal of the atlas is to stimulate and promote research activity on African climate variability by providing global and regional diagnostics along with text that highlights key scientific issues.

The VACS panel has adopted the 1997-2000 period for intensive study. Progress in 2002/2003 has been slow although indications are that a large community of African scientists is interested in contributing to the analysis and investigation of this period. To take advantage of this and to promote the case study issues more widely, the VACS panel plans to organize a workshop ahead of the next VACS meeting in Nairobi.

The VACS panel has initiated plans for a research initiative in Eastern Africa. In addition to the Indian Ocean, the climate of Eastern Africa is strongly influenced by the presence of three of the largest lakes in the world. The lakes are home to 80-100 million inhabitants and as a result socio-economic issues such as pollution control in the lakes are extremely important.

The first major challenge for VACS and its community is to mobilize adequate funds for research activity on African climate variability issues. Currently AMMA is attempting to lobby various funding agencies around the world. This task would be made easier if the key scientific issues important for Africa were more visible on the international scene. There is a responsibility for VACS and its community to make more effort to do this, hence the greater emphasis this year on outreach. The second major challenge is to enable scientists working in Africa on African climate variability to be more visible in the international community. This will help to raise their profiles and the subject itself. This will involve a combination of activities including encouraging collaboration through international projects like AMMA, international workshops and capacity building. There will be a special issue of CLIVAR Exchanges devoted to Africa.

The JSC endorsed the recommendation for a WCRP Workshop on Modelling Monsoon Environments to develop a pan-WCRP monsoon modelling strategy. In this regard, GEWEX and CLIVAR should take the lead and ensure participation of other relevant groups in the workshop. The JSC pointed out the need to review WCRP monsoon-related activities with a view to achieving better coordination and collaboration and, if at all possible, to reduce the number of monsoon-related panels. In particular, the possibility of a single WCRP Monsoon Panel should be explored. The JSC also supported the development of AMMA as a joint CLIVAR-GEWEX experiment.

5.4 Modelling activities in support of CLIVAR

5.4.1 The JSC/CLIVAR Working Group on Coupled Modelling and the Working Group on Ocean Model Development

Activities under this heading are reported in Section 9.2 below

5.4.2 The Working Group on Seasonal to Interannual Prediction

The CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP) held its most recent meeting in Cape Town, South Africa in November 2002. WGSIP's Seasonal Prediction Model Intercomparison Project (SMIP-2) was initially aimed at determination of potential predictability on seasonal time-scales given perfect knowledge of global surface boundary conditions. SMIP-2 is now being extended to investigate actual 1-season forecast skill. The extended activity is called SMIP-2/HFP (historical forecast projects). This will encompass a range of initial conditions reflecting the range of research and operational approaches to seasonal prediction being used and investigated by the community. An SMIP panel will identify potential participants, promote the project, guide analysis and encourage and coordinate diagnostic

studies. The proposed deadline for submission of data is July 2003 to enable preliminary analysis in time for the next session of WGSIP. Details of the experimental design can be obtained from http://www.pcmdi.llnl.gov.smip. Previously the WGSIP had initiated a new activity on model experimentation and output standards. In development of this, the WGSIP considered the WMO Commission for Basic Systems (CBS) report on verification of long-lead forecasts which they endorsed, regarding it as an excellent starting point but one which provided a minimum baseline only. As a consequence, WGSIP agreed to start a long-term evolving project on Standardised Verification Sets (SVS) for long-range forecasts, based on the CBS protocol. In order to keep the project manageable and affordable, the group favoured a distributed system guided from a central website located at the ICPO. The group have asked the ICPO to seek resources to build such a system.

WGSIP is planning a Workshop on Ensemble Methods in Weather and Climate with a focus on recent developments in the theory and application of ensemble methods, including the multi-model approach, and spanning a wide range of timescales. It will be co-sponsored by the WGNE and WGCM.

GEWEX/GLASS, the Global Land-Atmosphere System Study, designed to investigate the "climate signal" associated with the state of the land surface has clear interest for WGSIP. In this context WGSIP endorsed GLASS as relevant to its aims and expressed its interest in being involved in the discussion and planning of GLASS activities.

Clear linkages already exist with the WMO World Climate Programme's CLIPS (Climate Information and Prediction Services) project and wider links to seasonal forecast services for a variety of applications and end users. These links, e.g. to START, are appropriate items for the WGSIP agenda in the future.

An issue raised at the last CLIVAR SSG had been the need for a widely accepted definition of El Niño that would meet the needs of both the research and operational communities. The SSG had asked that WGSIP consider this. Within the research community the definition of Trenberth (1997) is commonly used but this formally requires 12 months of data before an El Niño can be declared. The Working Group agreed on the definition of a continuous numerical oceanic El Niño index (OENX) based on the NIÑO 3.4 index. It is intended to characterise the state of the tropical Pacific as it relates to ENSO but avoids categories and does not attempt to directly imply local and remote climatic impacts.

5.5 Joint CCl-CLIVAR expert team on climate change detection (ET/CCD)

The newly-formed ET/CCD is the successor to the joint WCRP/CCl Working Group on Climate Change Detection (WGCCD). The membership of the joint ET/CCD has only recently been finalized. The team now consists of four CCl and four CLIVAR representatives. It is chaired jointly by Dr A Mokssit (CCl) and Dr F Zwiers (CLIVAR). The ET/CCD is continuing efforts to enhance the availability of information that is required to detect climate change in data sparse regions by promoting regional workshops on the quality control of climate data and the use of those data for the calculation of climate indices for use in detection studies. Papers that base their conclusions on indices of mean and extreme climate are beginning to appear with regularity in the literature. Under the auspices of the WGCCD, workshops were held in the Caribbean (University of West Indies, Mona, Jamaica, 8-12 January 2001) and in Africa (Direction de la Météorologie Nationale, Casablanca, Morocco, 18-23 February 2001). A lesson from the African workshop is that these meetings are most effective when they engage scientists from neighbouring countries within a region, because these then work to strengthen regional collaborations that may already exist.

Future plans for panel activities include workshops on climate change indices for data sparse regions, designed to enhance the capacity of scientists from developing countries to quality control their climate data and to contribute indices computed from those data to global and regional detection studies. The first priority is for a workshop in South America that will help to fill the large data void that presently exists in that part of the world. As a second priority, the team also plans to exploit an opportunity in southern Africa to collocate a workshop with the 9th International Meeting on Statistical Climatology (Cape Town, South Africa, on 25-28 May 2004). The ET/CCD will, in particular, maintain a liaison with WGCM (AR4) and the US Global Change Research Program "Ad Hoc Detection Group" and is planning input to the IPCC Fourth Assessment Report (AR4) scoping process. The possibility of a combined GCOS and ET/CCD web site that updates indices of climate variability and change in near real time is being explored.

There are many aspects of the ET/CCD's work that are relevant to applications and policy. For instance, contributions from the climate change detection community will be extremely important to the IPCC AR4, and the policy synthesis that derives from that assessment should be influential in setting government climate policy throughout the world.

5.6 IGBP PAGES/CLIVAR intersection

This panel last met in July 2001 and a major restructuring is under way. The panel's remit focuses on detection of interannual to long-term climate signals over the past millennium using multi-proxy data sources and issues related to rapid climate change and climate variations. A key related activity is the Paleo Model Intercomparison Project (PMIP). PMIP is currently planning a new second phase with five modelling foci:

- coupled ocean-atmosphere (OAGCM) and ocean-atmosphere-vegetation (OAVGCM) simulations of the response to mid-Holocene (6,000 calendar years before present; 6 ka BP) insolation changes;
- coupled ocean-atmosphere (OAGCM) and ocean-atmosphere-vegetation (OAVGCM) simulations of the response to glacial conditions;
- Early Holocene (10 ka BP) simulations of the climate response to insolation changes in combination with ice sheet changes;
- early glacial (115 ka BP) simulations designed to understand the processes underlying glacial inception;
- prescribed freshwater fluxes experiment, jointly with CMIP

Plans for PMIP are outlined in more detail in the report to the JSC of WGCM (section 9.2.8).

Two panel-sponsored workshops are currently being planned:

- a Euroconference on 'Achieving Climate Predictability from Palaeoclimate Data', San Feliu de Guixols, Spain, 11-16 October 2003.
- a multi-millennia perspective on drought and implications for the future, Tucson, Arizona, USA, 11-13 November 2003.

5.7 CLIVAR supporting infrastructure

5.7.1 Data system

A major task still facing CLIVAR is the definition of an appropriate data structure that is capable of delivering ocean and atmospheric data and products to CLIVAR researchers in a timely and simple manner. The CLIVAR Data Task Team which was not functioning satisfactorily was disbanded in 2001. Each CLIVAR Panel and Working Group has a designated data representative whose task it is to identify to the ICPO datasets that CLIVAR will need and to highlight outstanding data issues, but these are working with only mixed success. Given the wide range of CLIVAR and CLIVAR–relevant datasets the decision as to what is and what is not relevant to CLIVAR is problematic. There is also a wide range of data archiving systems and procedures. Most atmospheric data and products are held by operational agencies. Real-time ocean data delivery via the GTS is expanding under JCOMM but delayed mode, high quality ocean data of the type collected by WOCE are most appropriately handled by specialist data centres. The key issue here is to identify the relevant data centres which act or are willing to act as the repository for CLIVAR data and to provide a data management and information interface between the range of data centres and users. Steps toward developing such a system which have taken place over the year are:

- the further development of the CLIVAR Portal within the NOAA Global Change Master Directory. This is, as yet, sparsely populated with appropriate links to CLIVAR-relevant datasets, but a start has been made which will be developed further in the coming year by the ICPO;
- the agreement to date by almost all of the WOCE Data Assembly Centres to seek resources to continue as CLIVAR Data Assembly Centres;
- the development of particular data archiving facilities under explicit CLIVAR projects, in particular VAMOS, dealing with output from explicit field programmes;
- the development of an interactive system on the CLIVAR home pages for notification of cruise plans for hydrography and carbon which will be developed further in collaboration with IOC.

However, the approach to date has been piecemeal and an important task for the ICPO is to develop a soundly-based data management and information plan for CLIVAR in consultation with data management experts and in the context of the long-awaited development of an overall plan for WCRP itself. Indeed, within this structure the role of the ICPO in integrating across the regional panels and working groups and providing a central global inventory of CLIVAR-relevant observations is paramount. But this has serious resource implications for the ICPO. The ICPO now has no explicit data management expertise within it. It will be essential to resource such a post if real progress is to be made beyond the development of the plan itself.

5.7.2 International CLIVAR Project Office

The ICPO continues to be hosted by the UK with current (March 2003) confirmed financial contributions from UK, USA, Germany and France. During the year, Dr John Gould retired from the post of Director of the ICPO with Dr Howard Cattle replacing him from 1 August 2002.

The development and maintenance of a high quality web site together with a searchable database of CLIVAR projects has been, and will remain, a high ICPO priority. The ICPO has produced a substantial number of documents during the year providing reports of CLIVAR activities including panel and working group meetings, workshop reports and posters. Additionally, CLIVAR Exchanges has expanded in popularity as a medium to provide themed issues of CLIVAR activities, early publication of results and brief reports of meetings. Some 1800 copies are published and distributed quarterly across the world. Funding difficulties may, however, result in web-only publication to the detriment of those with limited or no web access. Withdrawal of funding coupled with considerable uncertainty in the continuance of contributions from other previous funders place the ICPO with a current funding crisis, which needs to be addressed urgently.

5.8 Organization of CLIVAR Science Conference

A key event for 2004 will be the 1st International CLIVAR Science Conference to be held from 21-25 June 2004 in Baltimore, USA. The JSC was informed that planning for this conference, under the chairmanship of Professor Lennart Bengtsson, is well advanced with the structure of the programme and many of the keynote speakers now in place. The conference will provide an overall review of progress in CLIVAR to date, as well as serving as the impetus for an assessment of the overall direction of the programme.

6. THE GLOBAL ENERGY AND WATER CYCLE EXPERIMENT (GEWEX)

The main developments in GEWEX during the past year, including the main items and recommendations from the fifteenth session of the GEWEX Scientific Steering Group kindly hosted by UNESCAP in Bangkok, Thailand, 20-24 January 2003, were presented by Professor S. Sorooshian,Chair of the GEWEX Scientific Steering Group, Dr R. Schiffer, Director, International GEWEX Project Office, Dr J. Roads, Chair of the GEWEX Hydrometeorology Panel (GHP),and Dr J. Polcher, Chair of the GEWEX Atmospheric Boundary Layer Study (GABLS). The past year was the first full year of GEWEX Phase II and most projects underwent orientation changes following JSC-22 guidelines, resulting in an increased interaction between the various projects for a more global and a more interdisciplinary approach. GEWEX highlights for 2002 are:

- the beginning of the build-up phase of CEOP, with the joint commitment of the continental scale experiments, the space agencies and the global modelling community.;
- advances in closing regional water budgets;
- the reorganisation of global data sets under a common umbrella;
- the start of new modelling activities in close co-ordination with the GCM community.

Increased communication among GEWEX projects and panels has taken place as part of the preparation of "cross-cutting" activities in several areas: observation, modelling and forecasting of precipitation, closure of the energy and water budgets at various scales, data management, and as part of reflections undertaken to contribute to the WCRP "banner" discussions and to a strategy for observations.

Areas in which efforts were made for closer interaction between GEWEX and the other WCRP components include monsoon observation and modelling as part of CEOP, radiation-climate feedbacks, and the various modelling projects of GEWEX closely linked with WGNE. The issue of positioning of GEWEX with programmes outside WCRP was also considered, particularly the WWRP and the THORPEX experiment, with which a continuing dialogue is felt to be necessary, and for ESSP activities where there is a need for more involvement of the GEWEX community, especially with respect to the joint Global Water System Project.

There is a continuing effort to keep close relationship with space agency programmes, with the participation at SSG of ESA, NASA, NASDA and NOAA, the leading role of GEWEX in the IGOS-Partners water theme and the reflection undertaken within the satellite-working group. Relationships with main modelling centres are maintained on a continuous basis (several workshops organised in 2002) and with the participation of ECMWF and NASA/DAO at the SSG.

6.1 Overview and main recommendations from SSG

6.1.1 Evaluation of GEWEX phase II advances

A preliminary evaluation of advances in GEWEX phase II was carried out with the contribution of SSG members acting as "rapporteurs". Main conclusions can be summarised as follows:

- **Objective 1:** production of consistent descriptions of the Earth's energy budget and water cycle and their variability and trends, and data sets for the validation of models

This has been a primary goal of GEWEX since the beginning and significant progress has been achieved. The land surface water budgets are now successfully characterised across a range of climatic regions and closed to about 20% in the best-instrumented regions; progress being under way in the other ones. Global surface water budget is closed to about 10%. With respect to energy budget, only TOA fluxes and surface energy fluxes are available yet. Significant progress is expected from the CEOP data set and the use of global reanalyses, among them the ECMWF ERA-40 presented at the SSG. Further work is clearly needed in a combined approach of the global energy and water budget and in the associated GCM formulation and assimilation techniques.

With respect to global data sets, 12 to over 20-year records are now available for most pertinent observable variables at a time and space resolution suitable for GCM validation. Regional variability can be properly assessed but the accuracy of those data sets is still marginal for climate trend detection. An integrated observational analysis strategy has been proposed for further advances in this area.

- **Objective 2:** enhancing the understanding of how energy and water cycle processes contribute to climate feedbacks.

Progress in this domain requires a strong interaction between observations and modelling approaches, including detailed process models and GCM studies. The three GEWEX panels contribute to this objective but there are divergent opinions concerning an overall strategy. Progress has been made in understanding the main issues related to radiative climate feedbacks, as part of the workshop held in Atlanta, USA, November 2002, and further work is planned on this subject in coordination with WGCM. A second workshop is envisioned in about 18 months. In expressing its appreciation for the workshop held in November 2002, the JSC felt that this topic needs to be given more attention throughout WCRP, with the help of a specific task group composed of modellers and data analysts. In particular, the JSC recommended that a workplan should be established for further joint activities with WGCM in this domain.

- **Objective 3:** developing improved parametrizations encapsulating these processes and feedbacks for atmospheric circulation models

The GEWEX Modelling and Prediction Panel (GMPP) is the main contributor to this objective and achievements are noticeable in the validation of existing parametrizations for cloud and land surface processes. In addition field observations and process simulations (column and three-dimensional large-eddy models) concur with the development of new schemes in global modelling centres. A good cross-fertilisation between experimentalists, process and GCM modellers is seen as a common feature of workshops organised by the three components of GMPP, including the new GABLS project. It is proposed to address this question more specifically at the next SSG.

- **Objective 4:** interacting with the wider WCRP community in determining the predictability of energy and water cycles

Apart from the radiative climate feedback mentioned above, GEWEX/CLIVAR interaction is important in the general domain of monsoon studies, from the observational and modelling point of view. Quantification of the components of regional water cycles over continents is necessary for understanding monsoon dynamics and, reciprocally, the forecasting of monsoon systems is essential to forecast precipitation variability. Most continental scale experiments are involved in studies which are directly relevant to CLIVAR projects and GEWEX/CLIVAR cooperation is underlying the second main objective of CEOP (Monsoon systems studies). If one considers the various regional experiments, the GEWEX Americas Prediction Project (GAPP) is a partner in the North American Monsoon Experiment (NAME); the Plata Basin experiment in preparation can be considered as a future joint GEWEX/CLIVAR experiment; a CEOP Asian-Australian Monsoon Project (CAMP) has been jointly established between GEWEX and CLIVAR communities. The AMMA (African Monsoon Multi-disciplinary Analysis) project in preparation has already been supported by both the GEWEX and CLIVAR SSGs will also be submitted to CLIVAR SSG and is an

example of a comprehensive approach involving the expertise of both communities for the understanding of an important regional component of the climate system.

CliC's newly defined scientific strategy takes into account GEWEX objectives and complements the GEWEX approach in areas where cryospheric processes are important. CliC complements GEWEX in relevant Continental Scale Experiments (MAGS, BALTEX, GAME Siberia and Tibet) and in the CEOP observational network. Frozen precipitation was the object of a joint workshop in June 2002 and will remain a focus of interest, from the observational and modelling points of view, with the prospect of a joint working group. CliC-GEWEX cooperation is continuing in the area of the observation of ungauged basins and is also important as part of GMPP activities, for the modelling of cloud systems and land-surface processes.

The interaction with SPARC is significant in the domains of water vapour transport at the troposphere-stratosphere interface and of the radiative effects of stratospheric aerosols. Joint activities on the Pinatubo event and the radiative effect of cirrus clouds are being explored.

- **Objective 5:** interacting with the water resource and applications communities to ensure the usefulness of GEWEX results

This objective is carried out by the Water Resources Applications Project (WRAP), which has organised a series of workshops with hydrologists (two in 2002 and another planned for July 2003). However, SSG has recommended a revision of guidance and objectives for WRAP in order to provide a broader interaction with the hydrology community. This would involve a "catalogue" of application projects related to the Continental Scale Experiments, jointly planned with users, as well as tighter links with the International Association of Hydrological Sciences (IAHS) and the PUB (Prediction of Ungauged Basins) project.

6.1.2 Recommendations of GEWEX SSG

GEWEX SSG main recommendations include the completion of a review paper highlighting achievements of GEWEX phase I and the development of a "roadmap" of activities focused on meeting the objectives of GEWEX phase II, along the lines described above. In addition, emphasis has been put on the development of two cross-cutting activities, namely the general question of precipitation measurement and modelling, and the problem of data management.

With respect to precipitation, several actions are under way in order to address critical issues in reducing errors in retrievals and mapping of global precipitation (including solid precipitation in collaboration with CliC), and to improve the representation of precipitating processes in NWP and climate models. The objective analysis and merging of precipitation data is the object of a specialised workshop in March 2003. Reviewing the experiences that the Global Precipitation Climatology Project (GPCP) and TRMM have had in trying to validate satellite- and ground radar-derived precipitation highlighted the need for consistent formulations between the different precipitation measurement communities, for adequate validation data sets especially over oceans, and for advances in measurement systems. The idea of an intensive "precipitation year" was discussed, however, this concept will most likely be delayed until planned future precipitation missions are launched.

Another "cross-cutting" issue concerns data management, which is being dealt with as one of the major CEOP items and by the GEWEX Radiation Panel (GRP), with one workshop planned for May 2003. It is recommended that these initiatives be followed by joint or overlapping meetings open to the wider WCRP community. As a first step, it is felt that there is a need for a parallel data management group within CLIVAR, or at least a point of contact, that can provide information on data sets being collected and exchange ideas on studies of mutual interest. The same suggestion would probably be also valid for CliC and SPARC.

Two other recommendations are sufficiently broad to deserve JSC's attention: (1) the evolution of the Baseline Surface Radiation Network (BSRN), and (2) the use of the new experimental satellite sensors.

The success of BSRN is widely recognised but relies upon the continuity of financial support to individual stations and to the archiving centre. In order to achieve this, a procedure has to be defined jointly with GCOS in order to prepare a transition from a research network into a long term observing system. This question raises the general problem of how to progressively convert well-established research systems into operational systems. The JSC encouraged close consultation with GCOS to explore options for ensuring the future of BSRN.

The GEWEX position with respect to the use of newly available satellite sensors is well reflected in the conclusions of the satellite working group, and the proposal for a co-ordinated, integrated observational

analysis strategy provided as input to the discussions of a WCRP banner. Important messages relate to the need for a concerted plan with space agencies for cross-calibration of the new experimental sensors and inter-comparison of derived products, as well as a plan for a co-ordinated analysis and re-analysis of all global observations pertinent to climate research.

Whilst appreciating the work done towards overall assessment of the achievements of GEWEX phase I, and the planning of a roadmap for phase II, the JSC stressed that the review paper on phase I should be brought out without further delay.

6.2 Hydrometeorology

The objective of the GEWEX Hydrometeorology Panel (GHP), which held its 8th annual meeting at the International Research Institute in Palisades, New York, September 2002, is: "to improve the capability to predict variations in water resources and soil moisture on time scales of seasonal and annual as an element of WCRP's prediction goals for the climate system". A crucial aspect of GHP overall strategy has been to carry out a number of regional research activities. In this regard, six continental-scale experiments (LBA, GCIP/GAPP, GAME, BALTEX, MAGS and MDB) as well as one affiliate experiment (AMMA/CATCH) have been initiated. Two projects with strong ties to CLIVAR are also in the planning stages, NAME (part of GAPP), and the La Plata Basin Study. These activities involve about 500 researchers to study water and energy fluxes and reservoirs over various land areas. In each regional experiment, efforts have been mounted to acquire the necessary observations to characterize water and energy fluxes and reservoirs and to simulate these with appropriate atmospheric, land surface and hydrological models, as described below. In addition, GHP was a driving force in the initiation and preparation of CEOP, which entered its implementation phase in October 2002.

In the past year, GHP has made progress in the closure of the water and energy balance for several basins, in the development of atmospheric coupled and uncoupled hydrological models at regional scale, and in the dialogue with the water resource community. The beginning of the implementation phase of CEOP was a milestone in the global coordination of efforts developed earlier at the regional level. One should also note the release of the International Satellite Land-Surcae Climatology Project (ISLSCP) initiative 2 data set which is almost complete, as well as substantial progress made by the two global data centres, the Global Runoff Data Centre (GRDC) and the Global Precipitation Climatology Centre (GPCC).

It is expected that the hydrometeorology community within GEWEX will ‘evolve’ considerably in the future given factors such as:

- the continued development of its initial continental-scale experiments as they individually mature, and as the interaction between the research teams is reinforced by CEOP and the thematic working groups;
- the evolution of new continental-scale experiments. Although it was formally approved as a continental-scale experiment only a year ago, the Murray-Darling Basin (MDB) project of Australia is already making significant progress towards addressing this region’s water and energy processes, including the role of groundwater;
- the development of new initiatives over other regions including the AMMA project in west Africa and the PLATIN in South America which is expected to apply for the status of continental-scale experiment next year;
- the development of new overarching issues and interactions within GEWEX, and with CLIVAR and CliC. There is also considerable room for linkage with WWRP, the ESSP joint projects (water, carbon and food) and the IGOS water cycle theme. Through isotope research, there may also be a good opportunity for collaboration with the International Atomic Energy Agency (IAEA).

The JSC noted the progress that had been made and pointed out the many uncertainties in our understanding of the role of the hydrological cycle. The JSC recommended continued specific effort on high-latitude precipitation under GHP, in coordination with CliC. It also recommended that GEWEX expertise on the hydrological cycle be properly recognised and taken into account in the preparation of next IPCC report.

6.2.1 Progress in the continental-scale experiments

The Baltic Sea Experiment (BALTEX)

The Baltic Sea Experiment (BALTEX) was established in 1992 to measure and model the energy and water cycles over the Baltic Sea and its catchment. Its purpose is to provide an improved understanding

of the processes controlling the fluxes of water and energy into and out of the entire basin and to use such knowledge for establishing and improving coupled atmospheric, hydrological and ocean models for better weather forecasting, climate studies and climate prediction. Phase I of BALTEX, now finalised (1993-2002), brought an improved understanding of the energy and water cycle in the Baltic Sea Basin. Two fully coupled model systems are currently being finalized and used for BALTEX purposes. An ongoing data assimilation project is focusing on parts of the BALTEX/*BRIDGE* period 1999 to 2002, and several BALTEX projects are ongoing in different countries funded by both national and European sources. At its 14th meeting in Lund, Sweden, 20 November 2002, the BALTEX SSG approved the general objectives for Phase II of BALTEX and a revised science plan is being drafted covering the period 2003 to 2010. The primary focus of BALTEX will be maintained and enlarged to regional climate variability, water management, air and water quality, global change impact assessment and international outreach.

GEWEX Asian Monsoon Experiment (GAME)

Phase I of GAME has now been finalised and scientific results, particularly from GAME-Tropics and GAME-Tibet were reported in the special issue of *Journal of the Meteorological Society* of Japan (Yasunari, ed., 2001). GAME entered in its Phase II, which includes further research and data analysis, some additional process studies, and modelling needed for the synthesis of the overall GAME objectives. Key research issues for the energy and water cycle of monsoonal Asia include the understanding of cloud and precipitation processes and their interaction with large-scale atmospheric circulation, and the interaction between the cloud/precipitation system and the land surface conditions, including topography and land use/land cover conditions. To fully understand the seasonal cycle and interannual variation of the Asian monsoon, GAME will include the large-scale atmosphere-ocean processes and their interaction with land surface processes. GAME modelling activity includes these processes using atmospheric GCMs and coupled atmosphere-ocean GCMs.

GEWEX Continental-scale International Experiment (GCIP)/ GEWEX Americas Prediction Project (GAPP)

GAPP, a follow-on to the GEWEX Continental-scale International Project (GCIP), has two main objectives:

- to develop and demonstrate a capability to make reliable monthly to seasonal predictions of precipitation and land surface hydrology through improved understanding and representation of land surface and related hydro-meteorological and boundary-layer processes in climate prediction models;
- to interpret and transfer the results of improved seasonal predictions for the optimal management of water resources.
-

The geographical area of study is the United States (the lower 48 states) with a focus on the western USA. Funded by NOAA and NASA, GAPP relies on a mix of observational, modelling and diagnostic studies to understand processes and build better prediction systems. GAPP was launched at a large conference in New Orleans in May 2002, which was also the occasion to review the achievements of GCIP, to be published in a special issue of the Journal of Geophysical Research (JGR). GAPP will serve as a key component of CEOP, with the contribution of four reference sites, the development of an operational land surface assimilation scheme, and studies of transferability of regional coupled atmospheric-hydrology models. GAPP will also contribute to the study of the monsoonal circulation and the carbon cycle.

Large-scale Biosphere-Atmosphere Experiment in Amazonia (LBA)

After a phase of implementation of field activities and the initiation of research and training activities, new developments include the implementation of several levels of climate and hydrological modelling, making use of the 70-km resolution global model of the Centro de Previsao de Tempo e Estudios Climaticos (CPTEC) and the Eta/CPTEC regional model at 20-km resolution. Future activities on this subject include the downscaling of climate change scenarios from IPCC (using the Eta/CPTEC model nested on the HadCM3 model from the Hadley Centre) and the preparation of long-term climate runs, on the newly acquired NEC-SX6 supercomputer. On the observational side, the involvement of LBA in CEOP, and the implementation and planning of field experiments in Amazonia from 2002 to 2005 guarantee the availability of high-resolution time-space data. The closure of the water budget over the Amazon basin remains a priority. With respect to new developments, one should note the field experiment on the South American Low Level Jet planned jointly with CLIVAR for summer 2003, which will allow a better knowledge of the moisture transport between Amazonia and the La Plata river basin. Currently, there are 102 projects going on in LBA, funded either by Brazilian or international funding institutions.

A special issue of JGR with the major findings of the first LBA conference was published in 2002 and the second international LBA Conference was held in July 2002 in Manaus.

The Mackenzie River GEWEX Study (MAGS)

The initiation of MAGS Phase-2 in 2001 brought a shift in the focus of the research programme, from data acquisition and experimentation to modelling and prediction. The major objectives of MAGS-2 are:

- to integrate knowledge of atmospheric and hydrological cycles into a unified system;
- to develop hierarchy of models for a range of spatial and temporal scales;
- to apply improved predictive ability to environmental and social issues

MAGS research in the second year of Phase-2 has focused on achieving the first two objectives. Some process models (e.g. lake models, frost models, blowing snow models etc.) have been improved and parametrizations based on those are under development for integration into coupled models. The development of intermediate-level coupled models (e.g. coupled atmosphere-land surface and coupled land surface-hydrologic models) has been completed and preliminary results are very encouraging. In addition, major projects initiated in Phase-1 have been completed and activities addressing the third objective have started.

The Murray-Darling Basin Water Balance Project (MDBWP)

The objectives of the MDBWP are:

- to enhance the capability of the operational systems of the Australian Bureau of Meteorology to provide accurate and reliable estimates of the real-time surface water budget across the MDB;
- to measure the spatial and temporal variability of soil moisture and temperature across one part of the basin (the Murrumbidgee River basin);
- to identify and reduce key limitations in the representation of soil moisture and temperature in Bureau of Meteorology Research Centre (BMRC) atmospheric model;
- to develop products for water authorities in the MDB.

These objectives are being achieved through a programme of combined observation and modelling studies, based on the hydrology and modelling expertise at the University of Melbourne and the meteorological modelling expertise in BMRC. Two CSIRO (Commonwealth Scientific and Industrial Research Organization) laboratories have joined the project, with expertise in land surface and land atmosphere interaction, as well as Macquarie University model for surface scheme intercomparison studies and ANSTO (Australian Nuclear Science and Technology Organization) for isotopic studies.

African Monsoon Multi-disciplinary Analysis (AMMA)

AMMA is a multidisciplinary and international project, building on projects such as the GEWEX continental-scale affiliate, Couplage de l'Atmosphère Tropicale et du Cycle Hydrologique (CATCH) and WAMP (West African Monsoon Project, a European modelling project). It aims at a global study of the West African Monsoon in order to:

- improve our understanding of the coupling between the atmosphere, the land surface and the ocean over a spectrum of scales ranging from regional down to local;
- evaluate the impact of the variability of this climate system on the water resources, food sustainability and health of one of the most vulnerable regions on Earth;
- improve the predictive capability of dynamical models, especially for seasonal rainfall prediction and for the production of hydro-climatic scenarios for this century;
- provide an array of adequate in situ measurements for satellite validation; and
- strengthen the partnership between African, American and European scientists.

AMMA is built around four main components: observing system, modelling activities, satellite component, training programme. Currently the main effort is on organising an Enhanced Observing Period and the related modelling and satellite activities. One major issue in this respect is to secure the operation of the existing radio sounding network over West Africa and, possibly, to reinforce it where needed, especially around the planned Long-term Observing Period. One major issue for AMMA is to obtain an official WCRP/WMO label that will help in obtaining the support of national meteorological services and international agencies (funding agencies, space agencies, etc.). This support is needed for maintaining and upgrading the

radio-sounding network as well as for getting access to satellite data at a reasonable cost. AMMA has been approved by the GEWEX SSG as an affiliated project.

6.2.2 Supporting projects and activities

International Satellite Land Surface Climatology Project (ISLSCP)

Following a wide distribution of the Initiative I data set, the Initiative II collection, consisting of a 10-year core global data collection spanning the years 1987 to 1995 with improved spatial and temporal resolution (one-quarter to one-degree) and including a larger range of products, is being finalized. This data collection includes carbon data sets designed to support global carbon cycling studies, and GCM data. An Initiative III data set is planned that would expand the physical and biophysical near-surface global compilation to over 25 years (1982-2007) and would focus on exploiting the data from the new satellite sensors becoming available, as well as the carbon/biophysical data needed for addressing the broad climate change issues. A major change from Initiative II to III is the increased focus on validation and cross-validation of surface exchange parameters. Two successful workshops were held in 2002. It is intended that the scientific plan of Initiative III will be refined during 2003, with a closer link with GRP activities, a stronger focus on land-surface data sets and a wider opening to international participations.

Water and Energy Balance Study (WEBS)

WEBS aims to quantify and characterise the water and energy fluxes and reservoirs over the GHP continental-scale experiments as well as other regions. Progress has been made to assess our capability to "close" the water and energy balance with global and regional models. Several workshops have been held and an article using NCEP re-analysis data over all of the CSE regions has been completed, WEBS-related efforts are ongoing within the individual CSEs, making use of global products covering the period 1987-2001. Two workshops will be held in 2003 at AGU/EGS/EGU in April and IUGG in July.

Water Resources Applications Project (WRAP)

WRAP is designed to structure the dialogue between the users of hydro-meteorological forecasts, and the researchers within GHP who are involved in the development of datasets and models on a global basis. A second workshop has been held in July 2002 in Dresden, opening a dialogue between GEWEX scientists and water resource managers. This dialogue will be pursued at a new workshop scheduled as part of IUGG in July 2003. This effort is duly appreciated by the hydrology community, but there is a need and demand to effectively start specific application projects.

Data Management Working Group

This group is concerned with improving the access to and distribution of various data sets. For example, each of the continental-scale experiments has produced a variety of special datasets. To help improve the use of these, this working group has summarized the various data listings and access guidelines of participating groups within GHP, and it is currently concerned with pulling together its first collective dataset on precipitation. This group is also playing a major role in the preparations for CEOP.

Large-scale hydrological modelling

These studies are being carried out in the continental-scale experiments. In some cases, these are using fully coupled atmosphere/land-surface models. As well, and in cooperation with GMPP and CliC, an inter-comparison activity has been carried out within the BALTEX region.

Transferability and validation

The transferability of regional models between regions and/or the validation of global models over continental-scale experimental regions and other regions is being addressed on a case-by-case basis. To move this effort along, BALTEX has volunteered that its 1995 pilot period can act as the basis for an inter-comparison of regional (and global) models. Under CEOP, specific tests of transferability and evaluation are being planned.

Prediction and Predictability

Prediction and predictability studies are under way within each of the continental-scale experiments. These are generally aimed at establishing our capabilities and weaknesses to predict water-related

parameters over these regions on time scales ranging up to interannual. At the September 2002 GHP meeting, further discussions were held in regards to moving this effort along in a more comprehensive manner.

In addition to the above topics, research examining “Water Sources” as well as “Extreme Water-Cycle Events” is being pursued to various degrees within the continental-scale experiments. Initial discussions have been held regarding whether more coordinated actions are needed or justified but final decisions have not yet been made. If it moves ahead, it is expected that the “Water Sources” issue will be pursued jointly with IAEA. Other topics under consideration include carbon and orographic hydrometeorology.

The JSC acknowledged the progress made in the continental-scale experiments and supported ISLSCP’s proposed extension to achieve a 25-year data set adequate to determine boundary conditions for climate modelling and prediction.

6.2.3 Co-ordinated Enhanced Observing Period (CEOP)

The overall goal of the Co-ordinated Enhanced Observing Period (CEOP) is to understand and model the influence of continental hydro-climate processes on the predictability of global atmospheric circulation and changes in water resources, with a particular focus on the heat source and sink regions that drive and modify the climate system and anomalies. To this end, a co-ordinated effort has been undertaken to put together the observations being taken by the CSEs, data sets derived from environmental satellites including the newer ones and data sets from global models. The primary objectives of CEOP are to:

- document, better understand, and improve the simulation and prediction of water and energy fluxes and reservoirs over land for water resource applications
- document the seasonal march of the monsoon systems and better understand their physical driving mechanisms and their possible connection.

CEOP had two major milestones in the past year: 1) the CEOP Implementation Planning Meeting, 6-8 March 2002 in Tokyo, Japan; and 2) a CEOP status session that was held on 13 September 2002, in conjunction with the GEWEX Hydrometeorology Panel (GHP) meeting. Since March 2002, CEOP has been focussing on the development of an initial enhanced observing period (EOP-1) data set, which covers the period from July through September 2001, and on the initiation of the build-up observation phase which started on 1 October 2002. The build-up phase of CEOP is on schedule. Progress has been made according to the CEOP Implementation Plan on the CEOP Data Management, Satellite Data Integration, Model Output Production, Water and Energy Simulation and Prediction (WESP) and Monsoon Systems Studies activities.

There are 36 reference sites reporting around the globe, most of them belonging to the existing network of the Continental Scale Experiments; data are being archived at the CEOP Central Archive at UCAR under the responsibility of the Data Management Working Group. A high degree of involvement of the GEWEX hydrology community in CEOP has been achieved since the kick-off of CEOP implementation, backed by multi-national commitments involving the main reference site operators.

Model output requirements have now been standardized and most major modelling centres are delivering their model products. Those are being centralised and handled by the Max Planck Institute for Meteorology in Hamburg, in view of integrating them into a World Data Centre.

The WESP Working Group has defined the methodology to document and simulate water and energy fluxes and reservoirs, and to predict them up to the seasonal timescale for water resource applications. The plan is to develop this skill at regional scale, and to transfer it progressively to global scales.

The Monsoon System Working Group has developed its plan to validate and assess the capability of climate models to represent physical processes which are pertinent in the simulation of monsoons. Its work will be further discussed at a workshop to be held in April 2003 in Milan.

Satellite data are handled by two integration centres at the University of Tokyo and at NASA Goddard with a strong support of NASDA and NASA and assistance of the CEOS Working Group of Information Systems and Services (WGISS). Data from most satellite sensors available are progressively included in an impressive archiving system.

GEWEX SSG has endorsed advances in the various aspects of CEOP implementation, including the work of the scientific coordination and the programme of the next CEOP implementation meeting to be held in Berlin, 2-4 April 2003. It supports the efforts of the CEOP organizational structure to formalise current

agreements and recommends the prompt finalization of the Advisory and Oversight Committee which should help in securing resources from the various participating organizations.

The JSC acknowledged the progress being made in various aspects of CEOP in accordance with the implementation plan and pointed out the needs of the modelling community for land surface boundary conditions to carry out sensitivity experiments. As regards coordination of monsoon studies, the need to explore the possibility of a single monsoon panel across WCRP was re-iterated (see also section 5.3).

6.3 Radiation and GEWEX Climatological Global Data Sets

The GEWEX radiation panel (GRP) leads studies on radiative processes, particularly in association with clouds and aerosols, and the development of global data sets making use to a large extent of satellite observations. One of the primary goals of the global data projects has been to create or foster the systematic collection of the global, long-term, atmospheric and surface property satellite derived data-sets needed to diagnose the joint variability of the global energy and water budgets and to improve understanding of the climate processes that determine its natural variability and sensitivity to changes. In order to facilitate better connections among the GRP satellite projects and with other data analysis activities within GEWEX, all of the GRP data activities will be organized into a single Working Group on Data Management and Analysis (WGDMA). The first tasks of WGDMA will be to undertake some common statistical analysis tasks, possibly including the creation of a merged collection of data for all of the GRP global satellite projects (ISCCP, GACP, GPCP, SRB, SeaFlux) and to make plans for the exploitation of new satellite observations. This new group will also liaise with the GEWEX Cloud System Study (GCSS)/Data Intergration for Model Evaluation (DIME), the Global Land Atmosphere System Study (GLASS)/Assistance for Land-Surface Modelling Activities (ALMA), the International Satellite Land-Surface Climatology Project (ISLSCP), as well as the GRP Data Management Working Group. The first meeting of this group is planned for May 2003 in Asheville, North Carolina, hosted by NOAA's National Climatic Data Center.

In order to foster development of integrative data analysis methods, the GRP held jointly with WGCM a Workshop on Climate Feedbacks on 18-20 November 2002 in Atlanta, Georgia, USA. A Workshop on Objective Analysis of Precipitation is being organized by GPCP to be held 11–13 March 2003 at the European Centre for Medium-Range Weather Forecasts, UK.

The global satellite analyses are supported by a number of studies to help evaluate their accuracy, a major one being the BSRN to support the Surface Radiation Budget (SRB) project. The ARM site in Oklahoma is also used as a key reference site for satellite measurements.

The GRP activity is central to the continued interaction between the GEWEX community and satellite operators. Under this panel the satellite working group presented a report separately to JSC recommending among other things, that WCRP emphasise the importance of the continuity of measurements from operational and polar orbiting satellites, and increase communication with all space agencies at the management, project and working levels.

GRP has stressed the risks of potential gaps in the continuity of the measurement of the components of the Earth radiative budget and of precipitation by space radar. It has also emphasised the benefit expected from the Global Precipitation Measurement (GPM) programme and from global soil moisture observations by the still not confirmed SMOS and Aquarius missions. A general plea is also made to space agencies to increase their financial participation and their coordination effort for the preparation of global climate data sets making use of all available sensors.

An increasing interaction with the hydrometeorology community has been recommended and is taking place as part of CEOP. Interaction with other communities is improving as the scope of global data sets evolves to meet some of climate scientific challenges. Major topics where specific effort is needed include radiative feedbacks in the climate system, which remains an open research area, the use of cloud-resolving models in the development and validation of retrieval schemes, the coordination of global data sets with GCM requirements, and the coordination of land flux activities which will be the object of a specific workshop in spring 2003. Further reflection on the last topic should also provide input for the evolution of the ISLSCP programme, which the GEWEX SSG recommended the GRP community to join.

6.3.1 Global data sets and satellite projects

International Satellite Cloud Climatology Project (ISCCP)

ISCCP produced a new 18-year (1983–2001) global radiative flux data product which provides physically consistent surface and top-of-atmosphere (TOA), as well as in-atmosphere profiles of shortwave and longwave fluxes for all-sky and clear-sky conditions. Flux values are provided at 3-hour intervals for the whole record and mapped on the 2.5 degree ISCCP grid. Preliminary examination of the global monthly mean shortwave (SW) and longwave (LW) flux anomalies at the surface, in the atmosphere and at TAO over this 18-year period show several notable features:

- a decrease of the net SW at the surface and TOA, as well as in the atmosphere produced by the Mt. Pinatubo volcanic aerosols in 1991–92;
- an overall increase of the net SW at TOA and the surface, but not in the atmosphere, from the 1980s to 1990s associated with a decrease in low-latitude cloud cover;
- three (possibly four) decreases in net LW at the surface and increases in the atmosphere, but not at TOA; and
- a small decrease of net LW at TOA and in the atmosphere and a larger increase of net LW at the surface occurring in the late 1990s.

Many new satellite instruments have been or will soon be launched that sense clouds at a new set of wavelengths and/or employ novel measurement techniques. These will progressively be acquired and integrated in the ISCCP approach.

GEWEX Global Aerosol Climatology Project (GACP)

Extensive theoretical studies supported the development of a two-wavelength aerosol retrieval method to be applied to AVHRR radiances; subsequent validation studies confirmed that the uncertainty in the retrieved aerosol optical thickness is much reduced compared with a single-wavelength analysis. This new method was applied to the ISCCP cloud product covering 18 years (1983-2001).

Surface Radiation Budget (SRB)

The available data record now covers 1983-1995 (12 years) (various products with resolutions from 100 km, 3 hr to 100 km, monthly). Production will resume later this year to extend the record to 2002. Another radiative flux product has also been produced by the ISCCP team covering 1983-2001. Surface shortwave flux variations are consistent with cloud cover changes; surface longwave flux variations suggest significant "slow" exchanges of energy between the atmosphere and ocean.

Earth Radiation Budget (ERB)

Analyses of top-of-atmosphere radiative fluxes from Nimbus-7, the Earth Radiation Budget Experiment (ERBE), the Scanner for Radiation Budget (ScaRaB) and the Clouds and Earth's Radiant Energy System (CERES) now cover 23 years of data (1979-2002). They show not only features associated with ENSO events and the El Chichon and Mt. Pinatubo eruptions, but also inter-decadal changes that appear to be associated with changes in clouds found in the ISCCP data set and upper atmosphere water vapour found in the analysis of High-resolution Infrared Radiation Sounder (HIRS) data.

Global Precipitation Climatology Project (GPCP)

There is now a 23-yr precipitation data record (pentad and monthly mean, 300 km) and a 5-yr record (daily, 100 km resolution); the development of a 3-hour product is being planned. TRMM data have provided a very useful input for the validation and improvement of algorithms. New developments are expected in microwave algorithms and procedures for using simultaneous data from several satellites; the elaboration of a "snowfall" product is being considered. There appears to be a notable decrease in global mean precipitation during the Pinatubo event but no other significant global variations. The issue of inter-annual variability and global change of precipitation will be further examined.

GEWEX Water Vapour Project (GVAP)

The NVAP pilot study produced an 11-yr water vapour record (daily, monthly at 100-km resolution) and a new 3-hourly data set is being undertaken. The NOAA operational sounder analysis provides a 300 km-daily record for the last 23 years. A validation of retrieval techniques has been achieved with ARM data.

GVAP will continue to carry out comparisons of existing water vapour data sets, together with newer methods/data to come.

Baseline Surface Radiation Network (BSRN)

A comprehensive BSRN review took place in May 2002 in Regina, Canada. It confirmed the maturity of the project and its usefulness as a reference network for satellite-based observations and a validation data set for modelling activities. There are now over 35 active stations participating and sending their observations to the central archiving centre at ETH Zürich. Some sites have more than 10 years of data available, the average being of the order of 4 years. Specific working groups are co-ordinating their efforts in order to improve measurement capabilities and methodologies in most major research domains, namely diffuse and direct solar, as well as thermal, irradiance, albedo, aerosol optical depth, and observations in the UV and photosynthetically active part of the spectrum. The success of BSRN is widely recognised but relies upon the continuity of financial support to existing and prospective stations, as well as to the archiving centre.

6.3.2 Specific study projects and working groups

GRP has organised several specific study projects to examine particular problems and to foster work towards their solutions. The following activities are on-going:

Intercomparison of radiation codes in climate models – shortwave (ICRCCM-SW)

A study comparing available parametrizations for treating cloud variability effects on short wave scattering to full 3-D calculations has been published. Results show that treatments that represent small-scale variability as an "independent column approximation" and calculate fluxes for horizontally varying layers provide fairly accurate results. Information about and representations of the radiative transfer of ice clouds remain significant problems. A test kit containing specifications of inputs and outputs from 3-D and other radiative transfer models is being prepared.

ICRCCM-Longwave

After completing the clear case, a more extensive set of test cases is being prepared for a large range of water vapour abundance and cloudy sky intercomparisons of climate model calculations.

Intercomparison of 3-D radiation codes

This study has shown that all of the various methods currently used to calculate 3-D radiation agree quite well. A test kit for checking new methods is on-line. A new working group is now being organized under the auspices of the International Radiation Commission to examine how radiation couples to the atmosphere (boundary layer dynamics) and the surface at the scales where the radiation is 3-D. The GRP endorsed this activity and highlighted the role that GCSS/GABLS/GLASS could play in this study. A survey of recent changes to global circulation model radiation transfer codes, to be published soon, showed that there has been rapid progress lately to improve the physical detail of these codes.

SeaFlux

The on-line database of ship case studies now encompasses over 300 data months, along with a complete collection of collocated satellite products. Several comparison activities are under way: retrievals of skin SST and air temperature/humidity, turbulent surface flux formulations and global flux products. This group is also interacting with others including the GODAE-SST group to compare retrievals of sea surface winds, especially from scatterometers, and precipitation over oceans. A workshop took place in February 2003 to review progress of the intercomparison projects.

A new working group, the Column Profiling WG, has been established to encourage cooperation among the several sites now producing long-term, if not continuous, atmospheric profile data-sets. The primary emphasis is on cloud profiling by radar and lidar, but efforts will be made to include and/or combine this with profiling of water vapour and winds where possible. The objectives are to discuss common issues, particularly regarding analysis methods, and to establish some common practices and data formats so that the rest of the research community can more easily use these data sets.

6.4 Modelling and prediction

The GEWEX Modelling and Prediction Panel (GMPP) has the objective of developing and evaluating improved interactive model formulations of atmospheric and land-surface processes that regulate the global hydrological and energy cycle. During 2002, GMPP initiated its third major component, the GEWEX Atmospheric Boundary Layer Study (GABLS), which is directed by Professor Bert Holtslag of Wageningen University in the Netherlands. In March 2002, GABLS held a very successful workshop at ECMWF. An additional meeting was held at Wageningen University in July 2002. These meetings refined the working plan, focussing on the stable boundary layer over land.

The GEWEX Cloud System Study (GCSS) held a major workshop in May 2002, the GCSS-ARM Workshop on the Representation of Cloud Systems in Large-Scale Models, which was held in Kananaskis Village, Alberta, Canada, and involved all five GCSS Working Groups. The Workshop was well attended by the global modelling community, and included a special breakout session focused on global modelling issues. The GEWEX Global Land-Atmosphere System Study (GLASS) is pursuing its series of off-line local intercomparison of land-surface schemes and is addressing the new approaches defined in its implementation plan, with a local-coupled study, the development of a global land-surface data set, the Global Soil Wetness Project (GSWP), and the initiation of a study of the role of land-surface on the variability of the climate system.

As is now usual, GMPP met jointly with WGNE in November 2002 in Toulouse, reinforcing the links between “process” and “global circulation” modellers. One of the important issues was the larger involvement of GMPP in the evaluation of present AMIP experiments and in the planning of new ones.

6.4.1 GEWEX Cloud System Study (GCSS)

The goal of GCSS is to improve the parametrization of cloud systems in GCMs (global climate models) and NWP (numerical weather prediction) 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 parametrizations of GCMs and NWP models, in conjunction with CRMs, LES models, and observations, to evaluate and improve cloud system parametrization. GCSS is composed of five working groups, relating to boundary-layer cloud systems, cirrus cloud systems, extratropical layer cloud systems, precipitating convective cloud systems, polar cloud systems. During 2002, C. Bretherton and P. Brown began serving as WG chairs for the boundary-layer and the cirrus groups, respectively.

The GCSS workshop held at Kananaskis in May 2002 reflected the increasing interest of the GCM community in GCSS activities and the increasing interaction of GCSS with the radiation, microphysics, aerosol, and cloud-remote sensing communities. The following scientific advances are expected in the GCSS WGs during the next several years:

- rapid progress on the representation of subgrid-scale cloud overlap and inhomogeneity due to the combination of CRMs, cloud radar observations, and faster methods of calculating radiative fluxes for arbitary cloud configurations;

- steady progress in the understanding and representation of cloud microphysical, formation, and dissipation processes due to integrated use of LES (large-eddy simulations) models, CRMs, SCMs, GCMs, and cloud-scale observations, plus insights from recent and upcoming field experiments; and

- use of super-parametrizations (i.e. CRMs used as parametrizations) in some GCMs will provide more physically realistic representations of cloud processes, to increase knowledge and understanding of interactions between cloud processes and large-scale processes (including cloud feedbacks), and to help improve conventional parametrizations.

6.4.2 GEWEX Global Land-Atmosphere Study (GLASS)

The GLASS project is progressing through the various actions which were defined in the implementation plan. Under PILPS (Project for Intercomparison of Land Surface Parametrization Schemes), a set of simulations at the local and regional level was finalised over the Rhône basin, a new local study including carbon fluxes was initiated over a forested land in The Netherlands, and a third off-line

intercomparison of land surface models is starting for the first time in a semi-arid region (San Pedro catchment in the south western USA).

The Global Soil Wetness Project 2 (GSWP-2) will start in early 2003 and first results should be available by the end of the year. Its goals are to:

- produce state-of-the-art global data sets of surface fluxes, of soil wetness and related hydrologic quantities;
- develop and test large-scale validation, calibration, and assimilation techniques over land;
- provide a large-scale validation and quality check of the ISLSCP data sets;
- compare land surface schemes and conduct sensitivity studies of specific parametrizations which should aid future model development.

A major product of GSWP-2 will be a multi-model land surface analysis for the ISLSCP II period.

In order to assess our knowledge on the role that surface moisture and temperature states play in the evolution of weather and the generation of precipitation, a new study called GLACE (Global Land-Atmosphere Coupling Experiment) will address the problem of the relative role of land-surfaces in the variability of the climate system. This will be based on a series of GCM experiments using coupled free and forced land-surface schemes.

6.4.3 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 (SBL) over land. Much of the warming predicted by climate models is during stable conditions over land (either in winter or at night), while at the same time the understanding and parametrization of the SBL is still very poor. GABLS aims to provide a platform in which scientists working on boundary layers at different scales will interact. A GABLS workshop on Stable Boundary Layers was held at ECMWF, Reading, UK, on 25-27 March 2002 with a balanced participation of process modellers, observation specialists and GCM modellers. Three task groups were defined on the following topics: the analysis of existing observations, in order to provide data sets to validate LES results and to help scope out the parametrization problem; large eddy simulations to help guide and evaluate proposed parametrizations; and GCM studies to provide feedback on updated parametrizations.

7. THE ARCTIC CLIMATE SYSTEM STUDY (ACSYS) AND THE CLIMATE AND CRYOSPHERE (CliC) PROJECT

Dr B. Goodison, Chair of the ACSYS/CliC Scientific Steering Group, and Dr C. Dick, Director of the International ACSYS/CliC Project Office, reviewed the main developments in ACSYS and CliC during the past year. ACSYS (http://acsys.npolar.no) started its main observational phase on 1 January 1994, and the project will finish on 31 December 2003. The final Conference on ACSYS will be held on 11-14 November 2003 at the Arctic and Antarctic Research Institute, St. Petersburg, Russia. CliC (http://clic.npolar.no) was endorsed as a WCRP project by the JSC – XXI (Tokyo, Japan, 13-17 March 2000), and has a likely lifetime of at least 15 years. The first CliC Science Conference is currently planned for 2005.

7.1 ACSYS and CliC issues, priorities, highlights

7.1.1 Issues

With the ACSYS project in its final year, and CliC now under way, issues mostly involve work towards the successful conclusion of ACSYS and the spin-up of CliC activities. The immediate tasks are to:

- complete ACSYS observational programmes and studies, summarise the results with the goal of improving representation of the Arctic region and corresponding processes in global climate models. This will be accomplished, in part, by the final ACSYS Conference (see below)
- prepare datasets relevant to studies of Arctic climate on CD-ROM and/or the Internet. This will be accomplished primarily via the ACSYS Data and Information Service
- ensure smooth and full transition of all relevant ACSYS activities to CliC
- refine CliC Implementation Strategy document

- define and guide CliC initial observational and modelling activities for determining the role of cryosphere in the global climate system and its realistic representation in models
- stimulate and coordinate national and regional contributions to CliC
- develop strategies for co-ordination of CliC national and regional initiatives, including establishment of partnerships with other scientific organisations, societies, and international committees
- strengthen links with other WCRP projects and relevant research and observational programmes outside WCRP.

7.1.2 Priorities

ACSYS Final Science Conference

The ACSYS Final Science Conference will celebrate ten years of progress in WCRP research on the Arctic Climate System and its role in global climate. The conference will be held at the Arctic and Antarctic Research Institute (AARI) on 11-14 November 2003. A Science Organising Committee has been formed under the Co-chairmanship of Professor Thierry Fichefet, an SSG member (Belgium), and Dr I. Frolov, AARI Director (Russia). The Local Organising Committee is Co-chaired by Dr Yu. Tsaturov and Professor V. Kotlyakov. A publications sub-committee will be established to investigate options for publication of the conference papers in a special issue of a referred journal. The conference title is “Progress in Understanding the Arctic Climate System: The ACSYS Decade and Beyond”. Session themes will address:

- state of the Arctic climate system (improvements in our knowledge of Arctic climate and its variability through historical data, ongoing measurements and process studies)
- observing the Arctic climate system (improvements in our ability to measure and observe various elements of the Arctic climate system and its processes across a range of space and time scales)
- process studies and modelling (improvements in representation of cryospheric, atmospheric, terrestrial and oceanic processes in models)
- interactions with the global climate system (improvements in our understanding of the role of the Arctic in the overall climate system and its response to larger-scale oceanic and atmospheric climate variations).

A final session will seek to identify important gaps in our knowledge and opportunities / initiatives to address them through new programmes, models and emerging technologies. The conference website is: http://acsys.npolar.no/meetings/final/conf.htm.

CliC Implementation Strategy

A version of the CliC Initial Implementation Plan was made available to the general science community during the first half of 2002, and comment was invited. Following limited feedback, the feasibility of publishing a shortened ‘Implementation Strategy’ and maintaining more detailed implementation and achievements documents on the web was considered. The Implementation Strategy document would be aimed at funding agencies, programme managers and relevant international programme and project committees, and should contain a thematic science structure with conceptual project areas, a framework for management of the programme and collaboration, recommended methodology, and data management strategy. Subsequent discussions at the joint NEG - OPP meeting in Yokosuka (see section 7.3), and the ACSYS/CliC SSG-III Session in Beijing in October 2002 approved the idea that CliC would have:

- a Science and Coordination Plan that would be updated periodically as necessary (already published as Allison et al., 2001);
- an Implementation Strategy document giving concise scientific background and discussing mechanisms for implementation;
- a Science and Implementation document on the web describing current and forthcoming contributions to CliC goals; and
- a Results and Achievements document providing information of scientific progress.

A first draft of a new Implementation Strategy has been circulated within the Implementation Plan Task Group.

First CliC Science Conference

It has been decided that the first CliC Science and Implementation conference should be held in 2005. The conference will have the objectives of presenting CliC science objectives and activities to funding, research and operational agencies and other national and international science and funding bodies, and of

discussing national and agency priorities and efforts to address CliC goals. Presentation of national, agency and institutional plans for CliC related activities would be invited. A suggested sub-title for the conference is "A changing cryosphere and its interaction with global climate". The organising committee for the conference will consist of the SSG Chair and 2 vice-chairs, chairs of the CliC panels, the Director of IACPO, and the CliC representative from the JPS for WCRP. An external chairperson for the conference is still to be determined. The format of the conference would include keynote speakers and posters from research contributors, and would provide an opportunity for potential research contributors to interact with project office staff and scientists already involved in the project. The conference would also stress the economic and societal impacts of a changing cryosphere.

WCRP participation in the proposed International Polar Year (IPY)

The year 2007 will mark the 125th anniversary of the First International Polar Year (1882/3), the 75th anniversary of the Second Polar Year (1932/3), and the 50th anniversary of the International Geophysical Year (1957/8). The concept of an International Polar Year in 2007/08 has recently been raised in many fora and ICSU has considered establishing an ICSU Planning Group on IPY. A web site devoted to these issues has been established at the NASA Goddard Space Flight Center at: http://ipy.gsfc.nasa.gov/about.shtml. The IPY provides an opportunity for raising the profile of polar climate science, and it may be possible to use it to generate resources and support for CliC. There are several possible approaches to the main focus of IPY with some, but not all, current ideas involving climate science. At its session in Beijing, the ACSYS/CliC SSG discussed the issue, including a draft concept paper for a Circumpolar Hydrosphere/Atmosphere Dynamics Programme written by the Director IACPO. The SSG's opinion was that this concept should be further developed. During the discussion, lack of continental scale study areas in polar regions was mentioned and the following was agreed:

- cryosphere and climate should be important elements of any IPY programme
- synchronous observations of snow cover, sea ice, permafrost, mountain glaciers and ice sheets should be made in both hemispheres
- a concept paper should be developed trying to justify the initiation of an International Polar Decade in 2007/08, rather than simply backing the idea of a Polar Year. If the concept seemed worthy, then this should be promoted through a letter to ICSU and WMO with a full justification. The concept of an International Polar Decade should be kept separate from individual project ideas.

The ACSYS/CliC SSG recommended that CliC and WCRP should participate actively in any discussions of the scientific direction of the IPY, to ensure a high profile for climate science in any science programme. WCRP may wish to consider setting up a committee to consider the IPY, so that it is in a strong position to take a lead in this activity. Since CliC is the major WCRP project with explicit interest in polar studies, CliC should be expected to play a leading role in this activity.

The JSC supported the involvement of WCRP in the activities associated with a proposed "International Polar Year" if it focuses on global change and asked CliC to organize preparations within WCRP, taking into account the interests of all relevant projects and working groups, and represent WCRP in corresponding discussions.

7.1.3 Project highlights

Within the many areas of scientific progress related to ACSYS/CliC goals, there have been a number of specific project highlights over the past year.

- The Scientific Committee on Antarctic Research (SCAR) has been the major driver of climate and cryospheric research in the Antarctic. Following earlier discussions, the SCAR Meeting XXVII confirmed the wish of SCAR to become a sponsor of CliC. It was agreed by delegates at SCAR-XXVII that SCAR would provide support to CliC of up to $US6000 per year for the next 2 years, to cover funding of two SCAR representatives on the ACSYS/CliC SSG. The SSG welcomed the involvement of SCAR in its activities. It was agreed that there should also be collaboration at the SCAR Action Group/CliC Panel level rather than just via the SSG. Possible links could be established between the SCAR Action Group on oceanography and the CLIVAR/CliC Southern Ocean Panel. There could also be links between the CliC Data Panel and SCAR Joint Committee on Antarctic Data Management.

- The ACSYS Historical Ice Chart Archive, containing 6000 sea-ice charts covering the period from 1553 to 2002 and the region of the Northern Hemisphere from 30ºE to 70ºW, was published on CD-ROM in February 2003. This was the culmination of 15 years of work, most of which was

supported by the ACSYS project. Final publication was funded by the World Wide Fund for Nature and carried out by IACPO and the Norwegian Polar Institute.

- A report entitled 'Recent variations in Arctic sea-ice thickness' (IACPO Informal Report No. 7) was presented to the Arctic Ocean Sciences Board in April 2002, following their request for ACSYS/CliC advice on the topic. This report followed from an expert workshop convened as part of the 2001 ACSYS/CliC Observation Products Panel meeting, and Co-Chaired by Dr S. Laxon (ACSYS/CliC OPP member) and Professor P. Wadhams (Scott Polar Research Institute). All recent refereed publications on Arctic sea-ice thickness were reviewed in order to provide an informed view of the state of knowledge. The report concludes that neither models nor observations provide a coherent picture of sea-ice thickness changes over the past few decades, and that further efforts are needed. Specifically, it recommended that ice profiling sonar (IPS) data should be made available, efforts should be made to secure the release of further historical submarine data, that studies using a variety of techniques need to be continued, and that in the long term satellites and models may be able to provide basin-wide ice thickness measurements, but these must be supported by calibration and validation of satellite data and sound data assimilation techniques.

- ACSYS/CliC expressed support for two very important proposals in response to the European Space Agency's (ESA) invitation to tender for the development of Synthetic Aperture Radar (SAR) applications for the Global Monitoring for the Environment and Security (GMES) programme. These proposals, which respectively addressed sea ice, and sea ice and other cryospheric monitoring, were both supported by ESA and will go forward over the next 20 months. Success during these phases should lead ultimately to ongoing enhanced operational monitoring of sea ice, snow cover, and glaciers.

- With the planned launch of ESA's CryoSat in 2004, ACSYS/CliC has played an active role in encouraging participation in calibration/validation activities. A team has now been formed that will guide an intensive period shortly after the launch of CryoSat. Together with NASA's ICESat, launched in January 2003, these missions will provide significant improvements in satellite altimetry observations of the cryosphere.

- National committees for CliC have been developed by China and Japan and are being considered by a number of other nations, including Australia, Canada, Germany, Russian Federation, UK, and USA. Development of national CliC committees is being strongly encouraged in order to provide an efficient mechanism for bringing national priorities to the attention of the ACSYS/CliC SSG. They could also provide a link from the international CliC panels to national science communities and, it is hoped, funding agencies. Regional cooperation is also encouraged where appropriate, and an Asia CliC may be developed.

7.2 ACSYS/CliC Workshops

In 2002 ACSYS/CliC organised four workshops and a mini-conference.

Workshop on Sea-ice Extent and the Global Climate System and a mini-conference on Long-Term Variability of the Barents Sea Region

An open workshop on Sea-ice Extent and the Global Climate System at Météo-France in Toulouse, France, on 15-17 April 2002, followed immediately by a mini-conference on Long-Term Variability of the Barents Sea Region (18-19 April 2002), attracted participation of about 70 scientists. The overall goal of the workshop, chaired by Dr R. Colony, International Arctic Research Center (IARC), was to place recent changes in sea-ice extent into the context of long-term climate variability. The workshop brought together modelling and observational scientists to address topics of modelling (sea-ice, regional climate and coupled global climate models), data analyses (climate reconstruction, diagnostics, and the physics of ice-cover variation) and data management (data set identification, error analysis and meta-data presentation). Covering both northern and southern hemispheres, the workshop sought to identify diagnostic opportunities provided by sea-ice data sets in the context of climate variations, and to highlight potential uses of available sea-ice data. A number of potential sources of data on the position of the ice edge in historical times were identified at the meeting, and the importance of a coordinated attempt to recover these data was highlighted. Creating an archive of all data in suitable format for use by modellers was seen as an important goal, and the vital need for detailed and credible metadata was also noted. These metadata are particularly important given the changes that have occurred in methods of observation since the first scientifically useful notes were made in 1553. Further work was also needed to quantify trends in sea-ice cover and to identify the mechanisms by which sea ice responds to climate forcing. Almost inevitably, the workshop extended the

discussion to include the importance of sea-ice thickness measurements and the need for more data on historical changes in this parameter, which could then be related to changes in ice edge position. There is a need for modellers to develop and improve formulations of processes that are presently observed but that are not (or only crudely) included in global models. Among the examples are polar boundary layer processes, katabatic winds, coastal polynyas, tidal forcing of sea-ice, thermobaric effects, and deep convection chimneys. In addition, research on the assimilation of sea-ice data into models, including both stand-alone sea-ice models and coupled models, should be a priority in response to the need for homogeneous and integrated datasets in efforts to evaluate and diagnose recent changes in the Arctic system. A full report is nearing completion and will be published soon. A special issue of Polar Research covering conference results will be published in June 2003. Following on from three days of rigorous discussion, the mini-conference provided some scientific highlights of recent research in the Barents Sea region. This included presentation of some new databases, work on Barents Sea modelling, results from lake sediments, and even some data from shell deposits in Russia that show the effect of tides thousands of years ago when Norway and Sweden were an island. The workshop and mini-conference were sponsored by ACSYS/CliC, Météo-France, the Office of Naval Research (USA) International Field Office, the National Ice Center/National Oceanic and Atmospheric Administration (USA), the Norwegian Polar Institute and the Arctic Climate Impact Assessment (ACIA).

Workshop on Determination of Solid Precipitation in Cold Climate Regions

Over fifty participants representing 13 countries attended a very successful CliC/GEWEX/GCOS Solid Precipitation Workshop (9-15 June 2002, University of Alaska Fairbanks, USA). CliC has identified solid precipitation as a topic of special focus in its Science and Co-ordination Plan, because of its special influence on radiation and energy budgets and hydrological cycle. As is known, accurate determination of precipitation over all regions that experience snowfall is particularly difficult. Dr B. Goodison (ACSYS/CliC) and R. Lawford (GEWEX/GAPP) therefore convened the workshop with the following objectives:

- to review the current status of measuring or determining precipitation, especially solid precipitation, in cold climate regions;
- to identify gaps and issues; and,
- to recommend actions that will allow us to determine precipitation over a range of time and space scales for use in climatological and hydrological analyses, regional water budgets, validation and process experiments, and models.

The session topics were: *Precipitation Measurement, Measurement Errors and Adjustment Procedures, Precipitation Data for Major Projects, Regional and Global Precipitation Analysis, and Precipitation Modelling and Model Validation*. The workshop summarised our current status and built on what we have learned from research projects such as the WMO Solid Precipitation Measurement Intercomparison, and the Global Precipitation Climatology Project (GPCP). There was a special effort to look at new approaches, including gridding, re-analysis, modelling, remote sensing, and methods for validation. There was a detailed discussion of the scientific agenda of the Global Precipitation Measurement (GPM) Mission and especially its ability to determine solid precipitation. The workshop programme and the abstracts for all the presentations are available at: http://acsys.npolar.no/meetings/precip/ws.htm. The proceedings for the workshop will be published by WMO/WCRP in 2003, including recommendations regarding the scope of future initiatives. In particular, co-ordination of the precipitation measurement issue was recognised as a major challenge. The ACSYS/CliC SSG supported the desire that the Global Precipitation Climatology Centre (GPCC) hosts a small workshop to discuss CliC needs, regions of interest, GPCC role, and data policy. A need for a Joint CliC/GEWEX/CLIVAR panel on precipitation, which could build logically on all existing efforts, such as through GPCC and GPCP, has to be explored. Sponsorship of the workshop by WCRP CliC and GEWEX projects; GCOS; Meteorological Service of Canada; NOAA Arctic Research Office and NOAA/NASA GEWEX Americas Prediction Project; and the International Arctic Research Centre and the Water and Environmental Research Centre (both at the University of Alaska Fairbanks) is gratefully acknowledged.

The JSC concluded that the newly formed Observational Council should address the need for a Pan-WCRP Precipitation Panel.

Workshop on Measurements and Models of Arctic Ocean Circulation

A workshop on Measurement and Modelling of the Arctic Ocean Circulation, sponsored by ACSYS/CliC and the IARC, drew 52 participants to the Lamont Doherty Earth Observatory, Palisades, New York, USA, 17-20 June 2002. Chaired by Professor P. Schlosser, the general aim of the workshop was to improve the contact between the modelling and observing communities by providing a platform of

discussion and exchange. Workshop sessions covered basin-scale observation and modelling, shelf-basin interactions, ocean/sea-ice/atmosphere interaction, and observing system design. Overview presentations were followed by group and plenary discussions.

Significant progress has been made over the last few years, and a “qualitative” picture of the Arctic Ocean circulation structure is emerging with a system of currents consisting of interconnected gyres in different basins. However, significant gaps in observations and significant differences between individual model results make model-observation comparison difficult. Models indicated significant time variability of the structures, and the low spatial and temporal resolution of observations therefore hampers model validation. Quantitative estimates of the mean transport associated with the circulation branches are only available at a few locations, such as Fram Strait, Bering Strait, Barents Sea, and to some extent the Canadian Archipelago and the Lomonosov Ridge. Less is known about the variability of the transport, both in magnitude and pathway, especially at decadal time scales. The causes of the circulation structure and its variability are also still poorly known, and, although there has been improvement in topographic information, further process studies are still required. Therefore, future measurement programmes must be long enough and of sufficient time resolution to allow separate identification of different processes, and this argues for a balance of moored instruments, hydrographical and geochemical surveys using ships, submarines and autonomous vehicle, and remote-sensing techniques. The use of floats and tracers offer methods for estimating circulation parameters, but both require further technique development. Data management issues were also highlighted as of concern. Improved data management is needed to make the measured data available to the research community (both observational and modelling). It was noted that existing data could be better exploited. For example, available atlases are not used as widely as expected. Model intercomparison efforts such as the Arctic Ocean Model Intercomparison Project (AOMIP) should yield useful information for defining model attributes and design of experiments that would be well suited for comparison with observations, but the models have to make appropriate output available in a form that is more amenable to direct comparison with observations, e.g. sections at the location of the measurements. A full report of the meeting is being prepared at the Lamont Doherty Earth Observatory.

Workshop on Sea-ice Thickness Measurements with Ice Profiling Sonars

In the light of concern regarding sea-ice thickness measurements, ACSYS/CliC organised an invitations-only, expert meeting on quality control of ice profiling sonar (IPS) measurements. The meeting was hosted by the IACPO at the Norwegian Polar Institute in Tromso, Norway, on 1-3 July 2002, with all leading IPS operators represented. The workshop, chaired by Professor K. Steffen and sponsored by the Met Office, UK, had overall goals to develop a framework for the processing, quality control, archiving and publication of all previously collected moored IPS data, and to examine methods that might facilitate the timely publication of high quality IPS data in the future. Mooring and data collection problems and solutions were discussed, and error sources were documented. New protocols for processing and archiving data were also agreed. The workshop participants agreed to release approximately 60-years of IPS data from Arctic and Antarctic regions to be archived at the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado. Further, an IPS inter-comparison programme was proposed to test different instruments under various conditions and to study the sensitivity of the different data processing algorithms to various environmental conditions. Also, additional theoretical work was identified, which was crucial in the study of under-ice morphology with synthetic IPS data. A detailed workshop summary will be published as a WCRP technical report in the near future.

7.3 ACSYS/CliC co-ordination and panel activities

ACSYS and CliC activities are co-ordinated by the ACSYS/CliC Scientific Steering Group (SSG), with support from its Numerical Experimentation Group (NEG, http://www.cccma.bc.ec.gc.ca/acsys/), Observation Products Panel (OPP), Data Management and Information Panel (DMIP), and the International ACSYS/CliC Project Office (IACPO). In addition, a joint CLIVAR/CliC Southern Ocean Panel and an *ad hoc* Panel on Polar Products from Re-analysis (PPPR) provide further input to the project.

ACSYS/CliC Scientific Steering Group (SSG)

The third ACSYS/CliC SSG session was held in Beijing, China, on 21-25 October 2002, with excellent support provided by local hosts the China Meteorological Administration. A joint meeting of the OPP and NEG was held in Yokosuka, Japan, 9-12 September, 2002.

Numerical Experimentation Group (NEG)

At its meeting in Yokosuka, the NEG reviewed progress in the second Sea-ice Model Intercomparison Project (SIMIP2), aimed specifically at sea-ice thermodynamics. Only three groups were actively participating. Shortcomings in the forcing data set had been identified (particularly related to snowfall and oceanic heat flux). These were being addressed and broader participation in the project was being solicited. To stimulate further interest, a small 1-day workshop on SIMIP2 is planned in conjunction with the next NEG meeting.

An ad hoc meeting to discuss an Ice Sheet Model Intercomparison Project was organised by Professor P. Huybrechts in August 2002, and strong interest was expressed by the ice sheet modelling community. There was particular interest in a project focused on grounding line processes and higher-order 3-D models. A small planning workshop is planned for 2003 to establish the experimental protocol and schedule. A larger 'wrap-up' workshop will likely be held in three years.

The NEG initiated a discussion of permafrost modelling, with reviews of observations, process modelling and climate model inferences about changing permafrost regimes. It was decided that the NEG would pursue the idea of a workshop in approximately a year to bring together researchers involved in process studies, in-situ and remote-sensing observations, and small- and large-scale modelling.

The NEG was updated on progress being made in the Arctic Ocean Model Intercomparison Project (AOMIP) and the Arctic Regional Climate Model Intercomparison Project (ARCMIP), which was developed jointly with GEWEX. In addition, Dr F. Bryan from NCAR was invited to give an overview of the WCRP Working Group on Ocean Model Development (WGOMD) and in particular the Ocean Model Intercomparison Project (OMIP). Subsequent discussion indicated common interests in protocols and forcing data for global sea-ice and ocean model intercomparisons, and diagnostic projects related to polar oceans and their ice cover.

ACSYS/CliC Observation Product Panel (OPP)

The two main topics discussed at the OPP session in Yokosuka were ice sheets and snow cover. The meeting aimed to: expand observational product review relevant for model validation and verification to the global scale with emphasis on Southern Hemisphere and mid-latitudes; review observational products from in-situ and remote sensing sources for snow surfaces (terrestrial and oceanic); review ice sheet observational products relevant for model validation and verification, including Greenland and Antarctica; and, discuss strategies for future cryospheric observations in support of model evaluation and process studies.

Data Management and Information Panel (DMIP)

DMIP activities have focused in four areas since the last combined panels meeting in 2001. They are:

- continued and expanded coordination with data management activities of WCRP programmes, world data centres and ACSYS/CliC related national scientific projects;
- wrap-up of ACSYS Project;
- ongoing support for DMIP related activities through IACPO including the ACSYS Data and Information Service (ADIS); and
- the development of a consistent data management strategy to support CliC.

DMIP continues to work on an ACSYS and ACSYS-related dataset catalogue that will be available by the time of the final ACSYS Conference in 2003. A number of additional ACSYS datasets have been identified and will be added to the catalogue listing. IACPO continues to support the ACSYS Data and Information Service (ADIS) serving as a focal point for information about ACSYS data and as a source for locating related project information. The URL is http://acsys.npolar.no/oelke/adis.html. The current strategy for ACSYS data management is to physically locate ACSYS data with existing national and global data centres wherever possible, with attendant activity to provide metadata information and links via the ADIS. A similar strategy would clearly be necessary for CliC and this should take place through expansion of the ADIS activity. There is a need for a DMIP meta-database providing information on model data archives (including re-analysis archives) relevant to ACSYS/CliC. Gathering of the metadata will be done by a suitably defined questionnaire. The work to support ADIS as well as to expand capabilities in support of CliC, does require more capacities in IACPO. DMIP, project office management and the ACSYS/CliC SSG are working together to increase resources available for data management support activities.

A Data and Information Service for CliC (DISC) that provides a clearinghouse of project related information and metadata is an important new focus. How best to organise this system to complement existing World Data Centres and take advantage of growing international data and metadata interoperability standards will be a focus of the next DMIP Panel meeting.

Panel on Polar Products from Re-analysis (PPPR)

The work of the ACSYS/CliC Panel on Products from Re-analysis (PPPR) had focused on developing momentum for an Arctic System Reanalysis (ASR) to be conducted under the US Study of Environmental Arctic Change (SEARCH) programme and on validation of output from the ECMWF ERA-40 reanalysis. The groundwork for an Arctic regional reanalysis can now be performed by capitalising upon ongoing efforts such as ERA-40 and NCEP's North American Regional Reanalysis (NARR). Part of the ASR development strategy is the ongoing, careful validation of the output of these two re-analysis efforts. These efforts will identify the strengths and weaknesses of each model, setting "benchmarks" to be met or beaten by the ASR and will point to model attributes that could be transferred to the ASR. The combination of the evaluations, developments and sensitivity experiments are intended to set the stage for a full Arctic System Reanalysis in the time frame of 3-5 years. The effort will entrain investigators from a broad cross section of the Arctic community and from established modelling groups, creating the critical mass of expertise needed to make the ASR a flagship activity of SEARCH. NOAA has provided significant seed funding towards the development of the ASR.

Validation efforts to date have largely focused on ERA-40, with particular emphasis on aspects of the moisture budget. Based on analysis of several years of ERA-40 output from a pilot run, patterns of the vapour flux convergence from ERA-40 for both the Arctic and Antarctic are similar to those from ERA-15 and NCEP/NCAR. ERA-40 provides greatly improved Arctic precipitation forecasts relative to NCEP/NCAR, but performance is little better than ERA-15. ERA-40 tends to overestimate precipitation over the Arctic Ocean. This may be related to a cold tropospheric bias noted over both the Arctic and Antarctic, which was traced to problems in cloud clearing TOVS data. The problem was subsequently addressed by ECMWF.

International ACSYS / CliC Project Office (IACPO)

The IACPO has continued to be supported by the Norwegian Polar Institute (which also hosts the office), the Japan Marine Science and Technology Center, and the Norwegian Science Council. During 2002, significant additional funding for the office was provided by the Met Office, UK, which made it possible to announce a vacancy at the IACPO with a view to maintain and further develop ACSYS/CliC data services. However, this position is not fully funded, and further support is still needed.

In addition to work on the major issues, priorities and highlights, IACPO has continued to publish the "Ice and Climate" Newsletter and to support and develop websites for ACSYS and CliC, as well as setting up the Arctic/Subarctic Ocean Fluxes (ASOF) Array website (now maintained through the International CLIVAR Project Office). The CliC website has been recently renovated and re-organised.

The resources of the IACPO need to be sustained and augmented for the successful development of a major project such as CliC. JSC members were asked to consider, or identify, possible ways of further supporting the office financially or through secondments and other means.

7.4 Progress in ACSYS programmes

ACSYS activities contribute to progress in five programme areas, addressing Arctic oceanography, hydrology, atmospheric and sea-ice sciences, with the final area addressing studies in modelling the interactions between these components.

Arctic Ocean Circulation Studies

In addition to the Measurements and Models of Arctic Ocean Circulation workshop and ongoing modelling efforts, the past year has seen various activities related to ACSYS objectives. Ship cruises took place to study the boundary currents in the Arctic Ocean basins by the Mendeleyev Ridge and Chukchi Borderland Project, and to study the Laptev Sea slope by the Nansen and Amundsen Basins Observational System project. In the framework of the SEARCH project, a hydrographical survey towards North Pole Environmental Observatory was carried out by aeroplane. In the Nordic Seas a joint effort of RVs ODEN and KNORR covered the Greenland Sea. In the Fram Strait surveys were again carried out by LANCE and POLARSTERN with CTD measurements and moored instruments, while measurements in the Canadian Arctic Archipelago and Bering Strait were also made in the framework of the ASOF Array. Repeat surveys of

water masses from Storfjord in Svalbard, both in the fjord itself and its vicinity, (R/Vs ODEN, KNORR, LANCE and POLARSTERN) detected that significant formation of dense water masses occurred in the Storfjord during winter 2001/2002, and the signature of descended water masses was found in the deeper part of the continental slope in the Fram Strait.

The ASOF Array programme (see http://asof.npolar.no) aims to monitor and understand the oceanic fluxes of heat, salt and freshwater into and out of the Arctic Ocean and Nordic Seas, and their role in controlling the global thermohaline circulation and climate. A co-ordinated, circum-Arctic ocean flux monitoring system is planned to provide long-term measurements.

ACSYS Sea-Ice Programme

ACSYS has had significant involvement in Arctic sea-ice studies during the year, through its workshops on sea-ice extent and ice profiling sonar measurements and its report on sea-ice thickness. It has also had input to successful proposals for CryoSat calibration/validation activities and the extension of synthetic aperture radar monitoring of the Arctic pack ice, and also publication of the ACSYS Historical Ice Chart Archive. Scientific highlights include publication assessments of passive microwave data from satellites that show not only a retreat of Arctic sea ice (by 2 to 3% per decade over the past 20 years), but also rapid decline in Arctic multiyear ice (by 6 to 9% per decade). A record minimum Arctic sea-ice extent and area were also observed in 2002, pointing to further removal of multiyear ice. Warm southerly winds from Siberia in spring, and persistent low pressure and high temperatures in summer have been suggested as the cause. Over broad areas, a simple model of ice thinning related to the number of melt days during a summer may be applicable, but further verification of this model's utility may be required.

ACSYS Hydrological Cycle Programme

The ACSYS/CliC/GEWEX/GCOS workshop on Solid Precipitation was a significant contribution to this programme. In addition, two ongoing activities for the ACSYS project have been the maintenance of the ACSYS Precipitation Data Archive (APDA) as an activity of the Global Precipitation Climatology Centre (GPCC) at the Deutscher Wetterdienst in Offenbach, Germany, and the ACSYS Run-off Data Base at the Global Runoff Data Centre (GRDC) in Koblenz, Germany. Drs B. Rudolf and T. Maurer, the directors of the GPCC and GRDC respectively, have both agreed to the continuation of the special ACSYS data collections as CliC activities following the completion of the ACSYS project. Both data centres will face new challenges in trying to serve the needs of CliC. High latitudes and mountains are the most difficult regions for precipitation analysis.

In other activities, the PILPS-2e Arctic Hydrology Model Intercomparison, a joint ACSYS and GEWEX project, has been completed in the Torne-Kalix River Basin.

The proposal to initiate an 'Arctic-HYCOS' as the Arctic component of the World Hydrological Cycle Observing System (WHYCOS), has been discussed by both ACSYS/CliC and GEWEX SSGs. Both projects have given tentative backing to the proposal, but indicated that further development is still needed. There is a need to contact the countries, and hydrological and meteorological services that may be involved, consider establishing an international steering team, and to discuss the project further with the Arctic Monitoring and Assessment Programme (AMAP) and through AMAP with the Arctic Council. Co-ordination with WMO Hydrology and Water Resources Department and the Global Terrestrial Network – Hydrology (GTN-H), the Arctic CHAMP (Community-wide Hydrological Analysis and Monitoring Program), and other initiatives in the area of Arctic hydrology, may be required. The WMO Hydrology and Water Resources Department and AMAP were involved in the project proposal preparation, and should now be involved in its further development.

7.5 ACSYS/CliC related programmes

The International Arctic Buoy Programme (IABP)

The International Arctic Buoy Programme (IABP, http://www.iabp.apl.washington.edu) is an Action Group of the WMO/IOC Data Buoy Co-operation Panel. Drifting buoys in the Arctic Ocean, contributed by 18 organisations from 8 countries, provide real-time meteorological and oceanographic data to the WCRP and the WMO World Weather Watch (WWW) for use in climate and climate change research, forecasting weather and ice conditions, validation of remote sensing, and tracking of ice motion. IABP "Participants" strive to maintain an array of at least 25 buoys evenly distributed across the Arctic Basin providing surface air pressure and surface air temperature to the WMO Global Telecommunications System (GTS). Data from

some of the IABP buoys are available only on the Internet. IABP participants are open to having additional sensors on their buoys, sharing deployments, and carrying out deployments for each other.

The current IABP problems are:

- having a well spaced array of data throughout the Arctic. At present only 7 buoys are on the Russian side of the Arctic. This is the most difficult area logistically and shortage of resources to maintain the array in that area is apparent;
- the need to put the IABP data on the GTS in timely fashion.

The WCRP International Programme for Antarctic Buoys (IPAB)

The WCRP International Programme for Antarctic Buoys (IPAB) was formally launched in 1995 to co-ordinate drifter deployments in the Antarctic sea-ice zone, to optimise buoy distribution over this region and to create a central archive of Antarctic buoy data. It is a self-sustaining project of the WCRP and an Action Group of the WMO/IOC Data Buoy Co-operation Panel. After initial launch as a five-year programme, in June 2000 the participants, with support from the WMO and WCRP, resolved to continue the programme indefinitely. Some 165 IPAB buoys have provided data (some - including more sophisticated meteorological data) to the programme between 1995 and 2002, mostly reporting through the WMO GTS. The complete data were also received and archived directly at the co-ordinating office (then in Hobart). The data for the period 1995 -1998 have been made available to the National Snow and Ice Data Center (NSIDC), Boulder, Colorado for public release: 1999-2000 data are now available for transfer to NSIDC. A number of difficulties are confronting the programme at present. Throughout its life, IPAB has lacked strong support from operational meteorological agencies, and the majority of IPAB buoy deployments are made to support specific research programmes, mostly designed as short-term projects. This is despite previous recommendations from both WMO and SCAR, and recognition of the positive impact of the buoy data on the Southern Hemisphere synoptic analyses (particularly in the South Pacific sector). In addition, partly because of changing communications systems (not all buoy data are now transferred via Service Argos) it is no longer possible to receive all data automatically at the IPAB co-ordinating office. Maintenance of the full IPAB research data set (as distributed via NSIDC) requires more regular interaction with buoy operators. Finally, the fourth meeting of IPAB participants has been twice postponed. However, the number of buoys deployed in support of the programme has remained fairly constant with time, and deployments in 2002 have actually increased over the last two years. Despite IPAB deployments, sea level pressure data in the Southern Ocean are still relatively sparse, and this has consequences for the interpretation of results of satellite gravity (e.g., GRACE) and altimetry (e.g., ICESat and CryoSat) missions, all of which are expected to contribute to knowledge of time-variability in ice sheet topography. In particular, the lack of data from the South Pacific region needs to be addressed. A periodic deployment of a buoy or automatic weather station on Peter the First Island would significantly enhance the coverage in this region, with immediate positive benefits for meteorological analyses, as well as improving the return from gravity and altimeter satellite missions, and filling a gap in a region where equator/pole teleconnections appear to be strongest. It is therefore recommended that WCRP seek a commitment for such a deployment by operators in this region.

In November 2002, a session of the WMO Executive Council Working Group on Antarctic Meteorology took place in WMO, Geneva. A representative of WCRP made a report to the session explaining the situation with IPAB. The group adopted a recommendation urging support to IPAB. It also expressed a need of deploying an atmospheric pressure and temperature sensor near Peter the First Island. Current measures undertaken by WCRP to solicit support for IPAB by operational agencies capitalise on this recommendation. They include preparation of a resolution on this subject by the forthcoming Executive Council of the WMO to be held in May 2003. Information on IPAB is also included in the report by the WCRP to the forthcoming 14th WMO Congress (May 2003, Geneva).

Other Projects in the Arctic Region

Two programmes in the Arctic region that will contribute to CliC goals are the Mass balance of Arctic Glaciers and Ice sheets in relation to Climate and Sea level changes (MAGICS) project (International Arctic Science Committee (IASC)), and the Program for Arctic Regional Climate Assessment (PARCA). MAGICS has initiated an international conference on Arctic Glaciology to be held in 2004 as a joint IASC and International Glaciological Society symposium. The PARCA programme has made significant progress in observing and understanding the Greenland ice sheet, including the observation of increased melt of 1% per year in concert with a warming of 0.24°C warming in 21 years, and discovery of a major ice stream in Northeast Greenland. The Greenland ice sheet appears to be thinning at the lower elevations and shows little change at the higher elevations, although significant regional variations have also been observed.

Other projects in the Antarctic Region

The Global Change and the Antarctic (GLOCHANT) Group of Specialists has been the main instrument by which SCAR has addressed many Antarctic topics of relevance to CliC over the last 10 years. This group was disbanded in 2002 with the reorganisation of the SCAR structure at SCAR XXVII. However, some of the key activities of GLOCHANT remain as Action Groups within the new SCAR Physical Sciences Scientific Standing Group. Relevant Action Groups now within the Physical Sciences SSG include:

- Ice Sheet Mass Balance and Sea Level (ISMASS),
- International Trans-Antarctic Scientific Expedition (ITASE),
- Antarctic Sea Ice Processes and Climate (ASPeCt) (see below),
- Reference Antarctic Data for Environmental Research (READER).

A number of other Antarctic projects and programmes are under way that contribute scientifically to the goals of CliC. CliC has links to many of these through members of ACSYS/CliC panels or groups.

International Antarctic Zone (IAnZone) is a SCOR affiliated programme, which seeks to understand the Southern Ocean and its role in climate change. Recent major activities for IAnZone have included continued planning for an international programme to study the processes by which water exits the Antarctic margins to ventilate the global ocean, and the continued co-ordination of the international Deep Ocean VEntilation Through Antarctic Intermediate Layers (DOVETAIL) programme (http://www.esr.org/dovetail).

The Cross-slope Exchanges at the Antarctic Slope Front (ANSLOPE) process study seeks to define the roles of the Antarctic slope front and continental slope morphology in the exchanges of mass, heat and freshwater between the shelf and oceanic regimes. The project is focussed on these issues primarily through an integrated field and modelling effort in the Ross Sea, where the shelf/slope region remains relatively accessible throughout the year and where dense water is known to form.

The Weddell Sea Convection Control (WECCON) study contributes to the understanding of the role of the open ocean convection in water mass modification and the formation of the Weddell Sea polynya. Exchange of multiyear moorings and a hydrographical survey were planned for summer 2002/03.

Since 1990 the Antarctic Sea Ice Thickness Project (AnSITP) has deployed 53 ice profiling sonars in the Southern Ocean to monitor sea-ice thickness variations. A high mooring loss rate and other instrument failures mean that data from only 27 instruments are available, some of them as partial records. The data can be found at http://www.awi-bremerhaven.de/Research/IntCoop/Oce/ansitp.html. Eight new moorings were planned for deployment in 2002.

ASPeCt is a SCAR programme studying physical sea-ice processes and ocean-atmosphere interaction in the sea-ice zone. Following publication of a CD on ice observation protocols and a tutorial on how to identify ice types in 1999, and work on a database of sea-ice (and snow) thickness observations, a database on sea-ice core physics, chemistry and biology is now being compiled. The sea-ice thickness database should be completed and published this year. Two studies of coastal polynyas have been completed - one in winter and one in summer conditions, and a drifting ice station in the Weddell Sea is being planned for late 2004.

7.6 ACSYS and CliC links to other programmes/activities

ACSYS/CliC – CLIVAR

Dr H. Cattle, the Director of the International CLIVAR Project Office (ICPO), was the former Chair of the ACSYS/CliC SSG. In addition to other existing links, this provides a solid foundation for further increase of co-operation between the projects. A joint CLIVAR/CliC Southern Ocean Panel has been formed. Enhancement of joint activities in the Atlantic sector is being sought, in particular in relation to ASOF, US SEARCH, joint interest in Arctic hydrographical sections and monitoring (including the peripheral Arctic seas and links to the thermohaline circulation). Other areas of co-operation include links between ACSYS/CliC NEG activities and the Working Groups on Coupled Modelling and Ocean Model Development. Potential joint interest between CliC and CLIVAR exists in studies of Asian-Australian Monsoon in relation to the role of the Tibetan Plateau. Both projects have links to GEWEX/CEOP. CliC, through ice studies, is expected to play an important role in palaeoclimate research and, like CLIVAR, provide fruitful collaboration with IGBP's PAGES. Both ACSYS/CliC and CLIVAR programmes are keen to benefit from receiving support to their data management activities.

ACSYS/CliC – GEWEX

Current co-operation with GEWEX includes contribution of CliC to the Co-ordinated Enhanced Observing Period (CEOP). Among GEWEX projects, GEWEX Asian Monsoon Experiment (GAME), Mackenzie GEWEX Study (MAGS), and the Baltic Sea Experiment (BALTEX) have a cryospheric component.

The effect of clouds and aerosols on the radiation budget in the polar regions still has the largest uncertainty, and because of this, the GEWEX Radiation Panel (GRP) recommends that efforts be devoted to comparing satellite products and field data in the polar regions. Given the robust dataset that the Surface Heat Budget of the Arctic Ocean (SHEBA) project provided, the Antarctic may need more attention than the Arctic. Noting, however, that as much as SHEBA has produced, it came too early for work with new satellite instruments such as MODIS, AIRS and AMSR, so additional Arctic observational data are needed. With SHEBA results now appearing in the scientific literature, the ACSYS/CliC steering group and the GRP are considering jointly sponsoring a workshop on Arctic and Antarctic clouds and radiation.

Precipitation remote sensing, another area of common interest with the GRP, still presents significant challenges, and there is a need for activity to compare methods of snow/ice remote sensing to field data. This includes not just snow on the ground but solid precipitation. With current field and modelling projects (e.g., BALTEX, MAGS, and GAME-Siberia) and new satellite instruments, CliC and GRP might also consider jointly sponsoring a workshop on snow processes and snow remote sensing, perhaps in conjunction with a clouds and radiation workshop.

CliC can help the GRP with the assembly of good field data for the validation of satellite products, while the GRP can assist with radiative fluxes needed by CliC. Since cryospheric studies tend not to emphasise cloud processes (including both radiation and precipitation), a joint workshop to emphasise radiation fluxes, clouds, and snow/ice remote sensing might be worthwhile. Relevant activities are considered by the GEWEX Cloud System Study (GCSS) Data Integration for Model Evaluation (DIME) working group No. 5.

ACSYS/CliC co-operation with GCOS and other partners

One of CliC's goals is the enhancement of observation and monitoring of the cryosphere. By this, CliC is mandated to contribute to the three global observing systems GCOS, GTOS and GOOS. It is therefore crucial that CliC observational requirements are reported to these observing systems, and to satellite operators and designers. CliC as a programme must be able to provide a globally coherent approach to specification of future cryospheric observations from space. To achieve this goal, CliC actively participated in the recent review of WCRP satellite data requirements.

At a meeting of GCOS/IPCC experts held in Boulder, USA, 12-14 August 2002, to prepare the Second Report on the Adequacy of the Global Climate Observing Systems, ACSYS/CliC SSG Vice-chair Professor R. Barry represented cryospheric components of the Terrestrial Observation Panel for Climate (TOPC). Status reports on three cryospheric elements were presented: glaciers and ice caps, snow cover, and permafrost. Freshwater freeze up / break up dates are additional high-priority parameters for the terrestrial system, and a further report has been prepared on this topic. A report on ice sheets is also in preparation. The Second Adequacy Report has now been prepared and is under review. In relation to the cryosphere the draft report indicates that:

- as a consequence of the contraction of in-situ observations there is an urgent need to develop optimal procedures to blend surface observations of snow with satellite and airborne data;
- glacier mass balance measurements need to be re-initiated in Patagonia, New Zealand, and Africa;
- the World Glacier Monitoring Service should assume an enhanced role for quality control, product development and dissemination.

Developments in the Global Terrestrial Network for Glaciers (GTN-G) including the World Glacier Monitoring Service (WGMS) and the Global Land Ice Measurements from Space (GLIMS) include studies of the glaciers mass balance around the world. There is a concern that limited financial resources present a threat to the operation of the WGMS.

The Global Terrestrial Network for Permafrost (GTN-P) includes the existing International Permafrost Association (IPA) Circumpolar Active Layer Monitoring (CALM) programme (http:/k2.gissa.uc.edu/~kenhinke/CALM/contents.html) and has expanded this to include a borehole thermal monitoring programme. Permafrost parameter descriptions were submitted as one of the cryosphere components for the Second Adequacy Report. There are now some 120 sites in CALM, mainly in the

Northern Hemisphere, with eight in the Southern Hemisphere. Some 360 candidate borehole thermal measurement sites have been identified, some of which are co-located with CALM sites, and a site metadata database is under development. A workshop (11-15 November 2002, Delaware, USA) focussed on analysis of spatial patterns of thaw from observation grids at several of the CALM sites, analysis of air and soil temperatures, and review and future plans of the CALM programme.

The establishment of the GTN-Hydrology (GTN-H) was initiated by the WMO Hydrology and Water Resources Programme and the GTOS TOPC. The GTN-H deals with ten hydrological variables relevant to climate change: surface water discharge, surface water storage fluxes, groundwater storage fluxes, precipitation, evapotranspiration, relative humidity, soil moisture, snow water equivalent, biogeochemical transport from land to ocean, sediment load at large river mouths. CliC will develop links to GTN-H for cold climate regions, and will work to specify its requirements for data from GTN-H more precisely.

An issue causing concern for CliC is which GTN takes care of snow (beyond snow water equivalent) and fresh water ice. Growing from this issue is the question of whether a specific cryospheric component of GCOS should be developed. CliC would support the idea of a Cryospheric Climate Observing System, and the last SSG session requested the Chair to contact GCOS on these issues.

The JSC recommended to pursue activities aimed at strengthening the cryospheric component of GCOS.

Co-operation between ACSYS/CliC and relevant components of IGBP (and IHDP), contribution to the ESSP projects

CliC is planning to develop collaboration with the IGBP Past Global Changes Project (PAGES), which includes ice core studies for palaeoclimate research. Adoption of the concept of Pole–Equator–Pole (PEP) transects by PAGES is being considered by CliC for modern latitude-altitude distributions of cryospheric variables.

ACSYS/CliC involvement in the ESSP Global Carbon Project may include studies of:

- the role of permafrost, snow and ice in carbon vertical fluxes;
- the potential increase of atmospheric greenhouse gas concentrations along with permafrost thawing;
- issues related to solubility pump activity in the Arctic, and less intermediate water mass production in the sub-Antarctic due to decrease in surface water salinity; and
- ice coring studies.

There is also significant potential for CliC to contribute to the emerging ESSP Global Water System Project in all its aspects connected to cold region hydrology.

8. STRATOSPHERIC PROCESSES AND THEIR ROLE IN CLIMATE (SPARC)

Professors A. O'Neill and A.R. Ravishankara, Co-chairs of the SPARC Scientific Steering Group, summarized the main recent developments in SPARC, including the principal items and recommendations from the tenth session of the SPARC SSG, held in Kyoto, Japan, 18-22 November 2002.

8.1 Modelling stratospheric effects on climate

8.1.1 Intercomparison of stratospheric models

The primary goal of the "GCM Reality Intercomparison Project for SPARC", GRIPS, is to improve the representation of the stratosphere in coupled global climate models. Major efforts had been made in collecting and summarizing the results of the first phase of GRIPS, an intercomparison of basic features of model stratospheric simulations. Findings have been published in the Bulletin of the American Meteorological Society and the Journal of Geophysical Research. The recent results were recently submitted to the Journal of Atmospheric Sciences. A project web site was established at: http://userpages.umbc.edu/~pawson/html_flies/grips.htm. At a workshop in Tsukuba, Japan, the participants agreed on a further distribution of tasks within GRIPS. The work continued at all three established levels of GRIPS. Among the tasks of level 1 - which aim to answer the question “How well do we simulate the present-day climate system?” - studies of sudden stratosphere warming events, atmospheric tides and travelling waves, computation of spatial wave number spectra are close to completion. Work was pursued on preparation of model documentation, generation of basic climatological data, troposphere-stratosphere connection and exchange, polar vortices, and Southern Hemisphere variability. Problems in studies of

transport modules were indicated. The level 2 tasks are aimed at developing parametrizations and studying model sensitivity to them. Simulation experiments on imposed mesospheric forcing were successfully completed. Progress was reported in experiments on the evaluation of gravity-wave drag schemes. Evaluation of corresponding radiation schemes and retrieval of gravity-wave drag data need attention. The level 3 tasks are aimed at studying the mechanisms by which various forcing factors control the atmospheric circulation and how they are represented in models. The experiments on intercomparison of model response to the Mount Pinatubo eruption conditions and on response to ozone trends are proceeding satisfactorily. At the same time, assessment of ozone related sensitivity faces uncertainties in perturbation levels and even the base state. Therefore one of the GRIPS Level 3 tasks should be to lead efforts to resolve existing uncertainties in time for the next WMO-UNEP and IPCC assessments.

The year 2003 is seen as the right time for completion of GRIPS level 1 and level 2 tasks. A GRIPS workshop was expected to take place in March 2003 in the Washington DC area. It is important to support further studies of GRIPS level 3 tasks, which would require forcing simulation by complex models and would focus on climate – atmospheric chemistry interactions. The experience of model intercomparisons in the WCRP is very valuable, particularly under the auspices of the Working Group on Numerical Experimentation (WGNE) and the Working Group on Coupled Modelling (WGCM). Relationships of SPARC and GRIPS with these groups need to be maintained and strengthened. SPARC, and specifically GRIPS, should co-ordinate future efforts in forthcoming ozone and related climate change assessments, mostly concerning water vapour, column ozone, aerosol and solar cycle effects.

8.1.2 Stratospheric reference climatology

In December 2002, a compilation of middle atmosphere climatological data sets was ready to be published as a SPARC technical report. The title is "SPARC Intercomparison of Middle Atmosphere Climatologies". The reference climatology group was able to combine 12 different data sets. The inclusion of rocketsonde and lidar data into the data intercomparisons allowed the extension of the climatology of temperature and winds up to the middle mesosphere. Despite significant difficulties (due to the scarcity of rocketsonde and lidar sites, the non-simultaneity of the data sets, discontinuity in the rocket series), the work was successfully completed. The group was able to include the ERA-40 re-analysis from ECMWF into the data intercomparison.

8.1.3 Stratospheric data assimilation

A SPARC initiative in data assimilation has started to develop. Besides its other uses, data assimilation is seen by SPARC as the most efficient technique to obtain global quality-controlled, internally consistent data sets of the dynamical and chemical state of the stratosphere. The state-of-the-art was discussed at the first SPARC data assimilation workshop that took place in Catonsville, Maryland, USA, 10-12 June 2002. The workshop was hosted by the NASA/Goddard Space Flight Center Data Assimilation Office and the University of Maryland Baltimore County. Participants from 16 research groups gave presentations on stratospheric data assimilation techniques, data intercomparisons, constituent satellite data, reconstruction of potential vorticity, assimilation of ozone and chemical composition data.

As a result of the above efforts the SPARC Data Assimilation Working Group was formed. Its meetings are anticipated on a yearly-basis. The group's plans are:

- to collect information on availability, quality, formats, reading software and documentation for stratospheric meteorological data sets that can be used in the intercomparisons;
- to perform process-focused quality assessments of stratospheric meteorological data;
- to collect, validate, and intercompare chemical assimilated data,
- to collect information on chemical transport model (CTM) and GCM assimilation systems.

8.2 Long term changes in the stratosphere

8.2.1 Stratospheric temperature trends

The objectives of the first phase of SPARC activities in this area were the intercomparison of various relevant data sets (radiosondes, lidars, rocket-sondes, satellite measurements etc.) containing temperature values, assessment of the temperature trends apparent in the lower stratosphere and up to the level of the mesosphere, and evaluation of the extent to which these trends could be explained by specific causes. The first phase has been completed. Its results were reported at previous sessions of the JSC and a summary of the work published in Reviews of Geophysics in February 2001. The findings were an important input to the IPCC Third Assessment Report and the WMO 2002 ozone assessment.

The Temperature Trend Assessment report has been delayed in order to include the data on seasonal variations, but will be completed soon under NOAA-SPARC auspices. In the meantime, the temperature trend record continues to be updated. A comparison of the stratosphere temperature trends for the periods 1979-2000 with the previous 1979-1994 SPARC studies was made. A significant and clearly seen temperature trend was reported for the summer 50 hPa series at 70°N. A new focus has been on observed seasonal trends (winter/spring versus summer) and on understanding the causes of global-mean trends, in particular, the role of trace gases changes (ozone, greenhouse gases, and water vapour) in generating the trend. The results demonstrated that model simulations had a tendency to underestimate observed stratospheric cooling. Winter anomalies showed some variability of unknown origin. Preliminary projections of 50 hPa temperature variations up to the year 2020 indicated the relative signs and amplitudes of the variations under the different forcing mechanisms. Another area of intensive research was focused on transient experiments aimed at explaining observed annual variability. The simulations included effects of aerosol variations, chlorine and bromine concentration variations, and solar radiance. A Heraeus Seminar on trends in the upper atmosphere co-sponsored by SPARC and SCOSTEP was held in Kühlungsborn, Germany, in May 2002. This seminar showed the difficulty encountered in the determination of trends in these upper layers due to the lack of long series of data and indicated that further work is needed. The updated trend detection in the upper mesosphere using all the rocket data should be available soon.

8.2.2 Ozone trends

Most of the effort of the ozone trend community went into the Ozone WMO-UNEP Assessment 2002. An important milestone in this work was a SPARC/IOC (International Ozone Commission) workshop on understanding of ozone trends, held at the University of Maryland, on 7-9 March 2001. The main aims of the workshop were to identify the major current issues concerning ozone trends, to improve quantification of the contributions and uncertainties of the chemical and dynamic mechanisms to observed ozone trends, particularly at mid-latitudes and to identify how to assess the consistency of these proposed contributions. The main emphasis was on the dynamical influence on the ozone trends. Consideration of the ozone changes suggested that a cooler stratosphere would act to prolong ozone recovery. Nevertheless, ozone is likely to recover in the next 50-100 years because of the decline in the halogen loading due to the Montreal Protocol and its amendments. To move forward on the issue of Arctic ozone, a workshop on Arctic Ozone Loss was organised at the Alfred Wegener Institute in Potsdam, Germany from 4-6 March 2002. The relevance of this workshop to the Assessment is related to the fact that the two chemical, ozone-depletion processes about which there is most confidence are the high-altitude and polar-ozone losses, together with the subsequent impact on mid latitudes. About seventy scientists attended the workshop.

8.2.3 Indices for Antarctic ozone depletion

At the SPARC SSG meeting in November 2001, there was discussion on the need to assess the different indicators used to describe the interannual variability of the size, intensity and duration of the Antarctic ozone hole. The aim was to develop a small set of agreed indices that could be used to describe the ozone hole variability and its expected future recovery. There was a similar discussion during the preparation of the WMO/UNEP ozone assessment report. At the SPARC SSG meeting of 2001, D. Karoly agreed to co-ordinate a small working group that would undertake this project. M. Profitt of the WMO has prepared a list of possible indicators. This list gives an idea of some different indices that are being used at present. The SPARC SSG decided on a smaller set of agreed indices of key aspects of the ozone hole such as size (area), intensity (mass deficit, minimum column ozone, etc.) and duration (date of break-up). A short paper in a refereed journal will be produced.

8.2.4 SPARC aerosol assessment

Aerosol in the upper troposphere/lower stratosphere can have a significant impact on climate through radiative effects and on stratospheric chemistry, particularly on ozone. Accounting for aerosol effects properly is a key component of modelling climate/chemistry effects properly. As reported to the previous meeting of the JSC, a detailed SPARC Assessment of Stratospheric Aerosol Properties (ASAP) was being planned to advance the scientific understanding of upper tropospheric/lower stratospheric aerosols and to critically consider available aerosol measurements. The assessment is under way now, led by L. Thomason and T. Peter. It was initiated with a workshop in Paris, France, 4-6 November 2001. Five project areas (assessment chapters) were identified, namely: aerosol processes, precursor gases, aerosol record, trend analysis, and modelling. The various chapters are in different stages of preparedness, but the outlines have been developed, most of the data collected, and the writing has started. An intermediate result of the work would be a 20-year long, gap-free, higher spatial, temporal and spectral resolution data set. It will be available at the SPARC Data Centre. The authors have identified gaps in source gas distributions, poor quality of model

transport, and sparseness of stratospheric profile measurements of some constituents. Overall, the study is progressing at a good pace.

8.3 Stratospheric processes

8.3.1 Gravity wave processes and their parametrization

The SPARC Gravity Wave (GW) Initiative has two main goals: to produce a global climatology of the gravity wave field in the middle atmosphere using high-resolution radiosonde observations, and to improve the parametrization of GW processes in climate models. The Darwin Area Wave Experiment (DAWEX) is designed to characterize the wave field in the middle atmosphere over northern Australia, which is excited by intense diurnal convection known locally as “Hector”. Participants from 13 countries are involved. The experiment included three five-day intensive observation periods during which there were three-hourly radiosonde observations from three north Australian locations. In addition, ground-based air-glow imagers provided by groups in Japan and the USA, radars to monitor winds in the mesosphere and lower thermosphere and a Doppler radar (from the Australian Bureau of Meteorology) were deployed. The meridional and seasonal dependence of the potential energy associated with gravity waves in the lower stratosphere was determined using high-resolution data. A workshop on DAWEX was held in Honolulu, Hawaii, 3-5 December 2002. The GW initiative will continue to be involved in planning of a much larger field experiment (Effects of Tropical Convection Experiment, ETCE) to study effects of Hector convection in 2005 or later. Future efforts will focus on reviewing existing data and encouraging appropriate new observational and modelling projects to characterise the spectrum of gravity wave momentum fluxes, including its geographical and seasonal dependence and its short-term intermittence. The aim will be to distil the available observational data and limited-area model results to provide as much guidance as possible for the formulation of source specifications and saturation mechanisms for parametrization schemes.

Further insight on the study of the gravity wave processes is expected from the VORCORE (“vortex core”) Experiment. The experiment will allow the study of the stratospheric Antarctic polar vortex core at the end of winter, when it is well isolated, up to its final breakdown. Together with VOREDGE (“vortex edge”), this experiment represents a part of the STRATEOLE experiment (a study of stratospheric dynamics and ozone chemistry in the Southern Hemisphere by a set of instrumented drifting balloons). The STRATEOLE experiment goal is a study of the dynamics of the stratospheric Antarctic polar vortex, the transport of minor constituents and its interaction with ozone chemistry in late winter and spring. The main element of the STRATEOLE observing system is a set of small super-pressurised balloons equipped with lightweight instrumented gondolas. In the course of VORCORE, 20 small super-pressurised balloons will be launched from McMurdo Antarctic Base during September - December 2004. The balloons will drift for about two-three months at two different constant density levels of about 50 hPa (13 balloons) and 70 hPa (7 balloons). The data will lead to a better understanding of the vortex core dynamics. It will make it possible to obtain estimates of 2-D turbulence (dispersion rates), evaluate intensity of subsidence inside the vortex core, derive infrared radiation budget and study vertical fluxes of energy, detect sources of Antarctic gravity waves observed in the vortex. It is hoped that the Envisat observations will complement the data set.

8.3.2 Lower stratospheric/upper tropospheric processes

In the transition region between the stratosphere and troposphere the separation in time and space of chemical, radiative and dynamical processes is not feasible. A strong coupling between them exists there. The key characteristics of this part of the atmosphere are the very low temperatures, large vertical gradients and rapid variations of water vapour, ozone and other species. Understanding the processes is essential in evaluating lower stratospheric/upper tropospheric interactions, the role of the stratosphere in climate, and in the projection of long-term changes in ozone. The recent studies in SPARC showed that the decreases of ozone content were observed mostly in late spring / summer and were accompanied by the ozone build up in winter / early spring. Dynamical variability was certainly playing a role in this pattern, which was confirmed by the fact that ozone variations were associated with the Arctic Oscillation - type changes and variations in the tropopause height. The causality of these relationships was unclear. The anti-correlation of tropopause height changes and ozone changes up to 20 km is not understood, and furthermore the long-term ozone changes below 20 km are not yet well known. This indicates a need to focus studies on the mechanisms governing relations between ozone, dynamics and radiation in the lowermost stratosphere.

8.4 Other scientific issues

8.4.1 Dynamical coupling of the stratosphere and troposphere

Interesting results on the coupling between the stratosphere and the troposphere have been recently obtained by SPARC scientists. M. Baldwin showed evidence of the apparent downward propagation of anomalies from the stratosphere to the troposphere, implying that knowledge of the state of the Arctic Oscillation in the stratosphere could increase predictive skill for the troposphere. The analysis of the composites of weak and strong vortex regimes revealed that surface pressure anomalies after stratospheric events look like the Arctic Oscillation signatures. Examination of Arctic Oscillation persistence in winter and summer showed that winter signatures of the Arctic Oscillation were more persistent. Similar behaviour was characteristic for the annual variability in the stratosphere and could be traced in the troposphere. This apparent influence of the stratosphere on the troposphere could be a factor in increasing the predictive skill of atmospheric general circulation models.

These and other related questions will be the focus of attention at a workshop “The Role of the Stratosphere in Tropospheric Climate”, which is being organised in Whistler, British Columbia, Canada, 29 April-2 May 2003. More than 60 scientists and students are expected to participate.

There is an opinion that the SPARC/WGNE project on stratospheric predictability should be extended to include tropospheric predictability. The role of the stratosphere on tropospheric deterministic forecasts would be the desired focus of the SPARC/WGNE initiative. At the same time, the role of the stratosphere in statistical dynamic climate prediction on a variety of time scales is also a relevant theme. These thoughts will be discussed at the workshop in Whistler.

8.4.2 Chemistry-climate interaction

A significant proportion of both the IGBP International Global Atmospheric Chemistry (IGAC) and SPARC research agendas have their ultimate application in understanding chemistry-climate interactions. At the JSC-XXIII a need for a joint programme between SPARC and the IGAC Project was substantiated. This joint activity was felt as a natural progression of previous activities. Previous discussions indicated the major topics and most significant research interests for this joint activity. The IGAC community was given an opportunity to look at these issues and topics and decide on their interests at the IGAC symposium in Crete on 18-25 September 2002 where the SPARC Co-chairs were requested to make a presentation. The idea of having a joint initiative created enthusiasm and about 100 participants attended the evening SPARC/IGAC meeting. More than 20 proposals were put forward as potential joint research topics. The major conclusions of the meeting were as follows:

- the WMO Global Atmospheric Watch measurements are very useful
- satellite measurements of trace gases and aerosols need to be integrated with climate studies
- expertise of SPARC in stratospheric gas-particle interactions is an important asset in fundamental understanding of chemical and physical processes of the interaction of tropospheric aerosols with gases, and cloud droplets
- regional impacts on global states are an issue (this includes dusts and industrial aerosols, biomass burning, volcanic emissions, Asian Brown Clouds). The problem of dusts from Africa and Asia is a critical issue
- there is a need to involve more meteorologists and experts in biospheric processes.

For future collaboration, it is essential to realise the new structure and operating principles of IGAC (IGAC-II). It will be organised around a set of scientific questions. Limited lifetime tasks will focus on specific scientific questions relevant to IGAC and IGBP. They will include a timetable of research activities with a completion date, a quality assurance and data plans. The data plans include: public access to data, providing a brief annual summary to the IGAG Scientific Steering Committee, and writing a peer-reviewed manuscript as a final product. IGAC nominated Drs. K. Law, D. Parrish and Professor Shaw Liu as liaison points for SPARC. Much is expected by IGAC from the joint SPARC/IGAC workshop on chemistry and climate. The SPARC SSG discussed this issue and highlighted the following high priority issues in the area of climate – chemistry interactions:

- the role of convection (both deep and warm) in controlling upper troposphere-lower stratosphere water vapour abundance and redistribution of chemical constituents (to be addressed jointly with IGAC);
- tropical tropopause layer and climate-chemistry interactions;

- a need to achieve greater confidence in projecting future polar ozone;
- the role of upper troposphere-lower stratosphere aerosol and clouds in chemistry, climate, and their interactions (to be addressed jointly with IGAC);
- a need for relevant laboratory studies (to be addressed jointly with IGAC);
- stratosphere-troposphere exchange (to be addressed jointly with IGAC).

To proceed further in the concrete planning, a joint workshop is being organised in Giens, France, 2-6 April 2003. Dr C. Granier and the SPARC Office will act as the local hosts. NSF, NASA, and NOAA from the USA, EU from Europe, and Academia Sinica from Taiwan are providing monetary support for this workshop. The ultimate aim of this workshop is to produce a white paper on the needs of Climate - Chemistry Interactions research.

The JSC welcomed the ongoing efforts in the joint IGBP/WCRP "Atmospheric Chemistry and Climate" initiative and supported the forthcoming efforts in this direction including the joint SPARC/IGAC Workshop in April 2003.

8.5 Development of SPARC scientific strategy

At its most recent session SPARC SSG had a long and active discussion of future SPARC directions. The group agreed that a new structure for SPARC was indeed required and that the three first "pillars", i.e. stratospheric indicators, processes, modelling should be modified to represent better the new goals. The session agreed to establish three basic research themes, which contained fundamental questions each of them being of interest to the "outside" world, i.e. to SPARC "customers".

The themes and questions are as follows:

1. Stratospheric chemistry and climate:
   - How will stratospheric ozone and other constituents evolve?
   - How will changes in stratospheric composition affect climate?
   - What are the links between changes in stratospheric ozone, UV radiation and tropospheric chemistry?

2. Stratosphere-troposphere coupling:
   - What is the role of dynamical and radiative coupling from the stratosphere in extended range tropospheric weather forecasting?
   - What is the role of the dynamical and radiative coupling in determining long-term trends in tropospheric climate?
   - By what mechanisms do the troposphere and stratosphere act as a coupled system?

3. Detection and attribution of past stratospheric changes:
   - What are the past changes and variations in the stratosphere?
   - How well we can explain past changes in terms of natural and anthropogenic effects?

An update of the SPARC brochure and of the SPARC web site in the light of these discussions will be needed in a near future. The JSC approved the new formulation of SPARC science goals.

8.6 Interactions with other programmes and activities

SPARC maintains strong links and interacts widely with a number of other groups and activities in WCRP (in particular WGNE and WGCM). Closer ties are needed with CLIVAR on the issues of predictability, GEWEX on studies of water vapour, hydrological cycle, and radiation, and ACSYS and CliC on utilisation of results of reanalysis in polar regions. Interaction with WGNE on data assimilation was considered essential. SPARC research has generated significant interest among satellite agencies. At the SPARC SSG in Kyoto (November 2002), representatives of the European Space Agency (ESA), USA National Aeronautics and Space Administration (NASA) and National Space Development Agency of Japan (NASDA) participated and gave extensive reviews of their respective programmes including development of dedicated sensors. ESA has offered SPARC a two-year research fellow position, which is intended to support the SPARC office and to extend research using Envisat data. An EU programme "Validation of International Satellites and study of Ozone Loss" (VINTERSOL) is of significant interest. SPARC and NASA sponsored a symposium "Climate change processes in the stratosphere and at the tropopause". The meeting was very successful and well attended. There are close links with the Committee on Space Research (COSPAR). A SPARC session was arranged at the 34th COSPAR Scientific Assembly, which was held jointly with the 2002 World Space Congress in Houston, Texas in October 2002.

Outside WCRP, especially noteworthy is the developing co-operation with IGAC of IGBP, particularly in coupled chemistry-climate problems, which will bring the two projects even closer together.

SCOSTEP (Scientific Committee on Solar-Terrestrial Physics) has initiated a project entitled CAWSES (Climate and Weather of the Sun-Earth System), which is expected to run from 2004 to 2008. The project will deal with mechanisms governing solar influences on climate, foster a scientific approach to understanding the short term ("Space Weather") and long term ("Space Climate") variability of the integrated solar-terrestrial environment. Attention will be paid to mechanisms through which the solar variability influences the atmosphere. Co-operation between SPARC and CAWSES is intended.

Other valuable partners of SPARC are the WMO Global Atmospheric Watch (GAW seasonal ozone bulletins are posted at the SPARC data centre and a small joint SPARC/GAW group is expected to define a series of key indicators of ozone hole), the Network for the Detection of Stratospheric Change, and the Integrated Global Atmospheric Chemistry Observations Project of the Integrated Global Observing Strategy.

Current European stratospheric research related to SPARC is extensive. The funding going into stratospheric research is significant with 23 of 31 projects in the 5th Framework Programme being directly linked to stratospheric issues. They were closely associated with major national programmes and related satellite observations. Five research clusters are covering UV radiation, aviation impact in the upper troposphere-lower stratosphere, global atmospheric measurements, ozone-climate interactions, stratospheric ozone loss. A sound basis for planning is created by past assessments of European Research in the stratosphere (1997, 2001), major field experiments such as (EASOE, SESAME, THESEO) and regular European symposia on stratospheric ozone.

Determining the wind fields in the equatorial stratosphere on a global basis is a challenging problem owing to the scarcity of in situ observations and the limited value of satellite-derived temperature in constraining the wind field at low latitudes. Current stratospheric meteorological analyses display much more significant deficiencies in the equatorial region than elsewhere on the globe. Recent developments in the technology of long-lived constant level balloons and new satellite instruments to be deployed in the next few years will allow for more complete observations of the stratospheric wind field. By the end of this decade, there will be a need for extensive validation field campaigns with a focus on low-latitude stratospheric wind. The SPARC SSG expressed a need for international co-ordination of such campaigns that should include conventional radiosonde observations and remote sensing observations, and also co-ordination of field campaigns with on-going data assimilation efforts.

8.7 The SPARC Data Centre

The SPARC Data Centre at the State University of New York at Stony Brook, supported by NASA, continues to assemble key stratospheric data sets in a readily accessible form. After the tragic death on 17 May 2002 of its chief scientist, Petra Udelhofen, who had been in charge of the centre operations for about 3 years, Xuelong Zhou has supported the centre since August 2002. Since its establishment in 1999, the number of data sets has grown rapidly, with many being available on line. The centre administrator is compiling a new user list and an update of the operating system of the centre computer is taking place. The website http://www.sparc.sunysb.edu / may be consulted for the full list of data sets available, and for information on access and downloading.

8.8 The SPARC office

The SPARC office continued its regular activities in 2002 (compiling and editing SPARC Newsletters, updating the SPARC mailing list, maintaining contacts with the SPARC community of scientists, organising various SPARC meetings, maintaining the SPARC home page, preparation of SPARC reports for publication). At the SPARC SSG meeting in Kyoto, the participants applauded the director, Professor M.-L. Chanin and the office staff, Ms C. Michaut and Dr Y. Koshelkov for their excellent multi-year support of SPARC activities. Continuation of the office operation in France after the retirement of Professor Chanin would depend on the continued provision of funding from French sources. However, this funding will cease in 2004 and so finding another home for the SPARC office is under way. Dr N. MacFarlane and Professor T. Shepherd, Canadian members of the SPARC SSG, are actively exploring opportunities for establishing the office in Canada. The prospects are encouraging.

8.9 Third SPARC General Assembly

The success of, wide interest in, and large attendance at both the First and Second SPARC General Assemblies (respectively in Melbourne, Australia, December 1996, and Mar del Plata, Argentina,

November 2000) have been reported to the JSC. The SPARC Scientific Steering Group is duly planning to arrange a Third General Assembly and has agreed to accept a kind offer to host the event in Victoria, British Columbia, Canada, on 1-6 August 2004. Active preparations are being led by Dr N. McFarlane. The programme committee is run by Professors Ted Shepherd and A. R. Ravishankara.

The JSC noted the preparations being made for the Third SPARC General Assembly and requested JSC members to help identify financial support for it.

9. CLIMATE MODELLING

The fundamental unifying and integrating theme in the WCRP is the development of comprehensive global models of the full climate system, pulling together and building on the results provided by the other supporting discipline-oriented WCRP projects. Such models are the fundamental tool for understanding and predicting natural climate variations and establishing projections of climate change. Activities in this area in the WCRP are centred round two main groups: the CAS/JSC Working Group on Numerical Experimentation (WGNE) and the (WCRP) Working Group on Coupled Modelling. The Chairman of WGNE, Dr K. Puri, summarized activities being undertaken under WGNE auspices concerned with the development of the atmospheric component of climate models, including a number of model intercomparison projects, the evaluation and intercomparison of surface flux fields produced operationally by NWP centres, reanalyses, and NWP topics of interest such as verification and comparison of precipitation forecasts and developments in ensemble prediction. Dr J.F.B. Mitchell, Chairman of WGCM, reported on the wide range of WGCM initiatives, notably the Coupled Model Intercomparison Project and organization of carbon-cycle experimentation (jointly with IGBP/GAIM) that were leading to steady progress in the development of fully coupled atmosphere/ocean/land/cryosphere models fundamental to WCRP.

9.1 Atmospheric modelling activities in support of WCRP

9.1.1 Organization of WGNE work

In view of their joint role at the core of the climate modelling effort in WCRP, close co-ordination was maintained between WGNE and WGCM. WGNE also worked in conjunction with GEWEX in the development of atmospheric model parametrizations and, in this respect, WGNE sessions were held jointly with the GEWEX Modelling and Prediction Panel. Liaison was also maintained with the SPARC GRIPS project (focussed on the intercomparison of model stratospheric simulations) and with the SPARC initiative on stratospheric data assimilation.

WGNE additionally had 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 underpinned many aspects of WGNE work and provided a strong impetus for the refinement of the atmospheric component of climate models. WGNE sessions duly included reviews of progress at operational centres in topics such as data assimilation, numerics, physical parametrizations, ensemble predictions, seasonal prediction, forecasting tropical cyclone tracks, and the verification of precipitation forecasts. A particularly strong area of collaboration was in the planning and development of THORPEX: A Global Atmospheric Research Programme.

9.1.2 Model intercomparison projects

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

Atmospheric Model Intercomparison Project (AMIP)

The most important and far-reaching of the WGNE-sposored intercomparisons was 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. AMIP, based on a community standard control experiment simulating the period 1979 – 'near present', was now reaching the end of its second phase (AMIP-II). Approximately twenty-five modelling groups had submitted simulations and much of the data from these runs were available for a wide range of diagnostic sub-projects. In addition to the standard runs, ensembles and runs at varying horizontal resolutions were being archived for specific research sub-projects. On the technical side, PCMDI now had a powerful open source software system which enabled efficient management of the voluminous AMIP data sets. An automatic system has been in place to organise simulations, perform extensive quality control, and

make the data accessible (via ftp) to interested users. Most importantly, the facility was able to rapidly provide a detailed diagnostic report on a model simulation.

Following the recommendation of the WGNE, an International AMIP Workshop was held in Toulouse from 12-15 November 2002. The WGNE-appointed AMIP panel served as the Scientific Organising committee which was chaired by Dr Peter Gleckler of PCMDI. A key decision made by the committee was to have a focus on innovative diagnostics and have a strong representation from the observational communities. Some key conclusions of the Conference included:

- despite limitations, the idealised AMIP SST experiment is still a powerful diagnostic test;
- a 'mean AMIP model' generally outperforms any individual model and is a useful reference;
- diagnostic subproject analysis has become an increasingly useful exercise;
- there was an encouraging synergism with the GEWEX modelling projects;
- there was strong support by conference attendees to see AMIP continue in some form.

The WGNE session immediately following the AMIP Conference discussed future directions for AMIP. The discussions included recommendations from an AMIP panel meeting held in Reading in February 2002 namely: comprehensive diagnostic reports should be made available to modellers soon after they submit a simulation to PCMDI; AMIP should be exploited as a diagnostic tool of the coupled system with WGNE and WGCM working towards integrating AMIP and CMIP; and process studies should become an increasing diagnostic focus. It was also noted that: (i) there was an external review of PCMDI in March 2002, which provided encouraging support for the continuation of systematically evaluating AMIP runs; (ii) diagnosis of coupled models was now a higher priority project at PCMDI than AMIP; and (iii) PCMDI would soon have a new director which would have a significant bearing on the future directions for the project. As with previous WGNE discussions on this topic and in line with the Workshop conclusions, WGNE continued to strongly support the continuation of AMIP as an experimental protocol providing an independent evaluation of atmospheric models and facilitating increasingly advanced diagnostic research. WGNE recommended that the AMIP panel should meet again to discuss and provide advice on future directions for the project.

The JSC expressed satisfaction at the successful AMIP-II Workshop and expressed continued strong support to AMIP while urging it to focus on innovative diagnostics. The JSC stressed that efforts should be made to include assessments of land-surface schemes in future AMIP activities and the usefulness to associate more closely the GEWEX community in the design and exploitation of future experiments. Noting the importance of AMIP, the valuable infrastructure developed at PCMDI for AMIP and the current uncertain funding support for AMIP, JSC urged that continued support be requested from PCMDI and that the prospects for alternative support be explored.

"Transpose" AMIP

Operational Numerical Weather Prediction has proven to be an excellent platform for examining parametrization methods as it allows direct comparison of the parametrized variables (e.g. clouds, precipitation) with observations early in the forecast while the modelled state is still near that of the atmosphere, but after initial transient computational modes are damped. Forecast centres report that such an approach is very useful in developing and evaluating parametrizations. Climate modelling groups not associated with an NWP centre generally have not been able to take advantage of such an approach because of the large amount of work involved in developing data ingest and assimilation systems. The question was how to obtain the benefits conferred by application of a model operationally in forecasting and assimilation for developing the parametrizations in climate models. The basic idea of a "transpose" AMIP and a companion project "CCPP-ARM Parametrization Testbed (CAPT)" being undertaken by PCMDI and NCAR was to apply climate models to forecasts and examine how well the models predict the detailed evolution of the atmosphere at the spatial scales resolved by these models. Comparison with state variables from analyses and reanalyses and with estimates of parametrized variables from field campaigns should yield insight into the errors in parametrizations and lead to improved formulations.

The critical aspect was the initialization of the model for the forecasts. The basic approach was to map the climate scales as represented in analyses onto the climate model grid, eliminating the unresolved scales. The mapping of atmospheric state variables was reasonably straightforward as long as changes in orography and vertical coordinate system were accounted for. The mapping of parametrized atmospheric variables which have a time history (e.g. cloud water) was less obvious, but might be possible by considering the details of the parametrizations in both the climate model and analysis model. However, these variables were often related to fast processes so their initialization might be less critical. Land model variables were more problematic because it was difficult to map the discrete/discontinuous land variables between different

grids, there might be different dominant land types in the two systems, and there was no uniform definition of land model state variables. One approach currently being tried to obtain appropriate initial land values was to spin-up the land, and possibly atmospheric parametrized variables, over a period of time by having them interact with the atmosphere model constrained to follow the analyses in time by either periodically (e.g. 6-hourly) updating the atmospheric state or by adding a term to the model to force the state to follow the analyses to some degree (nudging). Both approaches might be more successful if poorly predicted atmospheric variables which drive the land, such as precipitation, were replaced by observed estimates as they were exchanged. Alternative approaches could also be considered. These included mapping reanalysis soil moisture profile to the climate model by maintaining equivalent soil moisture availabilities, off-line land initialization (as in the GEWEX Global Soil Wetness Project) driven with global observations, and inversion of observed surface fluxes.

WGNE was duly developing a project on these lines. Although a number of questions need to be resolved, the work to date was promising. Appropriate contacts would be taken with potential participants in discussing how to proceed. Advantage would also be taken of the experience in the GEWEX Global Land-Atmosphere System Study (GLASS) where the planning of global scale interactive integrations had faced similar difficulties in the initialization of land surface and soil variables.

Snow Models Intercomparison Project (SNOWMIP)

SNOWMIP was being undertaken by Météo-France (Centre National de Recherches Météorologiques, Centre d'Etudes de la Neige, CNRM/CEN) under the auspices of WGNE and the International Snow and Ice Commission (ICSI) of the International Association of Hydrological Sciences. Liaison was also maintained with the GLASS. The objective of this project was to compare snow models of various complexity at four sites belonging to various climatic regions. A total of 24 models from 18 teams were involved. The models vary from simple models used for hydrology to sophisticated ones for snow physics research. The data for the runs were released in November 2000. After a workshop in July 2001 some teams were allowed to re-submit their results and the analysis began in January 2002. Some models showed a good ability to correctly simulate the snow pack features for all of the sites, whereas other models were more adapted to particular conditions. The high alpine site was the best simulated site, because the accumulation and melting periods were distinct. The current analysis showed that when looking at a specific parametrizations (e.g. albedo, water retention) the results were highly variable and some showed discrepancies between observations and models. For instance an albedo parametrization based on age only gave bad results for the onset of melting at some sites. In 2003, the project intended to submit several papers and begin intercomparisons of detailed snow models. More information was available at http://www.cnrm.meteo.fr/snowmip/.

Comparisons of stratospheric analyses and predictive skill in the stratosphere

In the past two or three 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 was thus undertaking a new intercomparison of stratospheric analyses initially, followed subsequently by an intercomparison of model predictive skill in the stratosphere. This work closely complemented that carried out in the SPARC GRIPS project.

Data from five NWP models (BoM, ECMWF, NCEP, NOGAPS and Met Office) had been received for the northern hemisphere component of this study. The target period was January - February 2000 which was an active period for the northern hemisphere polar vortex. The analyses were found to be relatively similar though there were distinct differences in the polar night jet magnitude, extent and location as well as the size and shape of the polar vortex low-temperature regions between the models. All the available model forecasts were found to provide reasonable forecasts but were also found to have difficulty with certain days associated with large changes in the polar vortex. These days were generally linked to the rapid elongation of the polar vortex. Some models were found to cope with these days better than others. This study had now been extended to the southern hemisphere and similar datasets would be examined for the polar vortex splitting event in September - October 2002.

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 Hadley Centre for Climate Prediction and Research, Met Office, UK, was to assess the extent to which climate variations over the past 130 years could 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. The initial experimentation being undertaken has involved carrying out "classic" C20C/extended AMIP-type runs using the observed sea surface temperature and sea ice as the lower boundary conditions (the HadISST 1.1 analyses provided by the Hadley Centre) for the period 1949-1997, with a minimum ensemble size of four members.

A workshop was convened in Calverton, MD, USA in January 2002 jointly by the Hadley Centre and COLA to review the results that had so far been obtained from the C20C model integrations and to plan a more highly structured C20C project. At the workshop the results from ensembles of runs forced with HadISST from the recent informal phase of C20C were summarized. Besides a number of diagnostic methods and new results on simulating 20th century climate, a presentation was made on the question of how limited AGCMs may be in simulating the variance of climate adequately. A specially designed experiment was created whereby the Hadley Centre HadAM3 AGCM was forced in ensemble mode with daily SSTs from part of a very long control run of the CGCM HadCM3. The initial conclusion was that the variances of those quantities on seasonal to decadal time scales were not significantly less in the AGCM than in the CGCM. Small differences that did occur were, however, consistent with the notion of excessive thermal damping in AGCM simulations. This supported the general validity of the AGCM approach for many types of climate predictability and trend studies. However an unresolved issue was whether some specific modes were missing in the AGCM that were present in the CGCM due to the lack of coupling. This work was being extended to include another AGCM/CGCM pair. The workshop decided that more emphasis should be placed on including forcings in addition to SST. Because of uncertainties in some forcings, and their tendencies to partially cancel, it was agreed to use (i) data from the Hadley Centre on changes in carbon dioxide since 1871, (ii) volcanic stratospheric forcing from 1950 only, and (iii) changes in tropospheric and stratospheric ozone. Participants would carry out a set of six integrations for 1871-2002 and a further set of 10 from 1950-2002. The HadISST would soon be updated in near real-time to make this possible. Participants would carry out a further 100-year control run with the 1961-1990 climatology of HadISST in order to study the role of naturally occurring modes.

Given that AMIP and C20C have a number of common features, WGNE expressed the view that both projects would gain by closer collaboration. C20C could, for example, follow AMIP in establishing a tighter experimental protocol and adapt some AMIP procedures, while AMIP should consider using the HadISST for any future phases.

The JSC stressed the need for closer collaboration and coordination between AMIP and C20C projects. The JSC recommended that an experimental protocol for C20C should be developed. It also recommended use of Hadley Centre SST fields in future C20C phases so that results can be compared with AMIP.

9.1.3 Standard climate model diagnostics

The WGNE standard diagnostics of mean climate had been in use for a number of years and, in particular, were the basis for the "quick-look" diagnostics for AMIP simulations computed by PCMDI. (The list of these standard diagnostics was available at http://www.pcmdi.llnl.gov/amip/OUTPUT/WGNEDIAGS/wgnediags.html).

The standard diagnostics of mean climate included traditional variance and eddy statistics, but additional diagnostics of large-scale variability were also needed to characterize models. Over the past three years WGNE members had developed a list of standard diagnostics of variability focusing on the troposphere. These diagnostics had been demonstrated to be useful by individual developers and included measures of intraseasonal variability, Madden-Julian Oscillation (MJO), El Nino - Southern Oscillation (ENSO), blocking, seasonal cycle, diurnal cycle, atmospheric angular momentum, and modes of variability. They also included wavenumber-frequency plots, and histograms of precipitation. Examples of these diagnostics calculated from simulations with the NCAR Community Atmosphere Model (CAM2) could be seen at: http://www.cgd.ucar.edu/cms/mstevens/variability/index.html.They would also be included in the PCMDI "quick-look" diagnostics. Code for the diagnostics would be available from both centres in the future.

9.1.4 Developments in numerical approximations

The range of approaches being followed in numerical approximations for integrating partial differential equations on a sphere, and the types of grids being tried, were well illustrated by the scope of presentations at the 2001 Workshop on the Solution of Partial Differential Equations on the Sphere, Montreal, Canada, May 2001, the International Workshop on the Next Generation Climate Model, Tokushima, Japan, March 2002, the Second Hybrid-isentropic Modelling Workshop, Louisville, USA, April 2002, and the 2002 Workshop on the Solution of Partial Differential Equations on the Sphere, Toronto,

Canada, August 2002. Examples included, for the shallow water equations, techniques for using icosahedral, cubed sphere, and spherical grids. Likewise for baroclinic systems to which much more attention was now being given, methods using isosahedral, cubed sphere, spherical grids with variable resolution, and adaptive meshes were described. In the vertical, although an example of the application of finite elements was presented, traditional "sigma" co-ordinates were still very much in use. Several new vertical approaches were being developed including the use of cubic spline in the vertical advection with the semi-Lagrangian scheme coupled with cubic finite-element in the vertical at ECMWF, and spectral element vertical and horizontal discretization coupled with semi-lagrangian transport at the Naval Research Laboratory. Additional studies in this area (e.g., to take advantage of isentropic co-ordinates) were now definitely needed.

Specific consideration was also being given to the development of new methods for application in climate models, and for simulation of atmospheric transport (e.g., of aerosols, trace chemicals) where local conservation and preservation of the shape of distributions were essential. Energy conservation in climate models was of particular importance. In practice, conservation of better than 0.1 Wm^{-2} is needed, whereas schemes with non-linear intrinsic diffusion (e.g., Lin-Rood, monotonic semi-Lagrangian) could lose energy at a rate of 1.5 Wm^{-2}, as could explicit diffusion schemes. This loss should be converted to heat, but this might not be the correct approach. This was still a basic uncertainty in model formulation that must be kept in mind. One possible approach being pursued was to move away from spectral to local grid point based methods with local conservation and shape preservation without polar filters.

The numerical representation of orography and transport modelling remained particular issues which WGNE intended to follow. Another important component of activities in this area was the development of tests of the various numerical schemes/grids in a baroclinic system before introduction into complete models where complex feedbacks could obscure effects of new schemes. Two new related tests were presented at the 2002 Workshop on the Solution of Partial Differential Equations on the Sphere which were based on the growth of baroclinicly unstable modes. These were developed by L.M. Polvani (Princeton University) and R.K. Scott (Columbia University) and by C. Jablonowski (University of Michigan). Due to the nonlinear interactions of the growing modes the true solution was not known and reference solutions were computed with very high-resolution dynamical cores.

In addition to tests of dynamical cores in isolation, the interactions of physical parametrizations with each other and with the dynamics needed to be examined. Stripped down versions of atmospheric models with very simplified surface conditions, in particular "aqua-planet" experiments with a basic sea surface temperature distribution, offered a useful vehicle in this regard, with considerable potential to understand the performance and effects of different dynamical cores and different representations of physical processes. For example, at NCAR, aqua-plant simulations with Eulerian and semi-Lagrangian dynamical cores coupled to the CCM3 parametrization suite produced very different zonal average precipitation patterns. Analysis showed that the contrasting structures were caused primarily by the different timestep in each core and the effect on the parametrizations rather than by different truncation errors introduced by the dynamical cores themselves. When the cores were configured to use the same time step, and same three time-level formulation and spectral truncation, similar precipitation fields were produced.

Aqua-planet experiments had wide application in testing basic model numerics and parametrizations in the way described above and WGNE had duly endorsed the proposal for an "aqua-planet intercomparison project". This would be led by the University of Reading together with NCAR and PCMDI. The objective would not only be to assess current model behaviour and to identify differences, but also to establish a framework to pursue and undertake research into the differences. An experimental design and data to be collected had been developed and a list of diagnostics to be computed and compared was being considered. Details of the experimental design were available at http://www.met.reading.ac.uk/~mike/APE/ape_home.html.

9.1.5 Regional climate modelling

The Chairman of the WGNE/WGCM Regional Climate Modelling (RCM) panel, Professor R. Laprise, reported on the second meeting of the PRUDENCE consortium that took place on 2-4 October 2002 in conjunction with the Second ICTP Conference on ‘Detection and Modelling of Regional Climate Change’, held at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. The PRUDENCE activities that relate directly to WGNE and WGCM included 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 included the use of several low resolution coupled GCMs (CGCM), atmosphere only GCMs (AGCM) and nested RCMs. AGCMs were usually run at medium resolutions, as time slices of high resolution uniform resolution models, or as variable resolution AGCMs. These models were driven with sea states based on recent climate analyses to which were added the climate change from

CGCM simulations. RCMs were usually nested in AGCM simulated atmospheric states rather than CGCM atmospheric fields in order to reduce systematic biases.

Experimentation continued at the University of Quebec at Montreal following the so-called 'Big Brother Experiment' (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 was not dominant. Further experiments had been carried out over a western North American region where there was a strong forcing exerted by orography, and for the summer season when surface processes exert a significant influence. The overall conclusions of these perfect model experiments were as follows. One-way nesting RCMs could 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 were improved by the presence of strong surface orographic forcing. The RCMs' ability to reproduce accurately fine scale features was substantially reduced in summer, due to less effective large-scale control by lateral boundary nesting. Additional findings of these studies concerned 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 appeared that a maximum jump of 6 (or possibly 12) was acceptable, which corresponded 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 appeared to be around 6 hours. It was noteworthy that the maximum acceptable values of resolution jump and boundary update interval were mutually dependent.

WGNE expressed some further concerns on RCMs such as possible problems at boundaries due to the response of the land surface scheme and the ability to simulate the variability of extreme events. It was agreed that relevant WGNE members would provide Professor Laprise with a write up of their concerns that would then be considered by the RCM panel. Following satisfactory resolution of these concerns, the RCM report would be finalised and submitted for publication in a general journal such as the Bulletin of the American Meteorological Society.

A number of options for the proposed WGNE/WGCM sponsored RCM Workshop (see also section 9.2.11) had been considered, including holding a special session at an already scheduled RCM-related meeting. The favoured alternative currently being considered was for a joint WGNE/WGCM/IPCC RCM Workshop in early 2004. This was expected to be the recommendation of the RCM panel Chair to WGNE.

The JSC accepted proposal for a Joint WGNE/WGCM/IPCC Regional Climate Modelling Workshop in early 2004 to consider optimal ways to use RCMs in different regions for climate change applications and recommended collaboration with START.

9.1.6 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. As well as the increasing concern in NWP centres with improving the treatment of surface fluxes, this activity responded to the request of the joint JSC/SCOR Working Group on Air-Sea Fluxes and the GCOS/GOOS/WCRP Ocean Observations Panel for Climate for a WGNE initiative to collect and intercompare flux products inferred from operational analyses. Moreover, the intercomparison of land-surface fluxes was of importance in the context of GLASS.

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 were already being accumulated 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, it was hoped that this issue could be resolved soon.

Air–sea fluxes were directly important for a number of WCRP projects. Therefore, a background paper on 'WCRP and Fluxes' had been prepared by the WCRP Joint Planning Staff and WGNE was invited to comment on it. WGNE was also requested to consider the need to setup a 'WCRP Coordinating Committee on Air-Sea Fluxes', given the very wide and varied requirements for air-sea fluxes within WCRP, and closely related programmes (e.g. GODAE, GCOS). WGNE supported the idea and suggested that the proposed committee should have a nominee from WGNE whose contributions to the new group would be in validation of surface fluxes and through AMIP subprojects.

The JSC recommended that WGNE should be represented on the proposed new WCRP Working Group on Surface Fluxes.

9.1.7 Atmospheric model parametrizations and Co-ordinated Enhanced Observing Period (CEOP)

The GEWEX "modelling and prediction" thrust, with which WGNE works in close association, was devoting efforts to the refinement of atmospheric model parametrizations, notably those of cloud and radiation, and land surface processes and soil moisture. The discussion of the GEWEX modelling and prediction thrust at the joint meeting of WGNE and the GEWEX Modelling and Prediction Panel (GMPP), encompassing the GEWEX Cloud System Study (GCSS), the Global Land-Atmosphere System Study (GLASS), and the GEWEX Atmospheric Boundary Layer Study (GABLS) was described in the report of GEWEX Scientific Steering Group to the JSC (see section 6.4).

In the joint discussions with the GMPP, the status of the planning and steps towards implementation of the GEWEX Co-ordinated Enhanced Observing Period (CEOP) were reviewed. CEOP had requested the WGNE community to provide comprehensive gridded output from global data assimilation systems. This requested output included 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) had been requested at 41 international reference sites, where there were extensive in situ measurements and where extensive satellite products were being developed. This small data set would be complemented by more comprehensive 3 dimensional globally gridded data. Minimum output would 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 was also requested, since this would provide some measure of how the models were adjusting (spinning up) to the initial state. These data would be archived initially by the individual meteorological centres and then later sent to the Max-Planck Institute (MPI), Hamburg, which would develop a model output archive. NWP Centres were only being asked for comprehensive analysis and forecast output for the period 1 July 2001-31 December 2004.

Most of the centres represented on WGNE were in principle ready to assist but raised questions concerning the complexity and long-term nature of the request, how the model data would be used in practice, and how CEOP would be useful for NWP centres. The need was expressed for a clearer exposition of the scientific strategy that would be followed by CEOP to exploit the in situ, remotely-sensed, and model output data to meet CEOP objectives. The point was reiterated that potential benefits of CEOP could be fully exploited by operational centres only if the data collected are available in real time. WGNE was asked to consider carefully what recommendations could be made to CEOP so that it could better serve NWP centres. In his response, Dr.J.Roads informed that (i) CEOP was developing a revised implementation plan, which would be made available soon,(ii) CEOP wanted to develop the best possible global hydroclimatological 3-dimensional synoptic snapshot to provide the basis for future global hydroclimatological research in a wide variety of climate regimes,(iii) University of Tokyo would archive the satellite data, UCAR would archive the in situ data, NASA would archive the Global Land Data Assimilation System (GLDAS) and US LDAS products, as well as pertinent satellite data, and MPI would archive the model output. WGNE was pleased with the responses. However, there was still some reservation concerning the request for 3-dimensional fields and it was felt that it might be better for CEOP to concentrate on relevant 2-dimensional fields with possibly higher resolution.

The JSC recommended that data from CEOP should be made available in real time for full exploitation by NWP centres.

9.1.8 Reanalyses

ECMWF

The ambitious and comprehensive 40-year reanalysis project at ECMWF (ERA-40, August 1957 to December 2001), with support from the European Union, was progressing well. The assembly of a merged data set of conventional observations carried out in collaboration with NCEP and NCAR was complete. A surprisingly large amount of extra data was available compared to the earlier 15-year reanalysis (ERA-15), with, in particular, a significant increase in the number of radiosonde and pilot wind soundings from the NCEP database. EUMETSAT was also reprocessing wind products from METEOSAT-2 from 1983-1988. The collection of observations was almost complete and the observational archive was itself a valuable resource that would be shared with NCEP and JMA for future reanalysis. Many problems with observations had been resolved although others remain, especially biases in radiance data.

The data assimilation was based on the system that was operational from June 2001 to January 2002 and includes 3DVAR analysis, T159 L60 resolution model, direct assimilation of raw radiances, analysis of ozone, a coupled ocean-wave model and enhanced set of post-processed products. Additional products included cloud statistics from TOVS radiance processing, fields from the physical parametrizations to support chemical-transport modelling, comprehensive outputs for selected grid points and catchment basins, vertically-integrated fluxes and data on isentropic and constant-PV surfaces. The reanalysis itself was being undertaken in three streams covering the periods 1987-2001 when TOVS, SSM/I, ERS, ATOVS and CMW data were available, 1972-1988 with VTPR, TOVS and CMW data, and 1957-72 (the pre-satellite era).

Tests of the assimilation of SBUV and TOMS ozone data had proceeded in parallel, and had given satisfactory results. SBUV and TOMS assimilation was thus added to the production system from January 1991 onwards. Ozone analyses for 1989 and 1990 would be produced off-line. In this connection, the ERA-40 experience had been invaluable in the development of operational assimilation of ozone at ECMWF.

A number of assessments of the ERA-40 analyses for the late 1980s and early 1990s had been made by the partners in the project (from ECMWF Member States and NCAR). In almost all respects, the quality of the ERA-40 analyses appeared to be superior to that of the ERA-15 analyses. The validation studies had identified some deficiencies especially with the tropical hydrology, and mixed results for the pre-1979 period.

ERA-40 data would be (i) available to all ECMWF Member States via direct access (free), (ii) condensed onto CD with limited levels and parameters, (iii) available nationally via specific data centres such as NCAR, MPI, the British Atmospheric Data Centre, and the Institute Pierre-Simon Laplace (IPSL), (iv) available to non Member States via ECMWF (with handling charges), and (v) available in small subsets on the ERA-40 website (public).

Comprehensive information on ERA-40, including the current status of production and archiving and monitoring plots could be consulted via http://www.ecmwf.int/research/era.

NCEP

The original NCEP/NCAR reanalysis from 1948 was continuing to be carried forward to the present in a quasi-operational manner (two days after data time). The reanalyses distributed through NCAR, CDC and NCDC were readily available either electronically or on CD-ROM. A joint NCEP/DOE reanalysis (NCEP-2) for the period 1979-1999 had also been produced (available electronically). This was based on an updated forecast model and data assimilation with corrections for many of the problems seen in the original NCEP/NCAR reanalysis and also improved diagnostic outputs.

The current initiative was the preparation of a regional reanalysis over the USA for the period 1979-2004 to be continued later in near-real time. This should provide a long-term consistent data set for the North American domain, superior to the global reanalysis in both resolution and accuracy. The regional reanalysis would be based on the Eta model and the Eta data assimilation system with the global reanalysis used as boundary conditions. Model resolution would be 80km with 38 layers in the pilot stage and 32km with 45 layers in the production stage. Important features would be direct assimilation of radiances and assimilation of precipitation (over the USA), as well as recent Eta model developments (refined convective and land-surface parametrizations). Free forecasts would be carried out to 72 hours every 2.5 days. 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) had been assembled and a large number of pilot runs carried out. Considerable improvements were apparent in the precipitation patterns which look very similar to the observed precipitation patterns in both summer and winter, especially in runs where precipitation was assimilated. The fits to the upper air temperatures and vector winds (as observed by radio-sondes) and surface temperatures were also notably better than those of the global reanalysis.

The production of the regional reanalysis was now in progress and two streams would be run when the Class VIII machine became available. It was planned to complete most of the production by 31 August 2003, the last date that Class VIII machine would be available. A Users' Workshop was planned for 2003.

Japan Meteorological Agency (JMA)

The Japanese Reanalysis Project, JRA-25, was a five-year joint project of JMA, which was providing the operational data assimilation and forecast system, and the Central Research Institute of Electric Power Industry (CRIEPI), a private foundation providing computer resources. The objective of the project was to provide a comprehensive data set for the period 1979-2004 which would 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. A 3DVAR system (operational since 2001) with a model resolution of T106 and 40 levels in the vertical would be employed. As well as data archived at JMA from 1975 to present, the NCEP/NCAR data used in the NCEP reanalysis and the merged ECMWF/NCEP data sets in ERA40, a range of satellite observations (including reprocessed GMS cloud motion wind data), and 'bogus' wind data surrounding tropical cyclones would be assimilated. The project was expected to be completed by 2005, with the products available to scientific groups contributing to the evaluation of the reanalysis and who provided feedback on improvements that could be made. Some recent developments included provision of tropical convection bogus data by PCMDI and two-year sample data of ERA-40 by ECMWF. The first announcement of invitation for evaluation group members was made in October 2002 and the second meeting of the JRA-25 Advisory Committee was planned for February 2003.

WGNE reiterated that the JSC needed to seriously consider making reanalysis an ongoing effort, given the importance and strong support for the project. The current situation was unsatisfactory and wasteful because expertise built up for a reanalysis was lost when a phase was completed and then had to be reassembled with a new phase. A further advantage of an ongoing exercise was that it would facilitate research that was relevant to WCRP projects. In response, the JSC expressed that reanalysis supported by WCRP had been an enormous achievement of great benefit to the scientific community and strongly recommended that efforts should be made to establish it as a continuous ongoing process

9.1.9 THORPEX: A Global Atmospheric Research Programme

At the invitation of WGNE, Professor Alan Thorpe gave a comprehensive presentation on THORPEX: A Global Atmospheric Research Programme. A key change in the past year has been the change in focus from a hemispheric to global experiment. Professor Thorpe described THORPEX as a ten-year international research programme designed to accelerate improvements in short-range (up to 3 days), medium-range (3 to 7 days) and extended-range (week two) weather predictions, and in the societal and economic value of advanced forecast products. The programme builds upon ongoing advances within the basic research and operational forecasting communities and it would make progress by enhancing collaboration between these communities. THORPEX core scientific objectives are to:

- advance basic knowledge of global-to-regional influences on the evolution and predictability of high-impact weather;

- contribute to the development of dynamically-interactive forecast systems, which will include the concept of targeting;

- develop and apply new methods for assessing the economic and societal value of weather information;

- carry out THORPEX Observing-Systems Tests and THORPEX Regional Campaigns;
- demonstrate the full potential of THORPEX research results for improved operational forecasts of predictable high-impact weather events on time scales out to two weeks and beyond. This demonstration, the THORPEX Prediction Experiment, will last for up to one year.

The themes proposed were of major interest to WGNE, and the studies of predictability and observing system issues being taken up would have benefits throughout the WCRP. The international coordination of THORPEX was under the auspices of the WMO, WWRP and WGNE. The THORPEX International Science Steering Committee defined the core research objectives with guidance from the THORPEX International Core Steering Committee whose members were selected by national permanent representatives to the WMO.

WGNE reiterated its support for THORPEX as a collaborative WWRP/WGNE experiment. At the WGNE session, a joint WWRP/WGNE draft resolution concerning the current status and the next steps in the development of THORPEX was reviewed and finalised in consultation with the Chair of the WWRP, Dr R. Carbone. The committees agreed that the essential next step is the development and submission of the detailed THORPEX Science plan for review and consideration by WWRP and WGNE.

9.1.10 Verification and comparison of precipitation forecasts

As a principal contribution to WGNE activities in this area, NCEP, DWD and BMRC had been verifying twenty-four and forty-eight hour quantitative precipitation forecasts from eleven operational NWP models for a six-year period against rain gauge observations over the USA, Germany, and Australia in order to assess the skill in predicting the occurrence and amount of daily precipitation. It had been found that quantitative precipitation forecasts had greater skill in mid-latitudes than the tropics where the performance

was only marginally better than persistence. The best agreement among models, as well as the greatest ability in discriminating rain areas, occurred for a low rain threshold of 1-2 mm/day. In contrast, the skill for forecasting rain amounts greater than 20 mm/day was generally low, pointing to the difficulty in predicting precisely where and when heavy precipitation may occur. In spite of the impressive progress made in numerical weather prediction, quantitative precipitation forecasts had only shown marginal improvement over the five to six year period examined. A paper documenting this work has been accepted for publication in the Bulletin of the American Meteorological Society.

The validation of precipitation forecasts had become an increasingly important activity. Accordingly this WGNE project had expanded significantly and the Met Office, Météo-France, JMA and the China Meteorological Administration had also started verifying precipitation forecasts in their regions. Of particular interest was the Met Office study which would attempt to verify precipitation in 3-hr periods. This should shed light on model performance during the spin-up period and diurnal variation of precipitation, in addition to the daily rainfall amounts. WGNE was prominently involved in the organization of the International Conference on Quantitative Precipitation Forecasts that was held in Reading, UK, in September 2002.

There were other WGNE projects involved with the validation of deterministic forecasts. These included the compilation of the so-called WMO scores, validation of tropical cyclone tracks and verification of stratospheric analysis and forecasts. There had also been the recognition that with models attaining increasing resolutions there was urgent need to move forward from the gross validation methods that had been used so far. Accordingly WGNE had prepared a position paper on verification.

The JSC supported the proposal for a joint WGNE/WGCM/WGSIP Workshop on Ensemble Techniques and stressed that the workshop focus should be on scientific issues rather than operational aspects of ensemble prediction.

9.2 Progress in coupled modelling

WGCM endeavoured to maintain a broad overview of modelling activities in the WCRP in its basic task of building up comprehensive climate models, and reviewed carefully work in hand by WGNE, the CLIVAR Working Group on Seasonal-to-Interannual Prediction (WGSIP), the WGCM/CLIVAR Working Group on Ocean Model Development (WGOMD), and the modelling-related studies of ACSYS, CliC and SPARC, as well as short summaries about the progress within the IPCC.

9.2.1 Outstanding issues in the development of coupled models

Drawing from the list of uncertainties and priorities listed in the IPCC Third Assessment Report and from the experience of the members of WGCM (representing the main coupled modelling groups), the following items had been set down as requiring urgent study and investigation:

- improved methods of quantification of uncertainties in climate projections and scenarios, including development and exploration of ensembles of climate simulations;
- increased understanding of the interaction between climate change and natural climate variability;
- the initialization of coupled ocean-atmosphere models;
- the reduction of persistent systematic errors in climate simulations;
- the variations in past climate as a means to understanding the response of climate to forcing factors;
- the reasons for different responses in different models;
- improved knowledge of cloud/climate forcing and the direct/indirect effect of aerosols (including refined methodologies for refining the analysis of feedback processes);
- improved simulation of regional climate and extreme events.

WGCM was directly addressing many of the issues through the specific initiatives being undertaken (see descriptions below).

9.2.2 Coupled Model Intercomparison Project (CMIP)

CMIP (http://www-pcmdi.llnl.gov/cmip/) was one of the most important and long-standing initiatives of WGCM, having been started in 1995. There were now three components: CMIP1 to collect and document features of global coupled model simulations of present-day climate (control-runs); CMIP2 to document features of control runs and climate sensitivity experiments with CO_2 increasing at 1% per year; CMIP2+, as CMIP2, but many extra fields and data, and monthly means, and some daily data were being collected. The range of extra fields at higher temporal resolution being assembled in CMIP2+ (compared to the limited fields, in CMIP1 and CMIP2) was enabling in-depth study of many additional aspects of coupled model

simulations (e.g. feedback mechanisms, ocean processes, explaining higher frequency phenomena and why different models had different responses). Data from 6 models was already available and the submission from another four had been announced. 16 subprojects had been accepted for CMIP2+. A complete list of CMIP diagnostic sub-projects could be consulted at http://www-pcmdi.llnl.gov/cmip/. As well as the publications by individual authors of sub-project results, referred to above, the IPCC Third Assessment Report drew substantially on several CMIP sub-projects, and included an analysis of CMIP models.

WGCM had discussed the following issues for CMIP:

- maintaining the existing database, providing support to other intercomparisons including subprojects, completing archival and access to CMIP2+ monthly and daily data, closing submission to present CMIP phases over the next two months;
- the relationship with the IPCC Data Distribution Centre in Hamburg; 20th century runs and daily data;
- engaging other communities to use CMIP2+ ocean data;
- continued monitoring of technological developments regarding distributed model data access (e.g. Earth System Grid);
- a CMIP Workshop planned back-to-back with the WGCM/GAIM Conference on Earth System Modelling in Hamburg, 22-24 September 2003;
- the start of a new CMIP phase in early 2004, to be coordinated with AMIP and the Ocean Model Intercomparison Project (OMIP).

WGCM recommended starting a pilot project on Coupled Model Climate of the 20th Century experiments which should be announced through CMIP. There was an agreement on a set of diagnostics. Furthermore it was pointed out that since no single forcing was prescribed for these runs, a comprehensive documentation of the forcing was required.

Two sets of CMIP experiments were currently under way to better understand the response of the thermohaline circulation (THC) in AOGCM's: a) sensitivity of the THC to heat and water flux forcing and b) so-called 'water hosing' experiments. Contributions to both experiments should be submitted by the end of 2002.

WGCM noted that it would be very useful if a set of indices were developed to document important modes of variability in the coupled system. Model results could then be compared with these indices. This would provide a simple, clean way of evaluating model performance.

Finally, WGCM discussed the possibility of regarding CMIP as an overarching Model Intercomparison Project (MIP) guiding and coordinating the activities of other MIP's. WGCM offered GAIM/C4MIP to coordinate this activity with CMIP, including handling of the data. In addition, CMIP would collect basic information about the various MIP activities and make it available through the web.

9.2.3 Intercomparison of cloud feedbacks in models

In recent years, WGCM had undertaken an initiative entitled "idealized sensitivity experiments" involving intercomparisons of results from equilibrium doubled CO_2 experiments, in which the atmosphere was coupled to a slab ocean, thus not involving the complexity of the ocean response. This work has shown significant differences in inferred cloud forcings and changes in top-of-the atmosphere fluxes in different models (and had been drawn upon in the IPCC Third Assessment Report).

The scientific community had expressed considerable interest in continuing this study and various means for diagnosing feedbacks. WGCM had already endorsed a proposal, put forward by Drs B. McAveney and H. Le Treut, for systematic intercomparison of cloud feedbacks in climate models in order to understand climate feedbacks. Drs. McAvaney and Le Treut had reported at the most recent WGCM session about the recent developments of this project and presented details for a coordinated experiment on cloud feedback. WGCM thanked the authors for their efforts and endorsed the proposed strategy. The experiment has been announced and some preliminary results were expected to be available for the next WGCM session.

9.2.4 Initialization of coupled models

The problem faced by all modelling groups performing model experiments from past (pre-industrial) conditions were the unknown initial conditions of the ocean. Since there were no adequate observational data available, most groups were using (present state) initial conditions, in particular those compiled by

Levitus. At present the only alternative would be long coupled spin-up experiments which imply a very high demand in computer resources because of the lengthy time-scales involved.

9.2.5 Ocean model development

The WGOMD was established in 2000 as a joint working group under the WOCE SSG and the WGCM. The reporting relationships are currently under revision, with the end of the WOCE programme in 2002. The WGOMD group has been active for three years. The membership was comprised of scientists working in both oceanographic and climate centres or departments. The WGOMD was charged to "stimulate the development of ocean models for research in climate and related fields, with a focus on decadal and longer timescales at mid- and high-latitudes."

To disseminate and publicize information on the status of ocean models used in climate research, the WGOMD provided a Web directory of ocean modelling resources (http://www.clivar.org/organization/wgomd/index.html) and had published a major review paper (Griffies, S. et al., 2000, Ocean Modelling, **2**, 123-192).

The most significant activity undertaken by the WGOMD thus far has been the establishment of the Pilot Ocean Model Intercomparison Project (P-OMIP). This pilot study was intended to determine the feasibility and merit of a broad intercomparison among ocean and ocean-ice models used in coupled climate system modelling. The OMIP under consideration was intended to support CMIP in providing quantitative evaluations of the models participating in the IPCC and other climate assessments. In addition, it was expected that an OMIP would provide a common reference point for investigating sensitivities to model formulation, enable a pooling of resources (forcing and verification data sets, pre- and post-processing software, archival facilities) across modelling groups, and contribute to a shared understanding and broader dissemination of model developments and model results. The challenges faced in designing an OMIP included:

- difficulties in finding the appropriate level of detail for the protocol; it needs to provide for a meaningful comparison without being so detailed as to be too difficult for groups to comply with;
- difficulties in defining the forcing; a large number of poorly known fields were required;
- costs: groups would probably need to do runs specially for this intercomparison that would require significant expenditure of computer resources.

The P-OMIP builds on a mini-OMIP conducted in Germany by the Alfred Wegener Institute, Bremerhaven, and the Max-Planck Institute for Meteorology, Hamburg, most significantly by utilizing the ERA-15 based forcing data set developed for that project. The P-OMIP protocol specified that the experiments be conducted as coupled ocean-ice integrations. In the first phase of the P-OMIP, 7 models are participating. These first experiments already indicated a number of robust behaviours (both positive and negative) and suggested that an OMIP of this type should be feasible and had merit. Before a full-blown OMIP could commence however, resources to support the coordination and infrastructure would need to be identified. The WGOMD planned to make a recommendation on whether or not to proceed with a full-blown OMIP at its next meeting in spring 2003.

WGCM had welcomed the P-OMIP activity but had recommended that WGOMD should a) connect the timelines with AMIP and CMIP in order to meet the IPCC requirements and b) look systematically into the ocean components of coupled model experiments. WGCM had also endorsed the present membership of WGOMD but recommended that future changes should reflect a better representation of the variety of ocean models used and developed at present within the community.

9.2.6 Detection and attribution of climate change

WGCM reviewed the range of outstanding issues in the quest to detect and attribute climate change. Multiple regression or "optimal fingerprint detection" (as described in the IPCC WG1 Third Assessment Report, Ch. 12, section 12.4.3) has been widely used for this purpose. The method requires ideally ensembles of simulations of twentieth century climate with individual forcing agents to provide "fingerprints", and very long (multi-centennial or even millennial) control simulations to assess internal climate variability. Several groups had used this approach, with strong indications of anthropogenic influences on surface temperature being found and the results from different groups were generally consistent. The technique could also be employed to scale simulations of the twenty-first century to observations to give predictions with uncertainty limits, and to estimate key parameters such as climate sensitivity, ocean heat uptake and sulphate aerosol forcing.

Uncertainty remained as to the model-derived estimates of internal climate variability, which could not be fully validated with observed variability over the required timescales (of several decades to centuries). Reconstructions of temperature variations over the recent centuries from palaeoclimatic data were becoming increasingly important in this context. However, the influence of natural climate forcing on the palaeoclimatic record appeared to be considerable. Thus an essential step in verifying model performance and the simulated internal (or natural) variability would be model integrations over the appropriate period with the appropriate (reconstructed) natural forcing.

Optimal detection methods also tended to be sensitive to the model employed to derive fingerprints. This could be partly alleviated by using fingerprints averaged from several model simulations. Estimates of model error covariance (required for a comprehensive assessment of model uncertainty) depended on the availability of a range of simulations with varying parameters. Another key issue in increasing confidence in climate models was to understand better the different trends in surface and lower tropospheric temperature.

Attention was now expected to turn to identifying signals of anthropogenic climate change in other parameters that were relevant socio-economically such as precipitation, models of climate variability, or climate extremes. Assessment of changes on a continental scale instead of or in addition to global scale would be another means of verifying model simulations in more detail as well as the quality of the fields produced to drive regional or impact models.

9.2.7 Palaeoclimatic modelling

WGCM had received a report on the Palaeoclimate Modelling Intercomparison Project (PMIP) (http://www-pcmdi.llnl.gov/pmip/). PMIP was an international project involving members of all major climate modelling groups worldwide and endorsed by WCRP and IGBP. The project was launched in 1994 with the dual aims of:

- understanding the mechanisms of climate change by examining such changes in the past, when the external forcings were large and relatively well known and when various kinds of geological information provide evidence of what actually happened;
- providing a framework for the evaluation of climate models in order to determine how far they are able to reproduce climate states radically different from that of the present day.

In its initial phase, designed to test the atmospheric component of climate models, PMIP had focused on the last glacial maximum (LGM: ca 21,000 years before present, 21 ka BP) and the mid-Holocene (6 ka BP). The results of this study formed a crucial part of the evaluation of climate models in the Third Assessment Report of the Intergovernmental Panel on Climatic Change.

PMIP had not confined itself to analysing and evaluating the benchmark LGM and mid-Holocene experiments. Complementary experiments, examining the role of the ocean and of the land surface in past climate changes, were also carried out by several of the participating groups. Perhaps one of the most important conclusions emerging from the first phase of PMIP was the importance of including ocean and vegetation feedbacks in model simulations in order to simulate the regional patterns and magnitude of past climate changes correctly. Largely as a result of this realisation, PMIP created a working group to design protocols for palaeo-experiments using fully coupled models.

At the last PMIP meeting it was decided that Phase II of PMIP would have five modelling foci:

- coupled ocean-atmosphere (OAGCM) and ocean-atmosphere-vegetation (OAVGCM) simulations of the response to mid-Holocene (6 ka BP) insolation changes (contact: Pascale Braconnot, IPSL, France).
- OAGCM and OAVGCM simulations of the response to glacial conditions (contact: Chris Hewitt, Hadley Centre, UK).
- early Holocene (10 ka BP) simulations of the climate response to insolation changes in combination with ice sheet changes (contact: Paul Valdes, Reading University).
- early glacial (115ka BP) simulations designed to understand the processes underlying glacial inception (contact: Gilles Ramstein, IPSL, France).
- prescribed freshwater fluxes experiment (contact: Ron Stouffer, GFDL, USA).

WGCM had welcomed this new activity and encouraged PMIP to proceed and to further cooperate with groups within WCRP and IGBP, such as CMIP, PAGES/CLIVAR and GAIM, as appropriate.

9.2.8 Coupled ocean-atmosphere variability and predictability

WGCM had reviewed this topic only very briefly, addressing the question of how well present coupled AOGCM's simulated natural modes of variability, such as ENSO, the North Atlantic Oscillation (NAO) and the Arctic Oscillation, with special emphasis on the GFDL model results. Although, some modes of variability could in principle be reproduced, substantial differences amongst the models, and, compared to observations, in the spatial structure as well as in the frequency distribution, were still obvious.

9.2.9 Carbon-cycle modelling

WGCM and GAIM had discussed this project during their joint session. WGCM is co-operating with the Global Analysis, Integration and Modelling (GAIM) element of IGBP in the planning of the "Coupled Carbon Cycle Climate Model Intercomparison Project" (C4MIP). This would be organized on standard co-ordinated experiments in the same way as the other main WCRP model intercomparison projects such as CMIP and AMIP. The long-term goal was to compare and analyse feedbacks between the carbon cycle and climate, and to evaluate the sensitivity of the coupled carbon-climate system to anthropogenic perturbations. The project focused on CO_2 emissions and concentration and the response of the Earth System to CO_2 forcing, given a fixed scenario for future emissions. This "experiment" used an increase in atmospheric CO_2 concentration of 1%/yr. While this might be a modest increase relative to "business as usual" scenarios, it provided a useful baseline for this initial development and application of full complexity models. C4MIP introduced terrestrial and oceanic carbon cycle modules into coupled atmosphere-ocean-land climate models, with CO_2 as a prognostic variable, to investigate the co-evolution of climate and CO_2 given emission scenarios. The excitement lay in the identification and investigation of interactions in a climate space beyond known experience.

In a pilot phase, results from the Hadley Centre model and the Institut Pierre-Simon Laplace (IPSL) coupled climate CO_2 OAGCM had been compared. GCM sensitivity to CO_2 concentration differed between the IPSL and Hadley models. Also, Hadley had more land carbon uptake than IPSL as a result of climate change, but the situation was reversed in the ocean. While land response to increased CO_2 was comparable, ocean uptake was much more for IPSL than Hadley. Swapping land and ocean modules between the two models revealed that the land component largely explained the difference between the models. The first phase of C4MIP focused on historical land-atmosphere forcing. Six groups were involved already. A workshop to present initial model results was planned for summer 2003.

The first phase experiments were important for the organization and internal development of the project. However, phase two was of the greatest interest to IPCC and others. Scheduling to coordinate with PCMDI's handling of the CMIP data would be beneficial, so some collaborative planning with the CMIP C20C activity would be helpful.

The JSC endorsed the idea that C4MIP was an activity which could be well placed under the expanded scope of CMIP.

9.2.10 Intergovernmental Panel on Climate Change (IPCC)

Dr Mitchell reported on WGCM-related issues arising from recent developments within the IPCC. In particular he elaborated on the developments within the Task Group on Climate Impact Assessment (TGCIA). The TGCIA had recommended informally that if modelling groups planned to run scenarios from the IPCC Special Report on Emissions Scenarios (SRES), then A2 and B2 should have first priority, followed by A1FI, B1 and A1B.

In order to meet the timeline for the next IPCC report, the forcing scenarios have to be finalized in early summer 2003. WGCM recommended that the original preliminary scenarios used in the IPCC Third Assessment Report be used instead of taking new ones, unless the differences are large, to enable intercomparisons with previous calculations. Furthermore, this would provide a larger sample size for intercomparisons and for impact studies. In addition, it was requested that a simple concentration time series for each atmospheric parameter should be provided for each emission scenario and made available on the IPCC and the TGCIA website.

The JSC supported the proposal to conduct multi-CO_2 idealized experiments (e.g. $4xCO_2$, $8xCO_2$, …) in the time-frame of next IPCC Assessment and agreed that multiple hindcast experiments should be carried out.

9.2.11 Regional Climate Modelling (RCM)

Dr Mitchell noted that the report of the ad-hoc panel on regional modelling had been endorsed by the JSC. WGCM recommended that the task team on regional modelling should proceed in planning a workshop on regional modelling and subsequently plan a model intercomparison study for regional models. In order to meet the requirements for the IPCC Fourth Assessment Report (AR4), a timeline for these activities should be developed. WGCM further recommended that the RCM ad hoc panel convene a workshop on optimal ways to use RCMs in different regions for climate change applications. It was suggested that this workshop could be convened in close collaboration with the START community so that optimal ways of using RCMs and cautions regarding indiscriminate use of output can be fully explained to that community. The workshop should be designed to maximise the input of the RCM developer community to the user community prior to the development of regional climate change scenarios and regional climate impacts for the AR4 (see also section 9.1.5). The Workshop might also be an opportunity for the RCM community to assess the plans of the ad hoc committee for a co-ordinated assessment of RCM skill in reproducing small scale regional features that might be associated with large scale anomalies on the intraseasonal and interannual time scales (and longer).

9.2.12 Other issues from the joint session of WGCM and GAIM

The joint meeting of WGCM with the IGBP GAIM task force primarily served as a vital exchange of information about the various activities of the two groups. WGCM put major foci on CMIP and PMIP. GAIM introduced, amongst other topics, their so-called “Hilbertian Questions” and an Earth System Atlas Project. The latter had the overarching goal to publicize as broadly as possible the results of global change research. Specific objectives were to establish a single source of information that had undergone peer review, to present the research results in an easily understandable form, provide updates, enable superposing of various data sets, link maps and time series with original data, and identify conceptual and data gaps that would need to be filled by the scientific community through the development of new research projects. Data sources would include both ground-based and remotely-sensed data. GAIM invited WGCM to participate in this endeavour.

In addition, both groups agreed to foster their cooperation within the C4MIP project. Another joint activity was to develop a database of the existing model intercomparison studies. CMIP would take the lead on this activity. A preliminary web-based version was available through http://www.clivar.org/science/mips.htm.

The JSC endorsed WGCM’s involvement in IGBP GAIM’s Earth System Atlas effort. WGCM was well-versed in data management through its PCMDI activities, and could contribute significantly to the atlas effort. The JSC agreed that in order to foster the cooperation, WGCM and GAIM could hold future meetings jointly every two years.

9.2.13 Discussion

Following discussion on the report of WGCM presented by Dr Mitchell the JSC:

- endorsed the recommendation that effort should be made to ensure that major new modeling initiatives (e.g. PRISM in Europe and the Earth System Modelling Famework in the USA) should make their systems (code and data) as compatible as possible with a long-term view to producing a single infrastructure;

- emphasized that efforts should be made to co-ordinate chemistry components in WGCM, SPARC and IGAC towards the development of integrated troposphere-stratosphere models (see also section 8.4.2);

- decided that WGCM should remain a joint JSC/CLIVAR Working Group, but with a Vice-Chair recommended by the CLIVAR SSG;

- recommended that explicit terms of reference on “Evolution and development of Climate System Models” be prepared by WGCM.

10. CO-OPERATION WITHIN THE EARTH SYSTEM SCIENCE PARTNERSHIP (ESSP)

10.1 Earth System Science Partnership (ESSP)

The collaboration between IGBP, IHDP, WCRP and DIVERSITAS in the field of Earth System Science and the development of the joint projects (see below) was a manifestation of working together in a co-operative approach on issues of major relevance to society and global sustainability. The Earth System Science Partnership (ESSP) should provide the common platform required by the increasing emphasis on broad-scale integration in international Earth System science and on which programmes could work together on cross-cutting activities. In addition to the four evolving joint projects and START, other proposals were being considered, in particular "Integrated Regional Studies". The pressure for more emphasis at the regional scale of Earth System science has been growing steadily and such studies would respond to this by fostering collaboration between regional scientific communities and drawing on input from these, and establishing the necessary regional-global links. The type of studies envisaged was beyond the scope or expertise of any one of the global environmental change programmes and thus logically should be co-ordinated under the ESSP.

10.2 ESSP joint projects

9.2.1 Global Carbon Project

Dr R. Dickinson, Co-chair of the Scientifc Steering Committee (SSC) for the Global Carbon Project (GCP) reported on the highlights of the development of the project. The main research goal of the GCP is to develop a comprehensive, policy-relevant understanding of the global carbon cycle encompassing its natural and human dimensions and their interactions. The GCP held its second SSC meeting in Tsukuba, Japan, November 2002. The Science Framework has been thoroughly reviewed with major changes in the Implementation Plan and will be published in April 2003. A major partnership is being developed with the Integrated Global Observing Strategy Partnership (IGOS-P) via its theme on Integrated Global Carbon Observation (IGCO), and Global Terrestrial Observing System (GTOS). The SSC has approved the issue of a bi-monthly e-mail to all critical partners of the GCP, to include all projects of IGBP, IHDP, and WCRP. This will allow sending information directly to sponsors and partners and at the same time allow continuous feedback on the way the GCP develops. The Canberra International Project Office is fully operational and a second IPO will be established shortly in Tsukuba, Japan. Two affiliate offices are already operating in Europe, the first one at UNESCO, Paris, with the IOC-Scientific Committee on Ocean Research (SCOR) CO_2 Panel for international ocean coordination, and a second one with CarboEurope in Jena, Germany, largely on terrestrial carbon research in Europe. A proposal submitted to the US agencies for an office in Colorado was not successful but a resubmission will take place over the next three months.

While welcoming the progress made in the GCP, the JSC emphasized, in the context of coupled modelling, the need to consider what is feasible for inputs to IPCC, and how WCRP can feed into GCP not only in modelling (through WGCM), but also in process studies. In particular, there is a need to enhance the connection of GCP with the CliC Project.

10.2.2 Global Environmental Change and Food Systems (GECAFS)

Dr J. Ingram briefed the JSC on the status of the Global Environmental Change and Food Systems (GECAFS) joint project and the progress in the past year. GECAFS employs novel interdisciplinary approaches to global environmental change in studying the vulnerability of food systems to impacts, adaptations and feedbacks, a methodology allowing an analysis of trade-offs between managing resources for food provision and environmental concerns, and a design for analyses at regional and sub-regional levels but which was globally applicable in concept. GECAFS has developed rapidly during 2002, particularly in regional project development for (i) the Indo-Gangetic Plain food system and (ii) the Caribbean food system. For both these projects the planning process has so far identified the nature of the questions that need to be researched. The next step is to establish methodologies and research approaches that can be developed to best address them. Working to the specific questions identified in 2002 regional planning meetings, workshops involving IGBP, IHDP and WCRP representatives (and other groups, e.g. the Consultative Group on International Agricultural Research (CGIAR)) will be held in early-mid 2003 to establish research strategies and identify relevant ongoing and imminent work within the Programmes; and then jointly to develop research proposals. The next workshop for the Indo-Gangetic Plain is planned for 2-4 April 2003, to be held in Kathmandu. The next workshop for the Caribbean is planned for 24-25 February 2003, probably in Barbados. Plans are under way for research in Eastern Pacific coastal fisheries, and the Southern Africa food system. Regional research needs to be underpinned by improved understanding on the nature of vulnerability, especially in relation to food systems, and the comprehensive scenarios within which research

is set. Research plans in both areas are now under way, and an initial work programme for vulnerability research is already funded. A Scientific Advisory Committee (SAC) has been inaugurated with representatives from science, research partners, sponsoring programmes and the donor community. The SAC will meet annually. The GECAFS International Project Office is now well established in the Natural Environment Research Council – Centre for Ecology and Hydrology (NERC-CEH) Wallingford, UK, and the Executive Officer (Dr J. Ingram) and an administrative assistant are in post. A science officer is anticipated from April 2003. A Prospectus has been published, and a web site (www.gecafs.org) developed.

The JSC noted the progress in the planning/implementation of GECAFS during the past year. The JSC stressed the importance of the WCRP scientific community, particularly the WGCM and WGSIP, becoming involved in GECAFS in order to relay the information on climate variability required for constructing appropriate global and regional climate scenarios. The JSC also stressed the important contribution that would be made to the project by regional climate modelling.

10.2.3 Global Water System Project

Professor S. Sorooshian reported on the developments in the Global Water System Project (GWSP). A scoping document is available which provides a background to current thinking on the GWSP as well as a contribution to the ongoing dialogue within the ESSP. A first draft of a Scientific Framework is under preparation. The fundamental and overarching scientific question that GWSP addresses is: how are humans changing the global water cycle, the associated biogeochemical cycles, and the biological components of the Global Water System, and what are the social feedbacks arising from these changes? A series of guiding principles and set of initial questions that would indicate the scope of the activities to be pursued had been set down, i.e. assessment of the relative magnitude of changes in the terrestrial water cycle and constituent transport from and within continents that could be attributed to climate and land use change on one hand, and population and economic changes on the other; identification of the main mechanisms by which activities were affecting the global cycling of water and constituent transport apart from emission of greenhouse gases; the extent to which water management systems and ecosystems mitigated the effects of hydrological variability and change associated with a changing climate, and population and economic growth. In the initial phase of the project (0-2 years), a strong emphasis would be given on the identification of data needs, and early efforts to construct first generation global data sets via synthesis and coordination with other programmes. In the intermediate term (roughly 2-5 years), the GWSP would help to facilitate the development of first-generation models that would allow prediction of physical, chemical, biological, and socioeconomic aspects of human manipulation of the GWS. In the long term (5-10 years), GWSP would promote development of interactive models capable of predicting possible responses and feedbacks of the GWS (and especially its terrestrial components) to human use and abuse with reliable uncertainty estimates.

The JSC appreciated the thrust of the scoping document on the GWSP, the overarching scientific objective posed, and the recognition of the important role of many components of the physical climate system in water and constituent cycling questions. The JSC emphasized the leading contribution to be made by WCRP, in particular GEWEX, in the implementation of the project and stressed the need to avoid any duplication with existing WCRP projects.

10.2.4 Global Change and Human Health

Dr V. Satyan reported on the developments in the fourth ESSP joint project, 'Global Change and Human Health'. The project addresses the need to understand better the multi-faceted and complex linkages between global change (including climate change, land- and sea-use changes, global biodiversity loss and changes, global socio-economic changes) and human health. A scoping meeting on this project was held in Paris in February-March 2003. The goals of the meeting included: an initial discussion on the needs for and possible activities of the new international endeavour, production of a set of recommendations to the ESSP on the need for this new project, preparation of draft science and implementation plans for the project, and exploration of possible collaboration with other initiatives.

The JSC welcomed the report on the first scoping meeting to explore the need for an ESSP joint project on 'Global Change and Human Health'. The JSC encouraged the development of a draft science plan for such a project and stressed that *human* health must be the focus. The JSC further stressed the need to ensure appropriate WCRP representation and input at all stages of the process.

In conclusion of its consideration of these four ESSP joint projects, the JSC strongly reaffirmed its support for the overall concept and strategy of the projects as a basic link between climate and environmental studies and sustainable development. The JSC approved the proposal to hold a second

(ESSP) Global Change Open Science Conference in 2006, at a time and location yet to be determined and re-affirmed that WCRP should share fully in its organization and support.

10.3 Bilateral co-operation with IGBP

In addition to the physical processes which were the object of WCRP study, biological and chemical processes also had a vital role in the full climate system. Naturally, there was a close relationship between WCRP and IGBP in addressing key issues of mutual interest, and this relationship has continued to be reinforced. Examples of existing active and fruitful collaboration included those between GEWEX and the IGBP study of Biospheric Aspects of the Hydrological Cycle (BAHC), CLIVAR and the Past Global Changes (PAGES) project, WGCM and GAIM (particularly in the joint organization of the Coupled Carbon Cycle Climate Model Intercomparison), and SPARC and the International Global Atmospheric Chemistry (IGAC) project.

Professor G. Brasseur, Chair of the Scientific Committee for the IGBP, described the newly-launched “IGBP Phase II” which should offer new opportunities for co-operation and joint WCRP/IGBP activities. The structure of IGBP Phase II was based on Earth system compartments (ocean, land, atmosphere) and interfaces (ocean-land, land-atmosphere, ocean-atmosphere) involving significant re-organization of several of the existing IGBP core projects and with the ongoing GAIM and PAGES projects refocussed on cross-programme integration. A substantial integration role was also seen for the ESSP, particularly through the joint projects on food, carbon, water and health, and the "Integrated Regional Studies". In more detail, with regard to the "ocean compartment", a new project focussing on ocean bio-geochemistry and ecosystems (a follow-up to the Joint Global Ocean Flux Study, JGOFS) would be developed to complement and work closely with the Global Ocean Ecosystem Dynamics (GLOBEC) project. An IGAC Phase II was being planned for the atmosphere, and a land project would be formed bringing together the GCTE and Land Use Cover Change (LUCC) communities. The land-ocean interface would be the subject of a Land-Ocean Interactions in the Coastal Zone (LOICZ) Phase II Project and the ocean-atmosphere would be dealt with by SOLAS. For the land-atmosphere interface a new initiative was envisaged built round a core of BAHC and involving continuing collaborations with GEWEX.

Professor Brasseur gave an account also of the “Fast Track Initiatives” under IGBP. These included: integrated fire study (biological, chemical and societal aspects), global cycles of nitrogen, iron, and contaminants (e.g. mercury) in the Earth system, and global emission inventories. IGAC is focussing on oxidation, photochemistry and aerosols in the troposphere.

The JSC noted and welcomed the continuation and strengthening of the existing interactions between WCRP and IGBP activities and observed that further opportunities for such productive collaborations should continue to be explored as “IGBP Phase II” is implemented. The JSC welcomed the ongoing efforts in the joint IGBP/WCRP “Atmospheric Chemistry and Climate” initiative and suggested that links between IGAC and the cloud resolving model project (physics,chemistry and convection) should be explored. The JSC supported the forthcoming efforts in this direction including the joint SPARC/IGAC Workshop in April 2003.

Another area of co-operation where WCRP had already contributed and where further WCRP support was being sought was the Surface Ocean-Lower Atmosphere Study (SOLAS) initiative. The basic scientific focus of SOLAS was the interaction between the atmosphere, climate and marine biogeochemical processes. SOLAS was envisaged as a hypothesis-driven programme: hypotheses arising from critical issues related to global change would be posed and specific experiments and studies designed and conducted within SOLAS in order to test them. It was anticipated that, when the scientific mission, foci, and hypotheses were fully-elaborated, SOLAS should be of major interest to both the WCRP and IGBP. SOLAS was intended to build on the work of other projects such as IGAC, the Joint Global Ocean Flux Study (JGOFS) and WOCE and should also be closely linked to CLIVAR. Partnerships should be established between atmospheric and marine research scientists in the biogeochemical, atmospheric chemistry and physical oceanography communities. Such partnerships and overcoming barriers to interdisciplinary science were essential if SOLAS were to succeed.

The SOLAS programme web site is located at http://www.solas-int.org. In 2002-2003, active work has been continuing on the SOLAS Science Plan. It has been converted into a Science Plan/Implementation Strategy. This work involved refinement of all three foci of SOLAS and a number of cross - cutting activities in SOLAS, which include modelling, remote sensing, and time series studies. During the last year Dr K. Denman and Professor P. Schlosser have led a group of specialists, who have significantly re-worked and extended the section of the Plan on SOLAS Focus 2. The work on the SOLAS Science Plan/Implementation Strategy is nearing its completion.

The JSC welcomed progress in development and implementation of SOLAS and confirmed WCRP's qualified co-sponsorship. SOLAS is encouraged to establish contacts to relevant WCRP projects and vice versa. In addition to the specific co-sponsorship of SOLAS, 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, would be represented on the new WGSF. Since the interests of WGSF will overlap with those of the newly-proposed Modelling and Observation Councils of WCRP, it should work closely with them.

10.4 Global Change System for Analysis, Research and Training (START)

Professor S. Gadgil, Co-Chair, START Scientific Steering Committee, reported on a strategic review of START and of capacity building and regional research within the core projects/activities in the respective individual programmes, and also in the evolving Earth System Science Partnership (ESSP) joint projects (carbon, food, water). START was established, initially by IGBP, to help with capacity building and the development of regional networks. The initial aim therefore was to support the IGBP projects in a direct way. In the mid-1990s the sponsorship of START was expanded to include IHDP and WCRP. Over the last few years there has been a growing feeling in some quarters that START has been developing and implementing its own agenda, with the consequence of it having less direct relevance for the sponsoring programmes. For this and other reasons, it was felt timely to take stock of where each of the sponsoring programmes is with capacity building and with the spread and penetration of its project/activity networks into developing countries. To this end, a strategic review of START and its role within the international global change research community was initiated in late 2002. A questionnaire was submitted to the scientific leaders and secretariats of its core activities by each sponsoring programme of START.

In summary, the responses received from the core activities of WCRP indicated that their overall direct involvement with START had been minimal. There remains little evidence that WCRP projects are seeking to make any significant direct use of the considerable regional networks established by START or trying to help or influence START activities to their advantage. This is consistent with the general discussions on START and capacity building at recent JSC sessions. It should be recalled that, at the last JSC session (Hobart, March 2002), "the JSC again urged WCRP core programmes to establish links with START whenever appropriate and possible, and to take advantage of START facilities and networks to aid in the effective transfer of WCRP knowledge to developing countries". These JSC sentiments, requirements and aspirations for capacity building are not yet being effectively achieved, at least not directly or significantly through START. Based on the overall comments and specific responses from WCRP core activities, the Director, WCRP, made several recommendations to the JSC.

The JSC noted and discussed the presentation of the strategic review of START and of capacity building and regional research within the core projects/activities in the respective individual programmes and also in the evolving ESSP joint projects. It acknowledged the WCRP-solicited responses to the review's questionnaire, particularly that the involvement of core activities of WCRP with START has not been significant. The JSC again urged core projects of WCRP to establish appropriate links with START and to exploit START infrastructure to transfer their research knowledge to developing countries. The JSC encouraged increased interaction of WCRP with START regional networks in developing countries. In particular, the JSC supported the proposal that START should continue to implement several types of activities on behalf of its sponsoring programmes (i.e. WCRP, IGBP and IHDP). Specifically, it should work with the global programmes to facilitate the implementation of aspects of the core projects in developing countries; it should promote the development of scientific capability in developing countries; it should support capacity building activities of priority to developing regions. On the issue of capacity building, the JSC encouraged, in addition to interactions with START, increased interaction with other organizations involved directly with developing scientifically-relevant research networks in developing countries (e.g. the Asia Pacific Network (APN) and the Inter-American Institute for Global Change Research (IAI)), but within the limits of available resources and with due regard to the full range of WCRP priorities. The JSC supported and encouraged the direct actions of WCRP projects and activities in seeking to develop their own scientific capacities whenever and wherever appropriate, including in developing countries.

11. CLIMATE MONITORING AND CO-OPERATION/LIAISON WITH GLOBAL CLIMATE OBSERVING INITIATIVES

11.1 Global Climate Observing System (GCOS)

11.1.1 Second "Adequacy Report"

Professor P. Mason, Chair of the GCOS Steering Committee (SC), briefed the JSC on some issues of concern to GCOS. The GCOS SC, at its Ninth Session in September 2000, requested the GCOS Secretariat to develop a Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC. This report was to build on the information on systematic observations submitted as part of the national communications to the Conference of the Parties (COP), in accordance with reporting guidelines developed by GCOS and adopted by COP, along with other available information on climate observing systems. At its Fifteenth Session in Marrakech in November 2001, the UNFCCC Subsidiary Body on Scientific and Technological Advice (SBSTA-15) endorsed the preparation of such a report addressing the needs of the Convention and invited the GCOS Secretariat, in its preparation of the report, to take into account relevant COP decisions on capacity-building, technology transfer and adaptation. It also asked that the report consider an integrated approach to global climate observing systems, including the exploitation of new and emerging methods of observation. SBSTA-15 also noted the need to complete the Second Adequacy Report in the shortest possible time to provide a framework for further work to improve global monitoring systems. It therefore asked the GCOS Secretariat to prepare an interim report on the synthesis and analysis of the national reports from Parties for consideration by SBSTA-16 in June 2002, and to complete the final report by SBSTA-18 (June 2003) in order for it to be considered by COP-9 in November 2003. That Interim Report included a number of additional recommendations from the Tenth Session of the GCOS SC in April 2002 as well as the plan for completion of the Second Adequacy Report and a proposal to involve experts previously engaged in the work of the IPCC. SBSTA-16 welcomed the report and the process proposed for developing the Second Adequacy Report.

The GCOS Regional Workshop Programme is continuing, with four of the ten planned workshops having been completed (the fifth, for West and Central Africa, is scheduled for Niamey, Niger from 24-26 March, 2003). The main objective of the workshops is to identify problems in climate observing systems in developing countries and to facilitate needed improvements through the development and implementation of Regional Action Plans for each region. The programme is being supported by the UNFCCC through the Global Environment Facility.

The JSC welcomed and appreciated the "Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC" prepared by GCOS. The report assesses how well current and planned observing systems meet scientific requirements, observing principles and the needs of the Convention (including the IPCC). The JSC noted the critical finding of the report of the need to improve the availability of, and access to, climate data, particularly to hydrological data, such as precipitation, river discharge and ground water levels. Developing countries will need assistance to ensure global coverage of GCOS baseline networks and to meet regional data needs for impact and adaptation analyses.

11.1.2 WCRP/GCOS Atmospheric Observation Panel for Climate (AOPC)

Professor P. Mason briefed the JSC on progress being made by the AOPC. Recent progress in the implementation of the GCOS baseline networks for surface (GSN) and upper air observations (GUAN) consisted of review/prioritization of station lists, progress at monitoring and analysis centres, increasing historical data available, bringing out a manual on GSN and GUAN, and establishment of CBS Lead Centres for GCOS data. There has been increased liaison/cooperation with CBS, CCI, satellite agencies, and START and IPCC on data recovery and analysis. Two workshops were held: one on Historical Marine Climate Data (Boulder, USA, January/February 2002) and the second on Surface Pressure Observations (Norwich, UK, November 2002). The AOPC eighth session has endorsed the concept for a joint GCOS/WCRP International Conference on Atmospheric Observations for Climate in 2003 or 2004.

The JSC noted with appreciation continuing progress in a range of AOPC activities.

11.1.3 WCRP/GCOS/GOOS Ocean Observations Panel for Climate (OOPC)

Dr D.E. Harrison, Chair, recalled that the WCRP/GCOS/GOOS Ocean Observations Panel for Climate (OOPC) was tasked to provide advice on requirements for sustained ocean data for climate and related physical ocean systems. Its principal partner in research is CLIVAR (in particular its Ocean Observations Panel and Basin Panels). With new activity in ocean carbon, new partnerships are developing

with the international carbon bodies (e.g. the ESSP Global Carbon Project). The Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), and particularly its Observations Coordination Group, is an important implementation coordination partner. An updated website has been produced at: http://ioc.unesco.org/oopc/. Dr Harrison provided an overview of the seventh session of the Panel held in Kiel in June 2002 and subsequent activities. Following the success of the OceanObs99 meeting and the refereed publication of core action elements for sustained observations in "Observing the Ocean in the 21st Century", implementation, evaluation and evolution of the action plan, as well as additional Pilot Projects will be needed. Development of instrument systems for sustained measurement of important variables and of refined observing strategies needs to be fostered. Another look at present recommended actions will occur through the preparation of the Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC.

The Global Ocean Timeseries Observatory System was aimed at the development of a global network of multi-disciplinary time series stations supplying high-quality fixed-point data sets for testing and developing models and for monitoring change. The initial implementation consists of all operating sites and those planned to be established within five years, subject to evaluation in terms of the qualifying criteria by the Science Team. The Science Team are currently developing an implementation plan for the project, and updated information can be obtained at: http://www.oceanpartners.ucsd.edu/geo. A pilot system (2001-2006) has been defined consisting of all operating sites and those planned to be established within five years, subject to evaluation in terms of the qualifying criteria set by the Science Team. The Science Team for the Project is in the process of developing an implementation plan.

OOPC had also conducted a review of the tropical moored buoy network. The report is available at: http://www.ogp.noaa.gov/mpe/co/docs/tao_report.pdf The OOPC feels that the report would have been stronger had it provided more guidance concerning evolution of the system. Based on a variety of discussions, enhancements leading to greater vertical resolution as well as more observations of very near-surface currents and of salinity have considerable community support. To address the issue of data loss in some locations consideration should be given to alternative mooring strategies (e.g. small surface element), to investigation of the suitability of glider technology; and to cessation of array elements where the data return is consistently less than 75% with a routine maintenance schedule (because continuity of the time-series is then fundamentally damaged). The OOPC feels that implementation outside the equatorial zone should be coordinated as part of the Surface Reference Network strategy, and/or the Time-Series Array, and/or a strategy for boundary currents.

The importance of the GODAE Tropical Pacific pilot project (to begin in 2003) to provide guidance concerning a system wide observing strategy for the tropical Pacific was noted. Interest in the development of a plan for a tropical moored array in the Indian Ocean was noted, and work toward such a plan occurred at the Indian Ocean Global Ocean Observing System (IOGOOS) meeting in November 2002.

The Voluntary Observing Ship (VOS) Programme, Ship-of-Opportunity Programme (SOOP), and Automated Shipboard Aerological Programme (ASAP) were also central to the overall OOPC strategy, particularly in obtaining surface marine fields. A special effort VOSClim, subset of VOS, which aims to provide high-quality marine meteorological data is progressing well. Remote sensing requirements and implementation were covered in the Oceans Theme paper developed by the IGOS Partners. The document is available at: http://ioc.unesco.org/igospartners/IGOS-Oceans-Final-0101.pdf.

The OOPC had concluded that, for some ocean basins, it seemed more effective to tackle the issue of ocean observations on a more comprehensive basis, including both research requirements and the more general needs of GOOS. This enabled a broader constituency to be involved, for example, in the Indian Ocean, where a "whole-of-ocean" approach to the science, design, planning and implementation of an overall ocean observing network was being taken, building upon the outcome of a meeting in November 2000. A second conference to plan the IOGOOS was held in November 2002 in Mauritius. Agreement to establish a GOOS Regional Association (IOGOOS) was reached by many of the Indian Ocean rim nations and a Memorandum of Understanding was signed. The open ocean group identified the subseasonal variability in the atmosphere and ocean as key phenomena deserving enhanced observations and modelling. Working groups on coastal and open ocean needs met and plans are being prepared for elements of an Indian Ocean observing strategy. OOPC agreed to pursue a similar strategy for the South Atlantic, and the first South Atlantic Climate Observing System (SACOS) conference was held after the PIRATA-9 meeting in Rio de Janeiro, Brazil in February 2003. The case needs to be made, however, that the South Atlantic has impact larger than just the local effects in order to attract larger funding.

The JSC noted with approval the progress in, and future plans for, a wide range of OOPC activities. In particular, JSC acknowledged OOPC's assistance to WCRP by participating in forming a group to identify and push for a specific set of satellite observations. JSC also endorsed steps being taken by OOPC to move towards an integrated global ocean climate observing system. The need for OOPC to monitor and strengthen its interactions with CLIVAR and CliC was re-affirmed.

11.2 The Integrated Global Observing Strategy (IGOS)

The continuing development of the WCRP depended fundamentally on global remotely-sensed data and exploiting to the full the new generation of Earth observational satellites foreseen in the coming years. In this respect, IGOS, whose goal was to produce comprehensive global, regional and national environmental data and information for policy-makers and to support scientific and operational environment-related programmes, had significant potential importance for the WCRP. The IGOS Partnership (IGOS-P) was established in 1998 and, as well as the Committee on Earth Observation Satellites (CEOS) which had originally initiated IGOS, included GCOS, GOOS, GTOS and the WMO Global Atmosphere Watch (GAW) and the Global Observing System of the World Weather Watch; the international agencies sponsoring these systems, WMO, FAO, ICSU, IOC, UNEP and UNESCO; WCRP and IGBP; and the International Group of Funding Agencies (IGFA). WCRP participates in the development of several of the IGOS themes, namely the ocean, carbon, atmospheric chemistry and water cycle themes. CEOP has been adopted by the IGOS Partnership as the first major component of the Global Water Cycle Theme. WCRP has a leading role in the water cycle theme. A writing team is preparing the Water Cycle Theme Report. Several members of this team are WCRP scientists, including the two Co-Chairs R. Lawford and K. Nakamura. The Director of WCRP is the Chair of the advisory team. Three workshops have been organised at the beginning of 2003 in the USA, The Netherlands and Japan to help prepare the report.

The JSC noted with appreciation the progress achieved towards the preparation of the report of the IGOS Integrated Global Water Cycle Observations theme, under the leadership of Dr R. Lawford, and that, following three workshops in early 2003, a draft report would be prepared for the IGOS Partners meeting in 2003.

11.3 WCRP space mission requirements

The report prepared by the WCRP Satellite Working Group on an "Update of space mission requirements for WCRP" was presented at the GEWEX Scientific Steering Group (SSG) meeting in January 2003 and at the third session of the WMO Consultative Meetings on High-level Policy on Satellite Matters (CM-3) in February 2003. The document was discussed in depth and, in general, welcomed in that it highlighted three important issues namely, priorities for future space missions, requirements for data management and enhanced interactions with space agencies. While endorsing the views of the Working Group that space observations from current and planned missions offer an unprecedented potential for climate research, the GEWEX SSG and CM-3 participants urged that joint efforts should be made to integrate separate sensor/satellite data into high-quality, globally-integrated climate products. They also agreed that this potential would be further enhanced by the approval of new high-priority space missions focussing on the water cycle and cloud radiative processes (GPM- Global Precipitation Measurement and MEGHA-TROPIQUES missions), on ocean salinity and soil moisture measurements (SMOS-Soil Moisture and Ocean Salinity mission, and Aquarius). This statement does not preclude reinforcing the effort in other areas where one or several research missions are already firmly planned but where major observational issues remain, for example global 3-D wind measurements using a lidar technique. They also stressed the fact that the identification, by space agencies, of mechanisms to ensure the transition from research to operational systems should be considered with a high priority to meet WCRP's objectives. It was also suggested that WCRP liaise with IGBP to present a coordinated view on observational requirements with regard to the global carbon cycle and to greenhouse trace gases.

For data management issues, WCRP was encouraged to develop an overall strategy on how to further engage the broader community in the development, benchmarking and use of climate research products. It was recommended that this effort be conducted in close cooperation with and involvement of space agencies. Use of fora such as CEOS and its Working Groups (in particular WGISS, the Working Group on Information Systems and Services) was also recommended.

As regards the enhanced interaction with space agencies, it was not felt necessary to set up a new high-level coordinating body that would consider joint strategy, policy and plans but rather WCRP should make use of existing bodies. The IGOS-P was suggested as the most appropriate body where WCRP could discuss requirements articulated in the report, in addition to CEOS, the Coordination Group for

Meteorological Satellites (CGMS) and the WMO Consultative Meetings which should be involved in their respective capacities. Cross participation of space agencies and WCRP members in respective advisory committees was strongly recommended as a possible immediate/short term action to ensure optimal interaction at the project management level. At the working level, space agencies were encouraged to increase their links with WCRP projects to discuss, in particular, data analysis activities.

The JSC welcomed and appreciated the Satellite Working Group report and acknowledged and supported the need for closer interaction between WCRP and space agencies with WCRP taking the lead scientific role and exploring appropriate interaction mechanisms. The JSC encouraged WCRP to bring together climate modelling and satellite data communities, especially for the land-related issues. Efforts must be made to demonstrate how successfully WCRP has used the existing satellite data and continues to do so. The JSC pointed out that this activity would be the concern of both the proposed Modelling and Observation Councils. The JSC endorsed development of a plan for a coordinated analysis and reanalysis of all global satellite observations for climate research while keeping in mind the need for continued processing as sensors evolve. It also endorsed the main recommendations of the Satellite Working Group report, concerning: (i) the request for increased support of space agencies in the development of climate data sets, (ii) the need for cross-participation of WCRP and space agencies on respective advisory bodies and (iii) its proposed work-plans for 2003.

12. RELATIONSHIPS WITH IPCC AND UNFCCC

12.1 Intergovernmental Panel on Climate Change (IPCC)

Dr M. Manning, Director, IPCC Working Group I, Support Unit, presented the plans towards the preparation of the Fourth Assessment Report (AR4) which is scheduled to be completed in 2007. The areas of emphasis for AR4 are: regional climate including predictability and links between modes of variability (NAO,ENSO,etc) and global change, regional climate models and downscaling techniques to regional climate, the role of regional forcing aspects(ozone, aerosols, land-use changes), perturbation of the hydrological cycle, palaeoclimate studies and cryosphere.

The JSC welcomed with appreciation the comprehensive oral report on the status of the planning and preparations for the IPCC's Fourth Assessment Report (AR4). JSC noted with encouragement the strengthening direct liaison and interaction between WCRP and IPCC WGI with respect to specific emerging initiatives and supported WCRP's involvement in the proposed IPCC Climate Sensitivity Workshop in 2004. The JSC expressed that expertise from WCRP core projects should be made available in the preparation of AR4. WCRP should assist IPCC, where appropriate, with review of draft material through the AR4 process.

12.2 Subsidiary Body on Scientific and Technological Advice (SBSTA) of the Conferences of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC)

At its sixteenth session in June 2002, SBSTA discussed the Third Assessment Report (TAR) of the IPCC and noted the need for enhanced interaction with the international research programmes on the scientific questions related to the work of the Convention. Representatives of the IPCC and international research programme and bodies, including WCRP, IGBP and IHDP were invited to attend the seventeenth session of SBSTA (SBSTA 17, 23 October – 1 November 2002, New Delhi, India), to provide their views on the research recommendations identified in the TAR. The Director of the WCRP participated in the session and gave an invited oral statement on behalf of WCRP to the SBSTA 17 plenary under its Agenda item 8, Research and Systematic Observation, and represented WCRP at a special UNFCCC side event to enable Parties to have a substantial dialogue with the representatives of the invited international research programmes (WCRP, IGBP and IHDP), IPCC, the International Energy Agency, and the International Group of Funding Agencies (IGFA) for Global Change Research. This was the first time that WCRP had been invited to participate in a SBSTA session. The conclusions from two SBSTA 17 Agenda items (8, Research and Systematic Observation and 4(f), Methodological Issues: Scientific and Methodological Aspects of the Proposal by Brazil) are of direct relevance to WCRP, and required consideration and decisions by the JSC. SBSTA also decided to 'regularly consider issues related to research on climate at its future sessions'.

A SBSTA expert meeting was held on the matter of the so-called 'Brazil proposal' and SBSTA noted that a number of scientific and methodological issues remained. The SBSTA agreed that further work should be of a standard consistent with the practices of peer-reviewed published science. The process should be inclusive, open and transparent. The SBSTA noted that, for the purpose of validating the models against observed climate, the analysis should also include factors influencing global climate other than the greenhouse gases covered by the Convention and the Kyoto Protocol. Mr. Luiz Gylvan Meira Filho, Senior Scientific Adviser, UNFCCC Secretariat, sent an explanatory note to the Director of the WCRP saying that it

would be extremely helpful if the JSC of the WCRP were to agree that the issue of "attribution of climate change, as measured in terms of the increase in global mean surface temperature or mean sea-level rise, to individual sources of emission" is a relevant issue and would try to identify, within its structure of programmes, the aspects that are relevant to modelling the non-linearities affecting such attribution.

The JSC noted that the Director, WCRP, had participated, by invitation, in SBSTA 17 (at the eighth session of the COP) and: gave an oral statement on WCRP to the SBSTA 17 plenary under the agenda item on “Research and Systematic Observation”; represented WCRP at a special UNFCCC side event to enable Parties to have a substantial dialogue with representatives of invited international research programmes. The JSC welcomed the SBSTA decision to regularly consider issues related to research on climate at its future sessions. The JSC acknowledged that it is important to be able to detect climate change and attribute it to individual sources, but noted that the problem in reality is highly complicated, with no known methods for achieving relatively quick and sound answers that would stand the test of objective scientific appraisal. The full problem is too complex to be decided by the use of simple models. The JSC proposed that WCRP offer to: conduct a critical review of a comprehensive scientific report, submitted by SBSTA, on the clear objectives of the so-called ‘Brazilian proposal’, the methodologies used to date in addressing the scientific issues involved, and the results achieved (should such a report be available); provide WCRP representation at the workshop on the ‘Brazilian proposal’ that has been suggested for 2003 by the governments of Brazil and the UK; point out specific research activities being undertaken or planned by WCRP, which are of direct relevance to the fundamental science and methodologies which underpin the issues raised in the ‘Brazilian proposal’.

13. ADMINISTRATIVE MATTERS

13.1 Internal matters of the JSC

The JSC discussed in executive session various matters bearing on the overall management, organization and structure of the WCRP. In particular, the appointments of the Officers of the Committee were considered. Dr K. Trenberth was unanimously elected as the third Officer for the two-year period 1 April 2003-31 March 2005, to fill the vacancy left by Professor A. Sumi who stepped down from the Committee on 31 December 2002.

To ensure that the JSC overview is maintained and that appropriate interactions between WCRP activities take place, in the context of the emerging COPE, specific JSC members were appointed to liaise directly with specific projects and activities. These JSC members will: liaise directly with the Chair/Co-Chairs of the respective SSG, Working Group (WG) or Council, with discussion/consultation between JSC sessions as necessary and appropriate; serve as focal points, lead discussants and Chairs for items dealing with their respective activities at JSC sessions. Participation of JSC liaison person(s) at respective SSG, WG or Council session(s) is encouraged. The JSC liaison responsibilities include:

CLIVAR - B. Hoskins and G.B. Pant
CliC - P. Lemke
SPARC - V. Ramaswamy
GEWEX - T. Yasunari and Y. Ding
Modelling Council - J. Shukla and V.P. Meleshko
Observation Council - K. Trenberth
GCP - J. Church
GECAFS -D. Whelpdale
GWSP - T. Yasunari
Global Change and Human Health - L.A. Ogallo
SOLAS and Surface Fluxes - K. Denman, P. Schlosser, S. Gulev and M.T. Zamanian

The JSC also recommended that an annual meeting of WCRP “officers, Chairs and Directors” should be held, ideally about six months after the annual JSC session.

13.2 Organization and membership of WCRP scientific and working groups

The JSC decided that all membership issues should be discussed and decided ahead of the relevant expiry dates. To achieve this, the 25th session of the JSC (March 2004) will deal with expiry dates of 31 December 2003 and 31 December 2004. It was stressed that every effort should be made to involve developing countries and promising young scientists in WCRP groups, and that the names of such candidates should be sought and considered. JSC liaison persons should consult with respective Chairs of

SSGs, WGs, Councils, and the Director, WCRP, to agree membership proposals to be submitted to the JSC, starting with JSC-XXV, March 2004.

The JSC reviewed the organization and membership of the principal WCRP working and steering groups and proposed renewals of appointment or nominated new members as appropriate. Affiliations/contact information for members of these groups may be found via the WCRP web page at http://www.wmo.ch/web/wcrp/committees.htm.

JSC/CAS Working Group on Numerical Experimentation (WGNE)

Membership of the WGNE was determined by consultation between the Chairman of the JSC and the President of CAS. No changes were due to be made and the composition remained:

Membership	Expiry of appointment
K. Puri (Chair)	31 December 2003
P. Bougeault	" 2003
J. Côté	" 2005
Chen Dehui	" 2003
V. Kattsov	" 2003
S. Lord	" 2003
A. Lorenc	" 2003
D. Majewski	" 2005
M. Miller	" 2003
K. Saito	" 2005
D. Williamson	" 2003

JSC/CLIVAR Working Group on Coupled Modelling (WGCM)

The terms of the members Drs. C. Boening and G. Hegerl which expired on 31 December 2002 were extended by two years. As Chairman of WGOMD, Dr C. Boening continues to be ex-officio member of WGCM. The group was thus now constituted as follows:

Membership	Expiry of appointment
J. Mitchell (Chair)	31 December 2003
C. Boening	" 2004
P. Braconnot	" 2005
T. Delworth	" 2003
G. Hegerl	" 2004
A. Hirst	" 2005
M. Latif	" 2004
H. Le Treut	" 2003
B. McAvaney	" 2003
G. Meehl	" 2003
A. Noda	" 2003
A. Weaver	" 2003
D. Webb	" 2003

WOCE Scientific Steering Group

The mandate of this group formally came to an end following the WOCE Final Conference in November 2002.

CLIVAR Scientific Steering Group

Since the annual session of the CLIVAR Scientific Steering Group closely followed that of the JSC, changes in or renewals of, membership to take effect from 1 January 2003 were agreed in advance by the Chairman of the JSC on behalf of the Committee. In that context, Professor A. Busalacchi's term as a Co-chair of the CLIVAR Scientific Steering Group (SSG) was extended by two years. Three other members whose terms expired on 31 December 2002 (Drs T. Palmer, K. Trenberth, R. Weller) have also had their terms of appointment extended by two years. Dr H. Cullen (NCAR, USA) and Professor R. Zhang (Chinese Academy of Meteorological Sciences, China) have accepted invitations to be members of the SSG for an

initial term of four years in place of Drs G. Wu and F. Zwiers who stepped down from membership when their terms expired on 31 December 2002. It was also agreed that a further nomination to the CLIVAR SSG should be held over until 1 January 2004. The membership of the CLIVAR Scientific Steering Group was thus:

Membership	Expiry of appointment
A. Busalacchi (Co-chair)	31 December 2004
J. Willebrand (Co-chair)	" 2003
H. Cullen	" 2006
T. Palmer	" 2004
P.L. da Silva Dias	" 2003
I. Simmonds	" 2003
T. Stocker	" 2004
M. Suarez	" 2003
K. Takeuchi	" 2003
K. Trenberth	" 2004
R. Weller	" 2004
R. Zhang	" 2006

ACSYS/CliC Scientific Steering Group

Dr B. Goodison was appointed the new Chairman since Dr H. Cattle took up his new position as Director of the International CLIVAR Project Office in August 2002 and vacated the Chair. Dr E. Fahrbach whose term expired on 31 December 2002 was now leaving the group. Dr J. Turner (British Antarctic Survey, UK) and Dr D. Kane (Water and Environmental Research Centre, University of Alaska, USA) were being invited to accept membership for an initial term of three years. The composition of the group was thus:

Membership	Expiry of appointment
B. Goodison (Chair)	31 December 2003
I. Allison (Vice-chair)	" 2003
R. Barry (Vice-chair)	" 2003
M. Burgess	" 2004
M. Drinkwater	" 2004
T. Fichefet	" 2003
V. Kotlyakov	" 2004
T. Ohata	" 2004
Qin Da He	" 2004
H. Zwally	" 2004
J. Turner	" 2006
D. Kane	" 2006

GEWEX Scientific Steering Group

The terms of the Chairman and that of Dr R. Atlas and Dr U. Schumann, which expired on 31 December 2002, were extended by two years. Dr A. Hollingsworth (ECMWF) whose term expired on 31 December 2002 was now leaving the group. Dr A. Beljaars (ECMWF) was being invited to accept membership for an initial term of three years. The membership of the group was thus:

Membership	Expiry of appointment
S. Sorooshian (Chair)	31 December 2004
T. Ackerman	" 2004
R. Atlas	" 2004
L. Gottschalk	" 2004
A. Beljaars	" 2005
Y. Kerr	" 2004
Z. Kopaliani	" 2004
K. Nakamura	" 2004
D. Randall	" 2004
U. Schumann	" 2004
M.F. Silva Dias	" 2004

K. Takeuchi	"	2004
G. Wu	"	2004

SPARC Scientific Steering Group

Professors M. Geller (Co-chair) and D. Karoly whose terms expired on 31 December 2002 were now leaving the group. The terms of Professor A. O'Neill (Co-chair) and several members which expired on 31 December 2002 were extended by two years. Professor A.R. Ravishankara, presently member, was being invited to accept the Co-chairmanship. Dr J.P. Burrows (Institute of Environmental Physics, University of Bremen, Germany) and Professor D. Hartmann (University of Washington, Seattle, USA) were being invited to accept membership for an initial term of three years. The membership of the group was as follows:

Membership	Expiry of appointment	
A. O'Neill (Co-chair)	31 December	2004
A.R. Ravishankara (Co-chair)	"	2004
J.P. Burrows	"	2006
P. Canziani	"	2004
C. Granier	"	2004
K. Hamilton	"	2004
D. Hartmann	"	2006
T. Peter	"	2004
U. Schmidt	"	2004
T. Shepherd	"	2004
S. Yoden	"	2004
V. Yushkov	"	2004

WCRP/GCOS/GOOS Ocean Observations Panel for Climate

No changes were due for the membership of the Ocean Observations Panel for Climate, jointly sponsored by the JSC and the Joint Scientific and Technical Committees for GCOS and GOOS. The composition of the Panel thus remains as follows:

- E. Harrison, NOAA Pacific Marine and Environment Laboratory, Seattle, USA (Chair)
- E. Campos, Instituto Oceanografico, University of Sao Paolo, Brazil
- T. Dickey, Ocean Physics Laboratory, University of California, Santa Barbara, USA
- J. Johanessen, Earth Sciences Division ESA-ESTEC, Noordwijk, Netherlands
- M. Kawabe, Ocean Research Institute, University of Tokyo, Japan
- J.R. Keeley, Marine Environmental Data Service, Department of Fisheries and Oceans, Ontario, Canada
- J. Picaut, Laboratoire d'Etudes en Géophysique et Océanographie Spatiale, Toulouse, France
- R. Reynolds, NOAA/NESDIS, Washington, DC, USA
- P.K. Taylor, Southampton Oceanography Centre, UK
- R. Weller, Woods Hole Oceanographic Institution, USA
- W. Zenk, Institut für Meereskunde, University of Kiel, Germany

WCRP/GCOS Atmospheric Observation Panel for Climate

No changes were due and the membership of the group remained:

- M. Manton, Bureau of Meteorology Research Centre, Melbourne, Australia (Chair)
- P. Arkin, University of Maryland, USA
- E. Harrison, NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA
- P. Jones, Climatic Research Unit, University of East Anglia, Norwich, UK
- S. Maeda, Japan Meteorological Agency, Tokyo, Japan
- C. Nobre, Centro de Previso de Tempo e Estudos Climaticos, INPE, Brazil
- R. Okoola, Department of Meteorology, University of Nairobi, Kenya
- D. Parker, Hadley Centre for Climate Prediction and Research, Bracknell, UK
- T. Peterson, National Climatic Data Center, Asheville, NC, USA
- J. Schmetz, EUMETSAT, Darmstadt, Germany
- G. Stephens, Colorado State University, Fort Collins, USA
- M. Suzuki, National Space Development Agency, Tokyo, Japan

13.3 Publications

The following reports were produced under WCRP auspices in various series between the twenty-third and twenty-fourth sessions of the JSC:

WCRP Report Series

WCRP-116 SPARC Intercomparison of Middle Atmosphere Climatologies - December 2002 (WMO/TD-No. 1142) (SPARC Report N° 3) - (In press)

Informal WCRP reports and documents

3/2002 Report of the twelfth session of the GEWEX Radiation Panel (GRP) (Fort Collins, CO, USA, 12-14 November 2001)

4/2002 Report of the sixth session of the CLIVAR Working Group on Seasonal to Interannual Prediction (Budapest, Hungary, 5-7 November 2001)

5/2002 IPAB Report on the third meeting of Programme Participants (Fairbanks, Alaska, USA, 26-28 June 2000)

6/2002 Report of the ninth session of the SPARC Scientific Steering Group (Honolulu, Hawaii, USA, 4-7 December 2001)

7/2002 Report of the seventeenth session of the CAS/JSC Working Group on Numerical Experimentation and of the fifth session of the GEWEX Modelling and Prediction Panel (Offenbach, Germany, 29 October-2 November 2001)

8/2002 Report of the first meeting of the CLIVAR Pacific Panel (Hawaii, USA, 7-9 February 2002) - ICPO No. 61

9/2002 Report of the fifth session of the JSC/CLIVAR Working Group on Coupled Modelling (Bracknell, Berkshire, UK, 4-7 February 2002) - ICPO No. 62

10/2002 Report of the seventh session of the GEWEX Hydrometeorology Panel (GHP) (Paris, France, 6-7 September 2001)

11/2002 Report of the second session of the WCRP ACSYS/CliC Scientific Steering Group (Halifax, Canada, 15-19 October 2001)

12/2002 Report of Issues/Actions/Recommendations from the Coordinated Enhanced Observing Period (CEOP) Implementation Planning Kick-off Meeting (Tokyo, Japan, 6-8 March 2002)

13/2002 Report of joint meeting of the ACSYS/CliC Numerical Experimentation Group, Observations and Products Panel, and Data Management and Information panel (Cambridge, UK, 17-20 September 2001)

14/2002 Report of the third session of the WOCE/CLIVAR Working Group on Ocean Model Development (Hamburg, Germany, 6-8 May 2002) - ICPO No. 67

15/2002 Report of the fifth session of the CLIVAR VAMOS Panel (San José, Costa Rica, 13-16 March 2002) - ICPO No. 64

16/2002 Report of the first session of the CLIVAR/CliC Southern Ocean Panel (Hobart, Tasmania, Australia, 11-13 March 2002) - ICPO No. 65

17/2002 Report of the Comparison of Large Scale Sulfate Aerosol Models (COSAM) workshop (Halifax, Canada, 19-21 October 1998)

18/2002 Report of the seventh session of the BSRN Science and Review Workshop (Regina, Canada, 28-31 May 2002)

19/2002 Report of the second session of the CLIVAR VACS Panel (Niamey, Niger, 28 February – 2 March 2002) - ICPO No. 66

20/2002 Report of the fourth meeting of the CLIVAR Atlantic Implementation Panel ICPO No. 68

21/2002 Report of the seventh session of the OOPC (Kiel, Germany, 5-9 June 2002)

1/2003 Report of the thirteenth session of the GEWEX Radiation Panel (GRP) (Zurich, Switzerland, 31 July-2 August 2002)

2/2003 Report of the sixth session of the JSC/CLIVAR Working Group on Coupled Modelling (Victoria, Canada, 7-10 October 2002)

3/2003 Report of the eighth session of the GEWEX Hydrometeorology Panel (GHP) (Palisades, NY, USA, 10-12 September 2002)

4/2003 Report of the fourteenth session of the GEWEX Scientific Steering Group (Reading, UK, 28 January-1 February 2002)

Special WCRP reports

- Annual Review of the World Climate Research Programme and Report of the Twenty-third Session of the Joint Scientific Committee (Hobart, Tasmania, Australia, 18-22 March 2002) (WMO/TD-No. 1137)

CAS/JSC Working Group on Numerical Experimentation Report Series

No. 32 Research Activities in Atmospheric and Oceanic Modelling (edited by H. Ritchie) (WMO/TD-No. 1105)

Others (including reports produced by project offices)

- Arctic Climate System Study/ Climate and Cryosphere Project (ACSYS/CliC) Report to the Arctic Ocean Sciences Board by the ACSYS/CliC Observations Products Panel, 'Recent variations in Arctic Sea-Ice Thickness', IACPO Inf. No 7, April 2002

- Arctic Climate System Study (ACSYS) ACSYS Historical Ice Chart Archive (1553-2002), IACPO Inf. No. 8, January 2003

- *Challenges of a Changing Earth*, Proceedings of the Global Change Open Science Conference, Amsterdam, The Netherlands, 10-13 July 2001, Editor W. Steffen, J. Jäger, D.J. Carson and C. Bradshaw, 216pp, 2002, Springer

Most of the reports produced by the International CLIVAR Project Office also had a WCRP Informal Report number and have been included in the list of those reports. Other reports/documents available were listed on and accessible through the WCRP Home Page: http://www.wmo.ch/web/wcrp/otherwcrpreports.htm

13.4 WCRP resources

A summary of the proposed activities to be supported by the Joint Climate Research Fund (JCRF) for the Fourteenth WMO Financial Period (2004-2007) was presented to the JSC. This proposal was subject to review and decision by the Fourteenth World Meteorological Congress in May 2003 and the executive bodies of IOC and ICSU. Note that, if this budget is approved, the funds available for WCRP activities from the JCRF are very significantly lower for the period 2004-2007 than for 2000-2003 (less than 4.7M CHF compared to about 6.0M CHF). This will mean a significant reduction in the number of project meetings/activities that can be supported in 2004-2007 from the JCRF. Note also that these reduced funds are expected to support a much wider range of WCRP-promoted activities than was the case earlier.

The number of positions in the Joint Planning Staff (JPS), Geneva, is expected to be maintained at the current level (i.e. 7.3 FTE staff). The current workload on the JPS is high, increasing and widening in scope, consistent with the increasing range and number of activities being undertaken in the WCRP. The WCRP sectorial support to its core projects through its International Project Offices is also generally under-funded and otherwise under-resourced, and therefore under constant strain.

In view of the scarcity of and pressure on resources, and the anticipated decrease in available funds in the JCRF for period 2004-2007, JSC members are asked to act strongly as spokespersons in their home countries and to stress to national funding agencies the importance of supporting and increasing financial contributions to WCRP and project offices. JSC members are urged to continue to pursue possibilities for obtaining national or institutional resources to cover the costs of attendance of themselves in sessions of the JSC, and of other individual national participants in WCRP meetings, working group sessions and workshops.

14. DATE AND PLACE OF THE TWENTY-FIFTH SESSION OF THE JSC

The JSC gratefully accepted the kind invitation of Dr S. Gulev, JSC Member, to host the twenty-fifth session of the Committee in Moscow, Russia, from 1 to 6 March 2004. The JSC welcomed enthusiastically a proposal to hold one day (probably 5 March) jointly with the Scientific Committee for the IGBP.

15. CLOSURE OF SESSION

The Chairman thanked all participants for their contributions to the session, the high level of scientific discussions, and the steps that had been taken in the further development of the WCRP. He looked forward especially to further debate on, and development of, the concept of a “WCRP Climate system Observation and Prediction Experiment (COPE)”. The Chairman also acknowledged the excellent scientific presentations that had been given to the Committee by Prof. J. Slingo, Director of the NERC Centre for Global Atmospheric Modelling (CGAM), Department of Meteorology, University of Reading on "Climate Processes" and by Prof. J.F.B. Mitchell, Chief Scientist, Met Office, UK, on "Climate Modelling".

The Chairman paid special tribute to participants who were now retiring from their positions and who had been long involved in WCRP activities and in supporting the JSC. In particular, he noted the remarkable contributions of Dr H. Cattle, who vacated his position as Chair, ACSYS/CliC Scientific Steering Group to take up his new position as Director of the International CLIVAR Project Office.

Finally, the Chairman reiterated sincere gratitude to Professor B. J. Hoskins and all who had worked with him for the memorable arrangements that had been made for the JSC session, the excellent facilities, and generous hospitality. He asked that the appreciation of the JSC be relayed to all involved.

The twenty-fourth session of the WMO/ICSU/IOC Joint Scientific Committee for the WCRP was closed at 1530 hours on 21 March 2003.

APPENDIX A

LIST OF PARTICIPANTS

1. Members of the JSC

Professor Dr P. Lemke (Chair)
Alfred-Wegener-Institut
P.O. Box 12 0161
D-27515 Bremerhaven
Germany
Tel: 49 471 4831 1751/1750
Fax: 49 471 4831 1797
E-mail: plemke@awi-bremerhaven.de

Dr K. Denman
Canadian Centre for Climate Modelling and Analysis
University of Victoria
P.O. Box 1700 STN CSC
Victoria, BC V8W 2Y2
Canada
Tel: 1 250 363 8230
Fax: 1 250 363 8247
E-mail: ken.denman@ec.gc.ca

Professor Yihui Ding (Officer)
National Climate Centre
China Meteorological Administration
46, Zhongguancun Nandajie
Haidian District
Beijing 100081
China
Tel: 86 10 6840 6246
Fax: 86 10 6217 6804
E-mail: yhding@public.bta.net.cn and dingyh@cma.gov.cn

Dr S. Gulev
P.P. Shirshov Institute of Oceanology, RAS
Nakhimovsky Avenue 36
Moscow 117851
Russian Federation
Tel: 7 095 124 7985
Fax: 7 095 124 5983
E-mail: gul@gulev.sio.rssi.ru and gul@sail.msk.ru

Professor B.J. Hoskins (Vice-Chair)
Department of Meteorology
University of Reading
Earley Gate
P.O. Box 243
Reading, Berkshire RG6 6BB
United Kingdom
Tel: 44 118 931 89 50/53
Fax: 44 118 931 63 93
E-mail: b.j.hoskins@reading.ac.uk

Dr V.P. Meleshko
Main Geophysical Observatory
Karbyshev Street 7
St Petersburg 194021
Russian Federation
Tel: 7 812 257 4390
Fax: 7 812 247 8661
E-mail: meleshko@main.mgo.rssi.ru

Professor L.A. Ogallo
Drought Monitoring Centre
P.O. Box 30259
Nairobi
Kenya
Tel: 2542 5783 40
Fax: 2542 5783 40, 5783 43
E-mail: logallo@meteo.go.ke

Dr G.B. Pant
Indian Institute of Tropical Meteorology
Dr Homi Bhabha Road
Pashan
Pune 411 008
India
Tel: 91 20 589 3924
Fax: 91 20 589 3825
E-mail: gbpant@tropmet.res.in

Professor V. Ramaswamy
NOAA Geophysical Fluid Dynamics Laboratory
Princeton University
Forrestal Campus, US Route 1
Post Office Box 308
Princeton, New Jersey 08542
USA
Tel: 1 609 452 6510
Fax: 1 609 987 5063
E-mail: vr@gfdl.noaa.gov

Professor P. Schlosser
Lamont-Doherty Earth Observatory
Columbia University
Palisades
New York, NY 10964-8000
USA
Tel: 1 914 365 8707
Fax: 1 914 365 8176
E-mail: peters@ldeo.columbia.edu

Professor J. Shukla
George Mason University
Center for Ocean-Land-Atmosphere Studies
4041 Powder Mill Road, Suite 302
Calverton, Maryland 20705-3106
USA
Tel: 1 301 595 7000
Fax: 1 301 595 9793
E-mail: shukla@cola.iges.org

Dr D. Whelpdale
Meteorological Service of Canada (MSC)
Climate Research Branch
4905 Dufferin Street
Downsview, Ontario M3H 5T4
Canada
Tel: 1 416 739 4869
Fax: 1 416 739 5700
E-mail: douglas.whelpdale@ec.gc.ca

Professor T. Yasunari
Hydrospheric Atmospheric Research Center (HyARC)
Nagoya University
Nagoya 464-8601
Japan
Tel: 81 52 789 3465 (or 5926)
Fax: 81 52 789 3436
E-mail:yasunari@ihas.nagoya-u.ac.jp

Dr M.T. Zamanian
IRIMO
P.O. Box 13185-461
Tehran
Islamic Republic of Iran
Tel: 98 216 004 041
Fax: 98 216 469 044
E-mail: zamanian@irimet.net

Unable to attend

Dr J. Church (Officer)
Antarctic CRC and CSIRO Marine Research
GPO Box 1538
Hobart, Tasmania 7001
Australia
Tel: 61 3 6232 5207
Fax: 61 3 6232 5123
E-mail: john.church@csiro.au

Professor P. Cornejo R. de Grunaeur
Marine Science and Engineering
ESPOL-CAMPUS "GUSTAVO GALINDO"
P.O. Box 09-01-5863
Guayaquil
Ecuador
Tel: 593 42 269 478
Fax: 593 42 269 468
E-mail: pcornejo@espol.edu.ec

Dr K. Trenberth (Officer)
National Center for Atmospheric Research
P.O. Box 3000
Boulder, CO 80307
USA
Tel: 1 303 497 1318
Fax: 1 303 497 1333
E-mail: trenbert@ucar.edu

2. Invited experts and observers

Professor G. Brasseur
(Chair, Scientific Committee of the International Geosphere-Biosphere Programme)
Max Planck Institut für Meteorologie
Bundesstr. 55
Hamburg 20146
Germany
Tel: 49 40 411 73421
Fax: 49 40 411 73430
E-mail: brasseur@dkrz.de

Dr A. Busalacchi
(Co-chair, CLIVAR Scientific Steering Group)
Earth System Science Interdisciplinary Centre
University of Maryland
244 Computer and Space Science Bldg, Rm 2207
College Park, MD 20742-2425
USA
Tel: 1 301 405 5599
Fax: 1 301 405 8468
E-mail: tonyb@essic.umd.edu

Dr H. Cattle (Director, International CLIVAR Project Office)	Southampton Oceanography Centre Empress Dock Southampton SO14 3ZH UK Tel: 44 2380 596 208 Fax: E-mail: hyc@soc.soton.ac.uk
Dr C. Dick (Director, International ACSYS/CliC Project Office)	Norwegian Polar Institute The Polar Environmental Centre 9296 Tromso Norway Tel: 47 77 75 01 45 Fax: 47 77 75 05 01 E-mail: chad.dick@npolar.no
Professor R.E. Dickinson (Co-chair, IGBP/IHDP/WCRP Global Carbon Project Scientific Steering Committee)	Georgia Institute of Technology School of Earth and Atmospheric Sciences 221 Bobby Dodd Atlanta, Georgia 30332-0340 USA Tel: 1 404 385 1509 E-mail: robted@eas.gatech.edu
Professor Sulochana Gadgil (Co-chair, START Scientific Steering Committee)	Centre for Atmospheric and Oceanic Sciences Indian Institute of Science Bangalore 560012 India Tel: 91 80 394 3069 / 3942505 / 360-0450 Fax: 91 80 360 0865 E-mail: sulo@caos.iisc.ernet.in
Professor W.L. Gates (Past Chair, JSC)	PCMDI Lawrence Livermore National Laboratory P.O. Box 808, L-264 1000 East Avenue Livermore, California 94550 USA Tel: 1 925 422 7642 Fax: 1 510 422 7675 E-mail: gates5@llnl.gov
Dr L. Goldfarb (ICSU observer)	International Council for Science (ICSU) 51, boulevard de Montmorency 75016 Paris France Tel: 331 45 25 03 29 Fax: 331 42 88 94 31 E-mail: leah@icsu.org
Dr B. Goodison (Chair, ACSYS/CliC Scientific Steering Group)	Meteorological Service of Canada (MSC) 4905 Dufferin Street Downsview, Ontario M3H 5T4 Canada Tel: 1 416 739 4345 Fax: 1 416 739 5700 E-mail: barry.goodison@ec.gc.ca

Dr D.E. Harrison
(Chair, GCOS/GOOS/WCRP Ocean Observations Panel for Climate)

Pacific Marine Environmental Laboratory
NOAA/PMEL/OCRD
7600 Sand Point Way NE
Seattle, WA 98115
USA
Tel: 1 206 5266225
Fax: 1 206 5266744
E-mail: harrison@pmel.noaa.gov

Dr A.H. Hollingsworth
(Head of Research Department, ECMWF)

ECMWF
Shinfield Park
Reading RG2 9AX
UK
Tel: 44 118 9499005
Fax: 44 118 9869450
E-mail: a.hollingsworth@ecmwf.int

Dr M. Hood
(IOC observer)

IOC – UNESCO
1, rue Miollis
75732 Paris Cedex 15
France
Tel: 331 45 68 40 28
Fax: 331 45 68 58 12
E-mail: m.hood@unesco.org

Dr J. Ingram
(Executive Officer, GECaFS International Project Office)

NERC Centre for Ecology and Hydrology
Maclean Building
Crowmarsh Gifford, Wallingford
Oxon OX10 8BB
UK
Tel: 441 491 692 410
Fax: 441 491 692 313
E-mail: jsii@ceh.ac.uk

Professor P. Liss
(Chair, SOLAS Scientific Steering Committee)

University of East Anglia
School of Environmental Sciences
Norwich NR4 7TJ
UK
Tel: 44 1603 592 563
Fax: 44 1603 507 714
E-mail: p.liss@uea.ac.uk

Dr M. Manning
(Director, IPCC Working Group I Support Unit)

NOAA Aeronomy Laboratory, R/E/AL8
325 Broadway
Boulder, CO 80303
USA
Tel: 1 303 497 4479
Fax: 1 303 497 5686
E-mail: mmanning@al.noaa.gov

Professor P.J. Mason
(Chair, GCOS Steering Committee)

University of Reading
Department of Meteorology
P.O. Box 243
Earley Gate
Reading RG6 6BB
UK
Tel: 44 1344 854 604
Fax: 44 1344 856 909
E-mail: p.j.mason@reading.ac.uk

Professor J.F.B. Mitchell
(Chair, JSC/CLIVAR Working Group on Coupled Modelling)

Chief Scientist
Met Office
London Road
Bracknell, Berkshire RG12 2SZ
UK
Tel: 44 1344 856613
Fax: 44 1344 856912
E-mail: john.f.mitchell@metoffice.com

Professor A. O'Neill
(Co-chair, SPARC Scientific Steering Group)

University of Reading
Dept. of Meteorology, P.O. Box 243
Earley Gate, Whiteknights
Reading RG6 6BB
UK
Tel: 44 118 931 8317
Fax: 44 118 931 8316
E-mail: alan@met.reading.ac.uk

Dr J. Polcher
(Chair, GEWEX Modelling and Prediction Panel)

Laboratoire de Météorologie Dynamique du CNRS
Tour 25, 5ème étage
4, place Jussieu, BP 99
75252 Paris Cedex 05
France
Tel: 331 44 27 47 63
Fax: 331 44 27 62 72
E-mail: jan.polcher@lmd.jussieu.fr

Dr K. Puri
(Chair, JSC/CAS Working Group on Numerical Experimentation)

Bureau of Meteorology Research Centre
G.P.O. Box 1289K
Melbourne, Victoria 3001
Australia
Tel: 61 39 669 4433
Fax: 61 39 669 4660
E-mail: k.puri@bom.gov.au

Dr A.R. Ravishankara
(Co-chair, SPARC Scientific Steering Group)

NOAA/ERL Aeronomy Laboratory
Atmospheric Chemical Kinetics Program
325 Broadway, R/E/AL2
Boulder, CO 80303
USA
Tel: 1 303 497 5821
Fax: 1 303 497 5822
E-mail: ravi@al.noaa.gov

Dr J. Roads
(Chair, GEWEX Hydrometeorology Panel)

University of California, San Diego 0224
Scripps Institution of Oceanography
Climate Research Division
8605 La Jolla Shores Drive, NH 441
La Jolla, CA 92093-0224
USA
Tel: 1 858 534 2099
Fax: 1 858 534 8561
E-mail: jroads@ucsd.edu

Dr R. Schiffer (Acting Director, International GEWEX Project Office)	Goddard Earth Sciences & Technology Center University of Maryland, Baltimore County Technology Center, South Campus, Room 3.002 1000 Hilltop Circle Baltimore, MD 21250 USA Tel: 1 410 455 8899 Fax: 1 410 455 8806 E-mail: schiffer@umbc.edu
Professor S. Sorooshian (Chair, GEWEX Scientific Steering Group)	Department of Hydrology and Water Resources Harshbarger Building, Room 122 University of Arizona Tucson, AZ 85721 USA Tel: 1 520 621 1661 Fax: 1 520 626 2488 E-mail: soroosh@hwr.arizona.edu
Dr U. Svedin (Chair, International Group of Funding Agencies for Global Change Research)	FORMAS Box 1206 Birger Jaris Torg 5 11182 Stockholm Sweden Tel: 468 775 4037 Fax: 468 775 4010 E-mail: uno.svedin@formas.se
Professor A.J. Thorpe (Director, NERC Centre for Atmospheric Science)	Department of Meteorology University of Reading Earley Gate P.O. Box 243 Reading, Berkshire RG6 6BB UK Tel: 44 118 931 6979/6452 Fax: 44 118 931 6462 E-mail: a.j.thorpe@reading.ac.uk
Professor C.H. Vogel (Chair, Scientific Committee of the International Human Dimensions Programme on Global Environmental Change)	School of Geography, Archaeology and Environmental Science University of the Wiltwatersrand Post Bag 3, 2050 Johannesburg South Africa Tel: 27 11 717 6510 Fax: E-mail: vogelC@geoarc.wits.ac.za
Professor J. Willebrand (Co-chair, CLIVAR Scientific Steering Group)	Institut für Meereskunde der Universität Kiel Düsternbrooker Weg 20 D-24105 Kiel Germany Tel: 49 431 600 1500 or 4000 Fax: 49 431 600 1515 E-mail: jwillebrand@ifm.uni-kiel.de

3. WCRP Joint Planning Staff

Dr D.J. Carson

World Climate Research Programme
c/o World Meteorological Organization
7bis Avenue de la Paix
Case Postale No. 2300
1211 Geneva 2
Switzerland
Tel: 41 22 730 8246
Fax: 41 22 730 8036
E-mail: DCarson@wmo.int

Dr V. Satyan

World Climate Research Programme
c/o World Meteorological Organization
7bis Avenue de la Paix
Case Postale No. 2300
1211 Geneva 2
Switzerland
Tel: 41 22 730 8418
Fax: 41 22 730 8036
E-mail: VSatyan@wmo.int

Dr V. Ryabinin

World Climate Research Programme
c/o World Meteorological Organization
7bis Avenue de la Paix
Case Postale No. 2300
1211 Geneva 2
Switzerland
Tel: 41 22 730 8486
Fax: 41 22 730 8036
E-mail: VRyabinin@wmo.int

Dr G. Sommeria

World Climate Research Programme
c/o World Meteorological Organization
7bis Avenue de la Paix
Case Postale No. 2300
1211 Geneva 2
Switzerland
Tel: 41 22 730 8247
Fax: 41 22 730 8036
E-mail: GSommeria@wmo.int