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ANNUAL REVIEW OF THE WORLD CLIMATE RESEARCH PROGRAMME

AND

REPORT OF THE TWENTY-FIFTH SESSION OF THE JOINT SCIENTIFIC COMMITTEE (Moscow, Russian Federation, 1-6 March 2004)

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 Dr S.Gulev, P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, the 2004 session of the JSC, the twenty-fifth, took place at the Russian Academy of Sciences, Russian Federation from 1-6 March. The session was called to order by the Chairman of the JSC, Professor P. Lemke, at 0830 hours on 1 March 2004. 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 Dr S. Shapovalov, Secretary of the World Ocean Commission of the Russian Academy of Science (RAS). He was speaking on behalf of the Vice-President of RAS, Professor N. Laverov. Dr S.Gulev presented the statement from by Professor S. Lappo, Director, P.P. Shirshov Institute of Oceanology, RAS,welcoming the participants. Messages of welcome were also received from Dr A.I. Bedritsky, President, WMO, and Head, Russian Federal Service for Hydrometeorology and Environmental Monitoring, and also from the President of the Russian Academy, whose message was presented by the first deputy of the President of the Russian Academy of Science, Professor A. Maltsev.

The Chairman of the JSC thanked Dr S. Shapovalov for his welcome and his highly appropriate and inspiring remarks. It was for all a pleasure and privilege to be in Moscow and have the opportunity to acknowledge the outstanding contributions of Russian scientists to the WCRP. The Chairman also expressed deep gratitude to all the agencies, namely, the Russian Academy of Science, the P.P. Shirshov Institute of Oceanology, the Russian Foundation for Basic Research, and the Federal Ministry of Science and Education, Russian Federation, who had sponsored the organization of the session. He personally thanked Dr S. Gulev and all the others for their substantial efforts in making the arrangements for the session.

The Chairman continued by extending his greetings to the participants in the session. Whilst noting with regret that three JSC members, Dr K. Denman, Professor P. Schlosser and Dr D. Whelpdale could not be present. The Chairman was pleased to welcome the representatives of the Russian agencies sponsoring the JSC session. These were Dr S. Shapovalov, Secretary of the World Ocean Commission of the RAS, Professor A. Maltsev, first deputy of the President of the Russian Academy of Science, and Dr S. Gulev, P.P. Shirshov Institute of Oceanology. He also expressed thanks for the welcome messages from Professor S. Lappo, Dr A. Bedritsky, and the President of the Russian Academy.

The Chairman further acknowledged with appreciation the participation of observers on behalf of the organizations sponsoring WCRP: Dr A. Fischer, IOC; Dr L. Goldfarb, ICSU; Dr D. Carson (as well as Director of the WCRP), WMO. The Chairman was also pleased to welcome, Dr B. Goebel, Executive Director, International Human Dimensions Programme on Global Environmental Change (IHDP). No representative of the International Geosphere-Biosphere Programme (IGBP) could be present on this occasion as the Scientific Committee (SC)-IGBP was holding its session in parallel with the JSC at the same venue. The Chairman looked forward to the first joint session of JSC and Scientific Committee of the IGBP (SC-IGBP) later in the week.

The Chairman voiced his gratitude for the customary participation of the chairs or representatives of WCRP steering and 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 Dr T. Palmer, Co-chairs of the CLIVAR Scientific Steering Group; Dr B. Goodison, Chair of the ACSYS/CliC Scientific Steering Group, Professor A. O'Neill and Dr A.R. Ravishankara, Co-chairs of the SPARC Scientific Steering Group; 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 C. Fairall, Chair, Working Group on Surface Fluxes

(WGSF) and Professor B. Kirtman, Chair, Task Force on Seasonal Prediction. The Chairman noted with regret that Dr J. Mitchell, Chair, Working Group on Coupled Modelling (WGCM) could not be present on this occasion.

The Chairman was further pleased to note the attendance of Project Office Directors: Professor M.L Chanin, Director, SPARC International Project Office; Dr C. Dick, CliC International Project Office; Dr H. Cattle, International CLIVAR Project Office; Dr R.G. Lawford, Director, International GEWEX Project Office; Dr J. Canadell, Executive Director, Global Carbon Project. The Chairman was gratified by the participation also of Professor P.J. Mason, Chair of the GCOS Steering Committee, 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), Dr E. Urban, Executive Director, Scientific Committee on Oceanic Research (SCOR), Professor S. Solomon, Co-chair, IPCC Working Group I, Professor J. Alcamo, Chair, Global Water System Project (GWSP) Framing Committee, Dr C.J. Vörösmarty, Framing Committee, GWSP, Dr M. Shapiro, representing the WMO Commission for Atmospheric Sciences (CAS), and Professor S. Gadgil, Co-chair of the joint WCRP/IGBP/IHDP Global Change System for Analysis, Research and Training (START).

Finally, the Chairman looked forward with anticipation to the scientific lectures by two Russian scientists that had been arranged, namely "Arctic Climate in the 21st Century: modelling and scenarios", by Dr V. Kattsov (Main Geophysical Observatory, St Petersburg), and "European precipitation: long-term changes in the extremes, their reliability and impacts", by Dr O. Zolina (P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow and Meteorological Institute of the University of Bonn).

2. MAIN DEVELOPMENTS AND EVENTS SINCE THE TWENTY-FOURTH 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.

The past year has shown continuing progress towards the implementation of the Climate Variability and Predictability (CLIVAR) project. As its panels and working groups grow in maturity, links and common activities between them continue 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. In order to address critical issues slowing the advancement of coupled climate models, US CLIVAR has initiated three Climate modelling and Process Teams (CPTs) to improve model fidelity in three important areas: low-latitude cloud feedbacks; ocean mixing through gravity current entrainment (e.g. over deep overflows); and mesoscale eddy interaction with upper ocean mixing. These teams, comprised of observationalists, parameterization developers, and climate modellers, will diagnose, and develop or improve parameterizations and model treatments addressing these issues. More importantly, these teams will test their results in the context of climate models. The major climate modelling centres in the USA are actively engaged and coordination is developing with international projects and climate modelling centres. CLIVAR is also conscious of the importance of continuing to develop a global synthesis of its regional activities and a global perspective. In response to this need, the CLIVAR SSG has established a new panel on Global Synthesis and Observations (GSOP). GSOP replaces and has a broader remit than the CLIVAR Ocean Observations Panel which has been disbanded. The 1st International CLIVAR Science Conference will be held from 21-25 June 2004 in Baltimore USA. Arrangements for this conference were well advanced with the structure of the programme and the speakers all in place. The conference will provide an overall review of progress in CLIVAR to date and will look also to the future, identify current research challenges and provide a roadmap for future research.

In the Global Energy and Water Cycle Experiment (GEWEX), the past year saw an integration of the various GEWEX projects following the implementation of Phase II, and was marked by the appointment of Dr R. Lawford as the new Director of the International GEWEX Project Office in October. Major developments during 2003 were: (i) the first CEOP full annual cycle of observations and data gathering scheduled to last until the end of 2004, with the joint commitment of the Continental Scale Experiments (CSEs), the space agencies and the global modelling community, (ii) an increased coordination of CSEs with the development of joint studies and the approbation of the La Plata Basin (LPB) as a new CSE, (iii) the reorganization of global data sets under a common umbrella and the initiation of a GEWEX working group on data management and analysis, (iv) the completion of a first boundary layer model intercomparison study by the newly formed GEWEX Atmospheric Boundary Layer Study (GABLS) and (v) the approval by the Integrated Global Observing Strategy (IGOS) Partners of the IGOS Water Cycle theme report, in which GEWEX has a leading role.

In the study of Stratospheric Processes and their Role in Climate (SPARC), activities in the past year have been concerned with stratospheric indicators of climate change, study of stratospheric processes, development of modelling, various assessments and development of data assimilation. Recent deliverables have been: (i) an assessment report "Stratospheric temperature trends: observations and model simulations" (paper awarded the Norbert Gerbier-MUMM International Award, 2003), (ii) a stratospheric reference climatology report, and (iii) the 2002 WMO/UNEP Assessment of Ozone Depletion. The Third General Assembly of SPARC will take place 1-6 August 2004, in Victoria, Canada. The scientific programme of the Assembly will cover all the topics of relevance to SPARC. A particular emphasis for this General Assembly will be chemistry-climate coupling. The SPARC International Project Office is expected to move from Paris, France in 2004. After many years of outstanding service, the director, Professor M.-L. Chanin, will pass her duties to a new person in charge of the office. A proposal has been submitted to move the office to the Department of Physics, University of Toronto, Canada.

The Arctic Climate System Study (ACSYS), started in 1994, was the third WCRP core project to be brought to a successful completion. It had three main objectives: (i) to improve understanding of the interactions between the Arctic Ocean circulation, ice cover, the Arctic atmosphere and the hydrological cycle; (ii) to initiate long-term climate research and monitoring programmes in the Arctic so as to determine key Arctic processes and Arctic climate variability and trends; and (iii) to provide a scientific basis for a more accurate representation of Arctic processes in global climate models. The final Conference on ACSYS was held on 11-14 November 2003 at the Arctic and Antarctic Research Institute, St. Petersburg, Russia. The conference summarized the major improvements in our knowledge of the Arctic climate system during the ACSYS decade, drawing together advances in our understanding of each of the individual elements of the Arctic climate system and, more particularly, our understanding of the interactions between them. The conference also sought to examine the challenges for future research on the Arctic climate system. There were some 200 participants, 217 abstracts were submitted and 40 oral presentations were complemented by 161posters. The findings of the ACSYS project will be summarised in a monograph. The Climate and Cryosphere (CliC) project, successor to ACSYS, expects to gain momentum through the First CliC Science Conference scheduled for 11-15 April 2005, Beijing, China. This promises to be an important milestone in promoting and refining CliC's science goals and objectives, stimulating corresponding commitments, establishing partnerships, and making the project more widely known. The CliC project is fortunate to have its active growth stage coinciding with the development of the International Polar Year (IPY), 2007-08. CliC is expected to contribute to the IPY and to benefit from its associated activities.

WCRP's climate modelling activities are centred on two main groups: the CAS/JSC Working Group on Numerical Experimentation (WGNE) and the (WCRP) Working Group on Coupled Modelling (WGCM). Particular attention continues to be given to the two principal intercomparison projects, the Atmospheric Model Intercomparison Project (AMIP) overseen by the WGNE, and the Coupled Model Intercomparison Project (CMIP) overseen by the WGCM. The Second CMIP Workshop was held back to back with the WGCM/GAIM Conference on Earth System Modelling in Hamburg, 22-23 September 2003. CMIP subprojects had produced 25 peer-reviewed publications, 6 other publications, 4 Programme for Climate Model Diagnosis and Intercomparison (PCMDI) publications, as well as significant contributions to the IPCC Third Assessment Report (TAR). The WGCM session following the Workshop discussed perspectives and priorities for the next 3-5 years; of particular importance was WCRP and IGBP Global Analysis Interpretation and Modelling (GAIM) cooperation (on the carbon cycle and chemistry). In its continuing efforts to foster cooperation with the GAIM element of IGBP, WGCM would be involved with GAIM's Earth System Atlas. WGNE has the responsibility and leadership in WCRP for fostering the atmospheric reanalyses so important for many WCRP activities. WGNE was very pleased with the completion of the ECMWF ERA project in April 2003: ERA-40 has provided analyses for a 45-year period from 1 September 1957 to 31 August 2002. A comprehensive set of 2.5^{o}-grid single-level and pressure-level analysis or six-hour forecast fields from ERA-40 can be downloaded from the Centre's new data server http://data.ecmwf.intdata. It was gratifying to note the good progress being made in the 25-year reanalysis project (1979-2004) at the Japan Meteorological Agency and the regional reanalysis activities at the US National Centers for Environmental Prediction (NCEP). WGNE was also closely involved, jointly with the CAS World Weather Research Programme (WWRP), in the development of THORPEX, a ten-year international global atmospheric research and development programme under the auspices of the WMO CAS, which would have significant implications and benefits for a number of WCRP projects. In its last session, WGNE discussed a draft of the joint WWRP/WGNE THORPEX Resolution. The THORPEX International Science Plan was also presented and discussed. WGNE reiterated its support for THORPEX as a collaborative WWRP/WGNE experiment. Preparations for the Joint WGNE/WGCM International Workshop, in close collaboration with START, entitled "High-resolution climate modelling: Assessment, added value and applications" to be held in Lund, March 29 - April 2, 2004,were progressing well. The Workshop aims at promoting better knowledge of the potential and limitations of RCM.

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

3.1 Fourteenth World Meteorological Congress

At the Fourteenth World Meteorological Congress (Geneva, May 2003), Professor P. Lemke, Chairman of the JSC for the WCRP, reported on the scientific progress of WCRP since the Thirteenth Congress (May 1999).

Congress expressed its appreciation for the advances being made in the WCRP and the leadership of the JSC in formulating the overall scientific strategy for the programme. It was also recognised that WCRP had continued to serve the needs of WMO Members by contributing significantly to the development of climate-related services and applications and to the advances in understanding and modelling climate change, as reflected in the IPCC Third Assessment Report, published in 2001. Those achievements and other results gained from WCRP over the past two decades had demonstrated clearly and in a most practical way the value of investment in long-term research programmes. Such coordinated and collaborative international research efforts were needed for the future maintenance, improvement and extension of our predictive capabilities and their associated services and applications. In that context, Congress re-affirmed its belief in the strength and value of the productive partnership between WMO, ICSU and IOC, and encouraged that such successful international coordination between institutions and disciplines should be extended to the national level. Congress proposed that the occasion of the twenty-fifth anniversary of WCRP, in 2005, should be used to publicise more widely the achievements and benefits gained from WCRP to date, the challenges still to be addressed, and its plans for the future.

Congress voiced its full satisfaction with the significant achievements of the World Ocean Circulation Experiment (WOCE), which had formally concluded at the end of 2002. Through its planning, observational and analysis phases, WOCE had lasted two decades and had been by far the biggest and most successful ocean programme to date. Its achievements were celebrated at a final international scientific conference, 'WOCE and beyond', held in San Antonio, Texas, United States in November 2002. Congress was pleased to acknowledge that the legacy of WOCE included: significantly improved ocean observational techniques (both *in situ* and satellite-borne); a first quantitative assessment of the ocean circulation's role in climate; improved understanding of physical ocean processes; and improved ocean models for use in weather and ocean forecasting, and in climate studies.

Congress noted with appreciation the progress that had been made in all the other WCRP core activities since Thirteenth Congress. Most significant had been the implementation of many projects under the auspices of the CLIVAR study, particularly the regional studies to improve our ability to predict climate on seasonal to decadal timescales implemented in Africa, the Americas, and the Asian-Australian region; activities specific to the Atlantic, Pacific and Southern Ocean basins and adjacent areas which were being organized; particular emphasis that had been placed on the study of monsoons, which affected much of the world's population and which had major societal and economic consequences. Another fundamental concern was ocean-atmosphere interaction; Congress acknowledged the comprehensive report on the intercomparison and validation of ocean-atmosphere energy flux fields, which had been produced by the joint WCRP/SCOR of ICSU Working Group on Air-Sea Fluxes in November 2000.

Congress was impressed with the continuing accomplishments of the Global Energy and Water Cycle Experiment (GEWEX). The first phase of GEWEX had been celebrated at its fourth International Scientific Conference, held in Paris in September 2001. Congress recognized that the GEWEX global data sets, which now covered up to 20 years, made use of both in situ as well as remotely-sensed data, with a major participation of environmental satellite agencies, and that they served as a reference for the assessment of present climate and the validation of climate change models. Congress also noted that the continental-scale experiments had been extended in order to document most major climate patterns, and now included semi-arid regions in Australia and the Sahel. Those continental-scale experiments allowed, for the first time, the comprehensive modelling and evaluation of the components of the water cycle over large river basins. Congress was informed that GEWEX had begun a new major phase of its implementation, aimed at a fully global description of the Earth's water cycle and energy budget, at the development of improved capabilities for forecasting of precipitation and for predicting changes in the water cycle associated with climate variability and change, and at the development of tighter links with the water resource and applications communities. An excellent illustration of that evolution was the development and implementation of a major new component, the Coordinated Enhanced Observing Period (CEOP). CEOP had been recognized by the IGOS Partnership as a pilot study contributing to the IGOS Integrated Global Water Cycle Observations Theme, for which WCRP was playing the leading role. Congress noted with approval the development and implementation of GEWEX Phase II since Thirteenth Congress.

Congress learned that the achievements of the WCRP Stratospheric Processes and their Role in Climate (SPARC) project, to date, had been summarized at the Second General Assembly of SPARC, held in Mar del Plata, Argentina, in November 2000, which had generated significant attendance and interest. Congress noted with approval that SPARC had continued its significant efforts in the detection of stratospheric trends, which could indicate climate change or could affect climate. That included assessments of trends in stratospheric temperature, vertical distribution of ozone, upper tropospheric and stratospheric water vapour. In particular, Congress commended the publication of the *SPARC Assessment of Upper Tropospheric and Stratospheric Water Vapour* (WCRP-113, WMO/TD-No. 1043), in December 2000. Congress was also delighted to hear that the Norbert Gerbier-MUMM International Award for 2003 had been conferred on an international team of 17 SPARC scientists for their paper "Stratospheric temperature trends: observations and model simulations", published in *Reviews of Geophysics,* Volume 39, Number I, February 2001.

Congress was informed that WCRP Arctic Climate System Study (ACSYS), established in 1994 to understand better the role of the Arctic in the global climate system, would finish with a final international scientific conference, to be held in St. Petersburg, Russia, in November 2003. Congress acknowledged that the achievements of the ACSYS decade included: (a) creation of a basis for improved numerical simulations and re-analysis studies of the complex system involving polar atmosphere, oceans, sea-ice and land; (b) provision of a framework for active deployment of drifting buoys by the International Arctic Buoy Programme, declassification of submarine observations, deployment of moored sonars, intensification of ship-based studies, generation of new satellite products, and collection and upgrading of circumpolar data sets; (c) providing a rationale to Members for maintaining meteorological observing networks in remote locations; (d) stimulation of enhanced regional (Arctic) process studies; (e) intercomparison projects which had led to advances in modelling of the polar environment and created a better basis for projections of amplified impact of the climate change in the polar region (an important aspect of the IPCC assessments). Congress congratulated all those concerned with the development and implementation of ACSYS and expressed its best wishes and support for a successful final conference in St. Petersburg.

Congress was delighted to learn that the JSC had endorsed the Climate and Cryosphere (CliC) project in 2000, which aimed at understanding all components of the cryosphere and its interactions with the global climate system. Unlike ACSYS, CliC was a global project, which would build on the experience and results gained through ACSYS. The first Science and Co-ordination Plan for CliC had been published in January 2001, and an implementation strategy was being developed. Congress expressed the need to support CliC not only by Members with direct interests in polar environments but by the wider global community.

Since 1995, WCRP had also been supporting the International Programme for Antarctic Buoys (IPAB), which had proved its high value in filling gaps in surface meteorological observations in the Southern Ocean. Furthermore, recent assessments had shown that IPAB buoys had helped to reduce uncertainties in the analysis of mean-sea-level pressure in that region and created a significant positive impact on the accuracy of satellite altimetry. Congress therefore urged Members to continue their support for that programme by coordinated deployment of drifting buoys which reported their observations through the WMO GTS.

Congress observed that the fundamental unifying and integrating theme in the WCRP was the development of comprehensive global models of the full climate system, pulling together and building on the scientific and technical advances in the other discipline-oriented WCRP activities. Such models were the fundamental tools for understanding and predicting natural climate variations and for providing reliable estimates of anthropogenic climate change. WCRP modelling activities were centred mainly on the CAS/JSC Working Group on Numerical Experimentation and on the WCRP Working Group on Coupled Modelling. Congress appreciated the substantial work in WCRP devoted to internationally-coordinated model intercomparison exercises as a means of identifying and reducing errors in climate simulations. The current situation had been reviewed at a workshop on model systematic errors, hosted by the Australian Bureau of Meteorology Research Centre in Melbourne in October 2000. The second Atmospheric Model Intercomparison Project Workshop, held in Toulouse in November 2002, had brought out the need to focus on the dynamical mechanisms and better representation of processes in models. Coupled model intercomparison projects had also been organized, and standardized experiments were being undertaken, which should help in reaching consensus on climate change. The results produced by those activities in WCRP had been a key input to all the IPCC Assessments. Congress noted with approval that closer cooperation had been established with the Global Analysis, Integration and Modelling (GAIM) element of the ICSU-sponsored International Geosphere-Biosphere Programme (IGBP), in particular in the organization of the Coupled Carbon Cycle Climate Model Intercomparison Project.

Congress re-affirmed the importance of the series of re-analysis projects (providing homogeneous data sets for climate diagnostic studies and model validation) that had been promoted by WCRP in recent years. In particular, the ongoing ambitious and comprehensive 40-year analysis project at ECMWF (ERA-40) was progressing well and was already providing multi-year homogeneous data sets that were essential for a wide range of climate diagnostic studies in support of not only WCRP-related research, but also many operational services and applications. Congress recognized that those re-analyses were highly sought after and used by the international research and operational communities. An exciting development was the decision of the Japan Meteorological Agency (JMA) to conduct a new 25-year re-analysis (JRA-25) for the period 1979-2004, which was expected to be completed in 2005. Congress was pleased to learn that JMA would provide results and related products to both NMHSs and the international research community. An Internet site would be established to enable this.

Congress was pleased to note that the WCRP had continued to promote the development of regional climate research capabilities through the active involvement of scientists worldwide in its activities. In particular, WCRP had achieved that through the GEWEX continental-scale experiments being conducted in Africa, Asia, Australia, the Americas, and Europe; through the over 30 CEOP reference sites, which had extended the geographical distribution of experimental sites related to the continental-scale experiments; and through the major CLIVAR studies of monsoon systems in Africa, the Americas, Asia and Australia. Congress re-emphasised the importance of WCRP's continued co-sponsorship, with IGBP and the International Human Dimensions Programme on Global Environmental Change (IHDP), of the Global Change System for Analysis, Research and Training (START).

Congress welcomed the increased and closer cooperation that existed 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 that collaboration had been the Global Change Open Science Conference, held in Amsterdam, in July 2001 which had been an outstanding success. The Conference had presented exciting scientific advances of the past decade, drawing primarily on the work of the international global change programmes. In recognition of the growing need for such collaborations, WCRP, IGBP, IHDP and DIVERSITAS had established the Earth System Science Partnership (ESSP) for the integrated study of the Earth system, the changes that were occurring to the system, and the implications of those changes for global sustainability. In that context, three projects (on the global carbon cycle, food systems and global water system) were being developed and implemented, with a fourth on global change and human health being actively considered. Congress applauded the new collaborative initiatives that had been taken by WCRP as a member of the ESSP, and encouraged their further development and implementation.

In considering the future scientific direction, structure and priorities of WCRP, the JSC had begun to explore the concept of a comprehensive WCRP-wide initiative on predictability and prediction under the tentative title, “Climate system Observation and Prediction Experiment”. Among other priorities, JSC intended to reinforce WCRP's efforts in the research priority areas signalled in the IPCC Third Assessment Report (especially those listed under modelling and process studies).

In conclusion, Congress agreed that WCRP had continued to be most effective in pursuing its objectives through a number of large-scale research, observational and modelling projects that focused on climate problems that required international commitment, coordination and collaboration. Congress therefore duly approved the continuation of the Agreement between WMO, ICSU and IOC on the conduct of WCRP as adopted in Resolution 9 (Cg-XIII) — World Climate Research Programme. Congress also agreed on the priorities set for WCRP in the programme and budget for the fourteenth financial period.

3.2 Fifty-fifth session of the WMO Executive Council

At its fifty-fifth session (Geneva, May 2003) the WMO Executive Council noted the report of the JSC for the WCRP and expressed satisfaction at the continuing progress being made in the implementation of the programme. In particular, the Council acknowledged with immense satisfaction the successful conclusion of the WOCE. Its achievements were celebrated at a final international scientific conference in San Antonio, Texas, in November 2002. The Council expressed its gratitude to all those who had contributed to the undoubted success of WOCE.

As WCRP approaches its twenty-fifth anniversary, it was appropriate to consider the progress that had been made towards its main goals, its specific objectives for the next period and what changes in programme and structure might be required to achieve those. The Council therefore welcomed the conscientious and thorough deliberations at recent sessions of the JSC on the future scientific direction, structure and priorities of the WCRP. The two original aims of the WCRP were to determine to what extent

climate could be predicted and the extent of human influence on climate. Those remained the general mission statement for WCRP and were consistent with the vision of a seamless prediction problem, from weeks through decades to the projection of climate change. There were three fundamental ways in which WCRP approached its aims, namely, through the development, evaluation and use of climate models, through climate observations and their analysis, and through fundamental research on climate processes. To recognize a renewed emphasis of WCRP on its prediction aims and the observational activities that were needed to fulfil them, the JSC was contemplating a major overarching and integrating initiative, tentatively called the Climate system Observation and Prediction Experiment, conducted over a decade up to about 2015. It was intended that the proposed focus on the aims of the WCRP, setting objectives and viewing them in the context of such an initiative would provide a new stimulus for the science of WCRP, and widen the recognition of its relevance and importance for a globally-sustainable future. In supporting that in-depth review of the scientific direction and structure of the WCRP, the Council encouraged the JSC to develop further its initial thinking on an integrating framework for WCRP.

3.3 Intergovernmental Oceanographic Commission (IOC)

IOC statement at the Fourteenth World Meteorological Congress

The representative of IOC at the Fourteenth World Meteorological Congress (Geneva, May 2003) expressed satisfaction with the arrangements and management of the WCRP, and informed Congress that the twenty-first IOC Assembly (Paris, July 2001) had expressed great satisfaction at the achievements of the WOCE programme. The Assembly had attributed the programme's unqualified success to the sustained WMO/ICSU/IOC WCRP partnership and cited WOCE as an outstanding example for planning, managing, and executing large-scale, international ocean science programmes. Recognizing the fundamental role of the ocean in the climate system, the IOC is now strongly committed to working with WCRP and WMO to ensure the success of CLIVAR. The GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC) and the CLIVAR Ocean Observations Panel are working together to provide the necessary scientific underpinning for climate research and observations, as well as supporting projects such as the Global Ocean Data Assimilation Experiment (GODAE) and the Argo profiling-float programme. In November 2002, the IOC, with participation from CLIVAR, had hosted a conference to establish the Indian Ocean GOOS with a focus on ocean observations needed to understand and forecast climate in the Indian Ocean region. In February 2003, the OOPC and CLIVAR, together with the Inter-American Institute for Global Climate Research, had sponsored a workshop to discuss the needs for a South Atlantic Climate Observing System (SACOS). This workshop had been developed to produce a design strategy for observations and process studies in the South Atlantic required by OOPC/GOOS and CLIVAR. The IGBP/IHDP/WCRP Global Carbon Project and the SCOR/IOC Advisory Panel on Ocean CO_2 had developed a joint pilot project, the International Ocean Carbon Coordination Project (IOCCP), to facilitate the coordination of large-scale ocean carbon observations over the next decade. The IOCCP was working closely with CLIVAR to develop an internationally-coordinated approach for hydrographic sections with carbon measurements and a proactive policy of international information and data sharing. In conclusion, the representative of IOC reaffirmed continuing commitment to supporting the Joint Climate Research Fund, and through IOC governing bodies, continuing efforts to encourage IOC Member States to support and participate in the marine-related activities of WCRP.

Twenty-second session of the Assembly of the IOC

At the twenty-second session of the IOC Assembly, Paris, June/July 2003, several Member States noted the need for the Assembly to have an opportunity to review progress and priorities. They stated that there is a clear need for an advisory group for the Ocean Science Section, to assist in setting programme priorities that better meet the changing needs and ongoing development of the programmes of the Commission. Some Member States emphasised the need for the IOC to address more-applied aspects of ocean science in support of living- and non-living-resource management, environmental assessment and protection, and climate-change assessment. The Assembly endorsed the terms of reference for the programme elements in the new structure of the Ocean Sciences Section given in IOC/INF-1180, with the provision that the terms of reference be periodically reviewed by a small scientific advisory group and revised, if necessary, to better meet the needs of the Member States. The Assembly urged the Member States to promote, mainly through the IOC regional subsidiary bodies, the IOC ocean science programmes at the regional level and particularly to ensure that their scientists participated in these regional programmes.

On the occasion of the retirement of Mr A. Alexiou, after 18 years of service to the Secretariat, the Assembly awarded him an IOC Certificate of Appreciation and a UNESCO Medal for his substantial contributions to the IOC's Climate Programme, and in particular his tireless support for the work of the OOPC. The Assembly also awarded Professor W. Nowlin, an IOC Certificate of Appreciation and a UNESCO medal for his substantial contributions over many years to IOC's work on climate and the oceans, and in particular

for his seminal role in the planning and implementation of the WOCE, for his contributions to the GCOS Steering Committee and to the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Management Committee, and for his chairmanship of the Ocean Observing Systems Development Panel (OOSDP) from 1990 to 1995, and of the GOOS Steering Committee from 1998 to 2002.

The JSC was delighted to note that the IOC Assembly had awarded IOC Certificates of Appreciation and UNESCO medals to: Mr A. Alexiou for his substantial contributions to the IOC's Climate Programme, in particular the OOPC; and Professor W. Nowlin for his substantial contributions to IOC's work on climate and the oceans, especially his seminal role in the planning and implementation of WOCE. The JSC proposed that WCRP should introduce a corresponding formal 'Certificate of Appreciation'.

3.4 International Council for Science (ICSU)

ICSU statement at the Fourteenth World Meteorological Congress

The Fourteenth World Meteorological Congress (Geneva, May 2003) was informed that ICSU had been responsible for the input from the scientific community to the World Summit on Sustainable Development (WSSD). In reporting on successes and failures since the Earth Summit in 1992, ICSU had argued that high-quality, independent research results were essential for integrated assessments needed by the policy makers. The IPCC had been able to take advantage of the rapid expansion in global environmental change research, such as the Tropical Ocean and Global Atmosphere (TOGA) project that had significantly enhanced our understanding of the role of oceans in climate processes. The report to WSSD had concluded that one of the major successes over the past ten years had been the unprecedented international collaboration within the scientific community to address global environmental change. The recently concluded 11th session of the UN Commission on Sustainable Development had reaffirmed the role that science must play by not only being one of the nine Major Groups but by also providing best available knowledge. That could only be done through the type of excellent partnerships that WCRP was a prime example of. The sponsorship by WMO, ICSU and IOC ensured that the programme had both a solid scientific basis as well as a firm governmental framework. In 2001, the four global change programmes, sponsored by ICSU, had decided to form an Earth System Science Partnership (ESSP). ICSU was very pleased with this development and the strengthening of global change science through the close collaboration of WCRP with the other programmes. That would provide essential components of the follow-up to the WSSD and provide interdisciplinary science aimed at "global sustainability". Such new challenges as the ESSP were demanding from a scientific point of view, and necessitated new and innovative approaches based in the forefront of basic research in many disciplines. A basis for that new partnership was the growing collaboration between WCRP and IGBP, which was critical to the success of that unprecedented undertaking. ICSU welcomed the recent deliberations of the JSC on the future scientific directions, structure and priorities of the WCRP. ICSU had also recently launched a Priority Area Assessment on its portfolio in the environment area and its relationship to sustainable development, which was anticipated would lead to additional support for the development of WCRP as well as continued development of the ESSP partnership. The ICSU statement stressed the importance that WCRP be given sufficient financial support to develop its programme. In particular, it stressed the need for governments and various funding agencies to realize the importance of providing at least 2% of the research funding in support of the international planning and coordination efforts. ICSU, through its national members, would continue efforts to increase funding for WCRP and it urged national delegations to Congress to ensure continued and stabilized funding of this important undertaking. ICSU remained fully committed to supporting WCRP and viewed the past successes and future directions as essential components in making science more policy relevant. WCRP provided one fundamental building block in the attempts by the world scientific community to address the challenges of sustainable development.

Report of the ICSU Committee on Scientific Planning and Review Assessment Panel on Environment and its Relation to Sustainable Development

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, Capacity Building, and Data and Information, and starting with the one on Environment. The goal of the PAA process was to strengthen ICSU's overall capability in addressing priority scientific issues that are of emerging importance to science and society at large. The PAA was intended to be a mechanism to develop ICSU's strategies for selected priority scientific areas. It was designed to help ICSU develop a programme structure reflecting its priorities; to ensure synergies in the activities of the ICSU family; and to enable an appropriate allocation of limited resources. In order to be effective, the PAA process must involve relevant members of the ICSU family; i.e. Union and National Members, interdisciplinary bodies, and joint initiatives. It should also consider ICSU's priorities in the context of relevant activities outside of ICSU.

WCRP was classed as a 'joint initiative' within the ICSU family. The immediate outcome of a PAA was a report containing key recommendations that would be published and widely disseminated by ICSU. This report would form the basis for future actions by ICSU and ICSU Members, including the development of new programmes, policy initiatives and definitions of new priorities for the ICSU grants programme. Some of the recommendations might require the establishments of new partnerships with bodies outside the ICSU family or might be more appropriately taken forward by other organizations, in which case, the necessary dialogue(s) would be initiated. The ICSU CSPR appointed an *ad hoc* Panel for a PAA on Environment and its Relationship to Sustainable Development, chaired by Dr R. T. Watson, World Bank. In the context of that PAA on Environment, 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. Each of the members of the Earth System Science Partnership (ESSP), namely, WCRP, IGBP, IHDP and DIVERSITAS, is sponsored by ICSU and so was required to be involved in this PAA exercise. Additionally, the ESSP as an entity was also requested to make a written submission and was allocated a slot at the Panel meeting at ICSU. The Report of the ICSU CSPR Assessment Panel on Environment and its Relation to Sustainable Development was published in December 2003. The statements in the Executive Summary of the report of direct relevance to WCRP are noted here.

The four Global Environmental Change (GEC) programmes (IGBP, IHDP, WCRP and DIVERSITAS) have, to different degrees, made excellent progress and are producing knowledge that is policy relevant. In addition, the coordination and collaboration among the GEC programmes have successfully evolved over time. The Panel commended the progress made through the WCRP in establishing the physical basis for understanding and predicting El Niño events, and the improved understanding and predictability of natural climate variability and human-induced climate change at the regional and global scales. One of the major challenges for the WCRP was to develop improved transient, fully coupled atmosphere-ocean-land general circulation models that incorporate biogeochemical feedbacks. The ESSP was an important new development, and the joint projects under ESSP were expected to provide significant results of high relevance to the science for sustainable development. However, it was important to recognize that the science underpinning these joint ESSP programmes would come primarily from research conducted within the programmes of IGBP, WCRP, IHDP, and DIVERSITAS. The Panel noted that by adopting projects such as those proposed for ESSP, the GEC programmes raised high expectations. Prospects for success with this type of synthesis and integration required among hitherto separate research programmes was largely untested. The Panel recommended that ICSU be especially watchful during early formative stages of the ESSP projects to ensure that disciplinary fragmentation did not confound well-laid plans for the achievement of this integration. Given the centrality of the carbon cycle to the climate debate, the Panel endorsed the Global Carbon Project, which was highly policy relevant and timely. With regard to the Global Environmental Change and Food Systems (GECAFS) project, the Panel questioned: 1) Whether the approach of focusing only on regional case studies was appropriate or whether there should also be a series of more generic studies of the response of different agricultural crops to environmental changes and the development of improved crop traits and 2) whether the most important regional case studies were chosen. The Panel recommended that the initiative needed a "science plan" or at least a "framework" with well-defined criteria for the selection of case studies. The Global Water System Project was still in a formative stage. The Panel recommended that the project link with existing water research programmes within ICSU and other international programmes to increase synergies and avoid duplication, and that ICSU track the cooperative development of this initiative. There was not enough information available in the draft documentation to critically evaluate the initial plans of the Global Environmental Change and Human Health project. However, the overarching questions being considered were very appropriate and the Panel endorsed the need for such a project. To further promote international and interdisciplinary research more resources were required through national funding mechanisms, especially for the full participation of social scientists.

The Panel noted that ICSU National Members and National Committees provide essential support for the GEC programmes and recommended the establishment of national focal points where they do not exist. In future, GEC National Committees should be formed to encompass IGBP, WCRP, IHDP and DIVERSITAS.

Global observations were critically important in support of policy relevant science, but the Panel concluded that the current Global Observing Systems (GOS) and the Integrated Global Observing Strategy Partnership (IGOS-P) were not adequately addressing the needs of the scientific communities. The Panel would like to see a greater demonstration of the value of the GOS to the GEC programmes. The Panel recommended that there should be better integration and collaboration among the GOS, and that GOS and IGOS set their priorities based on the global requirements of the science community, especially the GEC programmes, as well as the policy community. Many ICSU Interdisciplinary Bodies have been involved in

defining IGOS themes. The Panel noted, however, that there was no ICSU research body with ocean expertise listed with membership on the ocean theme. ICSU should strengthen its involvement in the three GOS and IGOS-P to ensure that the ICSU science community has a significant impact on the development of the themes to build better connections with the ESSP.

Research collaboration within the ICSU family and with other organizations on questions related to environment and its relation to sustainable development was critical. The Panel noted the extensive cooperation among GEC programmes, but their links to other ICSU Interdisciplinary Bodies, with the exception of SCOR, is limited. Capacity building, both individual and institutional, was a central component in any effort to address the environment and its relationship to sustainable development. START is an excellent example of an initiative that addresses the need for involvement of scientists from developing countries in the GEC programmes and fosters the development of capacity building through regional priority setting.

The Panel recommended that ICSU develop programmes in the possible new high-priority areas: environment and human health; natural and human-induced hazards; human security-environmental refugees; and, transgenic crops and their implications for the environment.

The JSC noted that WCRP has strong links with IGBP, IHDP, DIVERSITAS, Scientific Committee on Antarctic Research (SCAR) and SCOR. However, JSC supported the ICSU Panel's inference that it had only limited links with the relevant scientific union IUGG and its associations, the International Association of Hydrological Sciences (IAHS), the International Association of Meteorology and Atmospheric Sciences (IAMAS) and the International Association of Physical Sciences of the Ocean (IAPSO), and recommended that the potential for stronger interactions with these should be explored.

4. SCIENTIFIC DIRECTION, STRUCTURE AND PRIORITIES OF WCRP

4.1 Review of the proposed 'Climate system Observation and Prediction Experiment'

WCRP: Current Activities and Future Scientific Directions

A draft discussion document, 'The WCRP:Current Activities and Future Scientific Directions', had been submitted to JSC-XXV by the Director, WCRP. This had resulted from the substantive further deliberations on the proposed WCRP Climate system Observation and Prediction Experiment that had taken place since JSC-XXIV, Reading, March 2003. The JSC was requested to: (a) note and comment on the document as a contribution to the continuing debate on the future scientific directions, challenges and opportunities for WCRP; (b) consider and decide on the new proposals to establish a WCRP Modelling Panel and a WCRP Working Group on Observations and Assimilation (WGOA) of the Climate System, respectively, as recommended by the WCRP Officers, Chairs and Directors Meeting, 21-23 January 2004, WMO, Geneva, and advise on their memberships and terms of reference; (c) consider and decide on the proposal to establish with immediate effect a Task Force for the further development of a major overarching and integrating initiative for the future of the WCRP and advise on its membership and terms of reference, and (d) consider and decide on the proposal to launch such a new initiative publicly at a major international conference in 2006, probably as part of the proposed Second ESSP Open Science Conference.

In welcoming the draft discussion document submitted by Director, WCRP, the JSC acknowledged that it placed the rationale and concept of '' an overarching and integrating initiative'', as perceived at JSC-XXIV, into the broader context of: WCRP objectives and research aims; WCRP's main achievements to date; current WCRP core projects and related activities; and, the JSC's responsibility to formulate the overall scientific concept and science goals of WCRP, with a particular requirement to look to the future. The JSC requested that the Director, WCRP, should further revise this document by end of March 2004, based on the outcomes of the intensive discussions at JSC-XXV and any further written input received immediately following JSC-XXV.

Post-meeting note: further discussions immediately following JSC-XXV led to the JSC's decision to focus its further deliberations on the development of a strategic framework to be called **Coordinated Observation and Prediction of the Earth System (COPES).** Therefore, this name and acronym will be used throughout the rest of this report.

The revised version of the document should be disseminated to inform and solicit input from the much wider scientific community engaged in WCRP-related research. Any such additional input should be taken account of in yet another draft, which should be made available to the Task Force, now for the development of COPES, ahead of its proposed first meeting at the CLIVAR Science Conference, June 2004.

Task Force for COPES

The JSC decided to establish a Task Force for the further development of the COPES strategic framework, to be Chaired by the Vice-Chair, JSC. As an immediate and interim measure, Professor Hoskins, the outgoing Vice-Chair, and Dr Church, the newly elected Vice-Chair, with effect from 1 April 2004, would act as Co-Chairs of this Task Force until JSC-XXVI, March 2005. Professor Hoskins would act as the lead Co-Chair until then. The Director, WCRP should establish the 'COPES Task Force' in April 2004. The opportunity provided by the CLIVAR Science Conference, June 2004, should be used to hold the first meeting of as many members as possible of the Task Force.

The JSC decided that one of the first tasks of the newly formed COPES Task Force should be to review the then latest draft of the 'COPES discussion document' and to revise it if necessary and appropriate. More particularly, the Task Force should use that document as a basis for deciding on, and producing, additional COPES-specific documents for wider distribution, especially to the range of WCRP stakeholders beyond the scientific research community. Such documents should include a relatively more focused, technical and more detailed document describing COPES (including its rationale, goals, aims, content, structure, milestones, metrics, etc) and also an explanatory leaflet suitable for broad and general use.

Modelling Panel

The JSC approved establishment of a Modelling Panel under the Chairmanship of Professor J. Shukla. Its prime role would be to coordinate and integrate modelling activities across WCRP with the purpose of meeting the WCRP objectives, especially in the context of COPES. Its members should include specified JSC members, the Chairs of WGNE, WGCM, WGOA and the project modelling groups, and IGBP and IHDP should each be invited to provide a representative.

Working Group on Observations and Assimilation (WGOA)

The JSC approved establishment of a Working Group on Observations and Assimilation (WGOA) under the Chairmanship of Dr K. Trenberth. Recognizing the existing affiliations and roles of AOPC and OOPC as key parts of WCRP, especially in its close links with GCOS, the WGOA should be established as a complementary WG to foster, promote and coordinate synthesis of global observations from the atmosphere, oceans, land and cryosphere, and for the coupled system, through analysis, reanalysis and assimilation activities across WCRP. Explicit terms of reference would need to be developed for both WGOA and the Modelling Panel.

Cross-cutting topics for JSC-XXVI

The JSC decided that, in the context of COPES, there should be increased focus at future JSC sessions on a few specific topics and issues each year where assessment, advice and decisions are needed from the JSC. Cross-cutting topics to be presented and discussed at JSC-XXVI, March 2005, should include: atmospheric chemistry and climate; sea-level rise; monsoons.

4.2 Report of the WCRP COPES Task Force on Seasonal Prediction (TFSP)

Professor B. Kirtman, Chair, WCRP COPES Task Force on Seasonal Prediction, presented to the JSC the report of the TFSP (this report is given in Appendix C). It included the report of the Workshop on Seasonal Prediction, 3-5 November 2003, University of Hawaii, Honolulu, USA, organized by the Task Force. The JSC was asked to consider endorsing the proposed 'Total Climate System Prediction Experiment' and if it had any recommendations or guidance for further activities of the Task Team. Recommendations were also sought from JSC concerning a timeline for the experiment and/or other activities, taking into account relationships to other potential COPES activities; consideration should be given to how best to launch the Experiment, if approved, and how to garner the resources required for its execution and coordination. Professor Kirtman further requested JSC for a decision, in the context of an overall COPES communications strategy, as to whether the report of the Workshop should appear as the first in a series of COPES (or other) reports (i.e. with distinctive cover design, distribution, etc.) and whether a web-site for TFSP and other COPES-related activities should be developed.

The JSC thanked Professor Kirtman for his leadership of the TFSP and for the report of its work to date. The JSC welcomed and endorsed fully the TFSP's proposal for a 'Total Climate System Prediction

Experiment' and requested that this should continue to be developed and refined and reported to the next JSC session. In particular, the TFSP should:

- seek to broaden and strengthen the involvement of the WCRP core projects and activities and regional panels in the TFSP
- develop a timeline for the proposed prediction experiment that takes full account of the opportunities of benefiting from and contributing to any complementary modelling activities in support of the IPCC Fourth Assessment Report
- perform a rigorous evaluation of current seasonal prediction capability and skill as part of the total climate system prediction experiment
- seek to embrace appropriate existing or planned national and international predictability and prediction experiments, in particular, the European Commission's ENSEMBLES project
- consider extending the range of possible predictability experiments to optionally include decadal timescales, in the spirit of the COPES principle of 'seamless prediction'
- ensure that appropriate data are archived to enable diagnostic studies of processes and errors
- include an element of model evaluation, diagnosis and development in the implementation plan for the experiment, which should provide feedbacks to the projects with respect to problems in processes and how these might be tackled.

The JSC requested that comments on the draft report of the TFSP be sent as soon as possible to Professor Kirtman.

5. CLIMATE VARIABILITY AND PREDICTABILITY (CLIVAR)

The JSC recorded its grateful thanks to Professor J. Willebrand, who had stepped down as a Co-chair, CLIVAR SSG, 31 December 2003 and welcomed Dr T.N. Palmer as his successor.

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 CLIVAR SSG has established a new panel on Global Synthesis and Observations (GSOP). GSOP replaces, and has a broader remit than the CLIVAR Ocean Observations Panel which has been disbanded. At the WCRP Officers, Chairs and Directors Meeting, January 2004, it was recommended that particular cross-cutting foci for JSC-XXV would be climate and chemistry, global precipitation, and tropical convection. CLIVAR has no significant activities in the first of these but has key contributions to aspects of the other two through the activities of the Variability of the American Monsoon System (VAMOS) panel and the Variability of the African Climate System (VACS) panel, in particular through their involvement (jointly with GEWEX) in the La Plata Basin experiment (PLATIN) and the African Monsoon Multidisciplinary Analysis (AMMA) project, and through the activities of its Asian Australian Monsoon Panel (AAMP). In addition, parameterization of convection and simulation of global precipitation and its inclusion as a component in the forcing of ocean models are of particular interest to the CLIVAR modelling Working Groups. The degree to which modes of climate variability are manifest in global precipitation datasets is also of interest across CLIVAR. Interest by the CCl/CLIVAR Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI) lies in the use of datasets of global precipitation to derive climate indices.

The CLIVAR Conference

The 1st International CLIVAR Science Conference would be held from 21-25 June 2004 in Baltimore USA. Arrangements for this conference, under the chairmanship of Professor Lennart Bengtsson, were now well advanced with the structure of the programme and the speakers all in place. The conference would provide an overall review of progress in CLIVAR to date but would look also to the future, identify current research challenges and provide a roadmap for future research. See www.clivar2004.org. CLIVAR was particularly grateful to NASA, NSF, NOAA, the US Climate Change Programmme and the American Meteorological Society in the USA together with WCRP, the Asia-Pacific Network for Global Change Research (APN), SCOR and the International Association of Atmospheric Sciences/International Commission on Climate for agreeing to sponsor and provide resources for the conference. The US CLIVAR Office under Dr D. Legler assisted by the Joint Office of Science Support (JOSS) at UCAR was providing major logistical support.

The CLIVAR Assessment

The CLIVAR SSG, at its last meeting, decided to carry out an assessment of progress to date, organized in conjunction with the 1st International CLIVAR Science Conference. Outcomes of this assessment would be discussed at the SSG meeting immediately following the Conference (27-29 June 2004) and would serve to guide the SSG in decisions concerning future directions and management of the CLIVAR project. The review was being organized by CLIVAR streams: GOALS, DecCen, and ACC and by unifying themes which have been grouped into two categories, i.e. "Data" (Global sustained observations, Improved historical data, Paleoclimate data, Reanalysis and Empirical studies) and "Modelling" (Predictability and prediction, Global and regional modelling, Downscaling). Each CLIVAR Panel or Working Group was being asked to prepare background material for the assessment. The five external reviewers, who have been selected from past SSG members, were being asked to comment on progress within their assigned CLIVAR stream or unifying themes based on the input from CLIVAR's panels and working groups and what would be presented orally and in posters at the Conference. Based on this input and their overall view of the subject, they were also being asked to assess the effectiveness of the CLIVAR organizational structure, and how it could be improved and made more effective.

The JSC welcomed the decision by the CLIVAR SSG to carry out an assessment of progress to date, in conjunction with the 1st International CLIVAR Science Conference. JSC members were requested to provide input to this assessment by end of March 2004.

5.1 Global synthesis and observations

5.1.1 Global Synthesis and Observations Panel

The new CLIVAR Global Synthesis and Observations Panel (GSOP) has been established to develop and seek to implement strategies for a synthesis of global ocean, atmosphere and coupled climate information. It would do this through analysis and reanalysis efforts and the use of other appropriate techniques. The panel's initial emphasis will be on global ocean synthesis efforts. The panel would also be responsible for the definition and fulfilment of CLIVAR's global needs for sustained observations in collaboration with relevant WMO and IOC bodies and CLIVAR's panels and working groups and for the development of a strategy for their evolution/optimization. It was anticipated that such a strategy would be based on new science and reanalysis insights, and from fostering the use of resulting data sets in global synthesis efforts. The panel would, in addition, promote activities to develop the surface flux data sets required by CLIVAR. It would do this in liaison with the WGNE, global atmospheric reanalysis efforts and the WCRP Working Group on Surface Fluxes. It would also provide overview of and directions to CLIVAR data management and information activities in collaboration with other WCRP projects and in liaison with CLIVAR-relevant data centres and the ICPO. It was anticipated that the CLIVAR GSOP would have strong ties to the proposed WCRP Working Group on Observations and Assimilation. The panel has a wide remit therefore and it was anticipated that it would be necessary to convene one or more specialist groups to tackle particular problems. The panel chairs have been agreed and its membership almost finalised. It was anticipated that the panel would have its first meeting in August 2004. In the meantime, the panel was developing its activities, in particular:

- The panel chairs have renewed plans for a workshop on Ocean Reanalysis, 8-10 November 2004 in Boulder, USA.
- The holding of the 1st CLIVAR (Ocean Observations) Data Planning Workshop, which would take place in San Diego, USA, 24-26 March 2004, to further engage the Data Assembly Centres and the CLIVAR user community as represented by the CLIVAR ocean basin panels and also assess the status of CLIVAR data and information management, including developments to the CLIVAR data pages on its website which the ICPO has been engaged in during the year.

5.1.2 Global hydrography and interactions with biochemistry and carbon

In January 2003 the SCOR-IOC Advisory Panel on Ocean CO_2 and the IGBP-IHDP-WCRP Global Carbon Project (GCP) launched the International Ocean Carbon Coordination Project (IOCCP). Coordination with repeat WOCE hydrographic cruises was an essential component of the total activity and the ICPO was working with IOC to actively document plans and carbon and hydrographic datasets as they became available. To aid the collaboration on carbon issues between IOCCP and CLIVAR, jointly appointed carbon representatives to each of CLIVAR's basin panels have been agreed. Links have also been established with the IGBP Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project. Working with CLIVAR forms part of the overall strategy for IMBER. Ways of further developing CLIVAR/IMBER collaboration need to be developed.

There was a clear continuing need here to bring together the physical, carbon and wider biogeochemical communities and to evolve an observations strategy which satisfies the needs of all parties. This would require continued work with the GCP, IGBP and OCCP and others to ensure that the issues are addressed completely and cohesively. One such issue is the need to decide on a core suite of carbon measurements to be carried out with repeat hydrographic cruises.

5.1.3. Tropical moored buoy implementation panel (TIP)

The Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network(TAO/TRITON) partnership continued to function well, providing a seamless real-time data stream for ENSO forecasting and analysis. During the recent 2000-03 El Niño, TAO/TRITON data proved to be valuable for characterizing the evolution of the event and for coupled ocean-atmosphere model forecast initialization. The data are disseminated to the operational and research communities via the GTS and the World Wide Web. Between October 2002 and September 2003, a total of 118,773 data files were downloaded from TAO/TRITON web sites at Pacific Marine Environmental Laboratory (PMEL) and Japan's Marine Science and Technology Centre (JAMSTEC) in 11,961 separate user requests. For October 2002-September 2003, real-time data return for the array was 86%.

Pilot Research Moored Array in the Tropical Atlantic (PIRATA), begun in 1997, has not yet achieved the same level of scientific productivity as TAO/TRITON. Use of PIRATA data for research and forecasting was growing though. Problems with vandalism, data return, ship time, and shipping still exist.

In recognition of its achievements in web-based data display and dissemination, the TAO project received the 2003 Grace Hopper Government Technology Award (a “Gracie Award”), for “Leadership in the innovative application of information technology that contributes to the advancement of scientific knowledge and its application’’.

Planning for an Indian Ocean moored buoy array had progressed over the past year with the development of array design strategy and identification of potential participants. These efforts would be accelerated with the formation of the CLIVAR/IOC Indian Ocean Panel. The TIP would work with this new panel (as well as other existing CLIVAR and IOC/WMO panels) to advance the implementation of a moored buoy network in the context of other observing system elements in the Indian Ocean for climate purposes. The two Spondylus surface moorings deployed by Instituto Oceanografico de la Armada (INOCAR) (Ecuador) along 2°S in mid-2002 were vandalised after about 6 months in the water, and Ecuador is evaluating its options for what to do next. The ocean observing project ‘’The Annual El Niño and Measurement of Anomalies in the Pacific (NAYLAMP, Peru)’’ has suspended its efforts to make surface observations from moored buoys in view of the vandalism it experienced with earlier deployments. Instead, Peru has deployed a subsurface mooring off its coast to internally record data for later recovery.

After what appeared to be a conclusive decision by the NOAA Administrator in March 2003 to defer immediate transfer of the TAO and PIRATA arrays from PMEL to NOAA’s National Data Buoy Office (NDBC), the NOAA Executive Council (NEC), which advises the NOAA Administrator on management and policy issues, requested a new plan in July 2003 to transfer responsibility for these arrays to NDBC. While at one level NOAA’s management of the TAO array is an internal affair, the JSC and other international bodies should be aware of potential impending changes in management practices, because 1) the TAO array was developed over a 20-year period with intellectual, organizational, and financial support from the international community; 2) it is presently maintained as a contribution to GOOS, GCOS, and the WCRP through international partnerships; and 3) it is universally recognized as a key element of the ENSO observing system.

The JSC noted that the new CLIVAR GSOP had been established to develop and seek to implement strategies for a synthesis of global ocean, atmosphere and coupled climate information, but with initial emphasis on global ocean synthesis. In particular, it considered that the initialisation of the ocean for a pre-industrial state (circa 1850) for climate modelling (cf WGCM) was also a topic that GSOP should address. The JSC recognised that these would be highly significant and important CLIVAR contributions to the proposed new WCRP WGOA and therefore COPES. The JSC stressed the need to ensure that this was achieved without duplication of effort in GSOP and WGOA.

The JSC noted the potential impending changes in management practices with the transfer of TAO array from PMEL to NOAA’s National Data Buoy Center (NDBC). The JSC recognized that the TAO array is presently maintained as a contribution to GOOS, GCOS and the WCRP through international partnerships; it is universally recognized as a key element of the ENSO observing system.

5.2 CLIVAR Ocean Basin Sector Panels

5.2.1 The 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.

In association with the planning for AMMA first discussions were held at a Tropical Atlantic Workshop at NOAA/AOML (Miami, March 2003) to outline an ocean/climate programme that might take place within the time frame of the AMMA observational periods and provide a focus on improving our understanding of the ocean's role in tropical Atlantic climate variability. The CLIVAR Atlantic Implementation Panel, at its last meeting in Villefranche-sur-Mer, France, April 2003 charged a subgroup of the Panel and other experts with developing a "White Paper" for a "Tropical Atlantic Climate Experiment" (TACE). A first draft is available at: www.clivar.org/science/atlantic.htm. TACE would complement a proposed US-CLIVAR process study on the Dynamics of the East Atlantic Marine ITCZ: interactions with the large scale environment, African Monsoon and Equatorial cold tongue. This process study is well coordinated with AMMA planning and makes use of existing and enhanced sustained observations as outlined in the TACE document (drifters, floats, moorings).

A substantial portfolio of process studies and observations targeting the Atlantic MOC in the Northern Hemisphere was now taking shape (http://www.clivar.org/organization/atlantic/IMPL/proc-stud.html#moc). This included ongoing national CLIVAR programmes in Canada, Norway, France, Germany, and USA as well as two international thematic programmes:

- The activities under and associated with the Arctic - Subarctic Ocean Fluxes study (ASOF; http://asof.npolar.no/).
- The activities under and associated to the UK RAPID Climate Change programme (http://www.nerc.ac.uk/funding/thematics/rcc/), in particular a moored array at 26.5°N to measure directly the meridional mass flux, time series of transient tracers in North Atlantic deep waters, an array along the western margin of the Atlantic to look at boundary wave signals, and an array between New England and Bermuda, jointly funded by the UK and USA.

For all the above, CLIVAR Atlantic provides a forum for an implementation strategy to address CLIVAR's goals in the region and for the coordination of associated activities. In addition the Atlantic Panel prompted by the CLIVAR SSG, liaised with WCRP/CliC on the forming of an "Arctic Climate Panel" which will address the role of the Arctic Ocean in the global climate.

The role of the South Atlantic and inter-ocean exchanges on the thermohaline circulation was addressed at the CLIVAR South Atlantic Climate Observing (SACOS) workshop (Angra dos Ries, Brazil, 6-8 February 2003). Among the proposals was one for a zonal section across the South Atlantic at about 30°S to monitor the net effect of the varying inter-ocean exchanges and subsequent mixing and water mass modifications on the vertical buoyancy characteristics of the South Atlantic and the basin-scale overturning fluxes. The CLIVAR Atlantic Panel was in the process of developing an implementation strategy for the South Atlantic Ocean that would allow the most salient of a variety of issues arising from the SACOS Workshop to be addressed.

The CLIVAR Atlantic Panel was addressing a basin wide synthesis, collaborating with the Working Group on Ocean Model Development (WGOMD) and WGCM to develop experiments to explore MOC responses and sensitivity. A joint workshop with WGOMD on Atlantic Thermohaline Variability with emphasis on synthesis was being scheduled for September 2004 in Kiel, Germany.

During the winter season the North Atlantic Oscillation (or Northern Annular Mode) is the dominant pattern of variability in the mid latitudes of the Atlantic sector. A large number of individual research projects are ongoing on this topic, most of them model based. The generic challenge was to identify mechanisms or indicators that could lead to some kind of predictability. Mid-latitude predictability in one of the themes for the upcoming CLIVAR (Atlantic) workshop on predictability to be held in Reading, UK from 19-22 April 2004.

Implementation of CLIVAR relevant sustained observations in the Atlantic was under way at an acceptable level (www.clivar.org/organization/atlantic/IMPL/). The North and equatorial Atlantic were at the forefront of the initial Argo implementation, the South Atlantic would be one of the targeted regions during 2004/2005. Funding had been secured for several hydrographic repeat sections that were occupied during WOCE and several long sections carried out during 2003.

New activities of the panel have been addressed above, namely TACE, the Panel's involvement in the CliC Arctic Panel and the planned workshops on Atlantic Predictability and North Atlantic Thermohaline Variability.

Although the Atlantic basin was arguably the best "supported" region, even here the resources are lacking to fully implement the plans developed for CLIVAR. Specific aspects that deserved attention were:

- Development of time series long enough to test decadal mechanisms and basin scale phenomena
- The limited reanalysis capabilities in the atmosphere and ocean which restrict our ability to "evaluate" the potential benefits and design tradeoffs from sustained observing systems.
- A piecemeal approach to data management and synthesis makes it difficult to tackle basin scale analysis using all of the observations.
- The need to optimise communication with the "customer" base, i.e. seasonal-decadal prediction centres, and the IPCC process. Both of these have a more natural connection to modelling activities which are only indirectly "handled" by the regional implementation panels.
- Difficulties in entraining "smaller" nations into the CLIVAR programme due to the large resource that this longer time scale science demands.

5.2.2 The Pacific

CLIVAR Pacific seeks to understand three phenomena, ENSO, the decadal variations of ENSO and decadal variability at higher latitudes, with the recognition that all three are connected. The observational strategy was to ensure adequate broad-scale sampling of the ocean to detect changes, provide dynamical understanding and enable hypothesis testing. Key processes fundamental to the coupled ocean/atmosphere system, and which need to be improved in coupled models are the subject of focused process studies. The panel's last meeting was held in Yokohama, Japan from 14-16 July 2003.

In respect of the broad scale network, the panel continues, through the ICPO, to maintain an overview of the status of, and developments to, the observational network over the Pacific. 2003 saw a large increase in the coverage of the Argo array, in particular in the South Pacific. It is hoped that by the end of 2004 the coverage across the entire Pacific will be more uniform. Other parts of the broad-scale network continue to provide valuable data through the TAO/TRITON array, satellite data (sea surface temperature (SST), sea surface height (SSH), wind stress), ship of opportunity SST and sea surface salinity (SSS), island stations and flux moorings.

With regard to process studies, analysis of the field phase of Eastern Pacific Investigation of Climate (EPIC), which came to an end last year, continues. Early EPIC contributions include the provision of critical observations for model validation, new parameterizations for climate models and new insights into low-latitude cloud feedbacks. These include:

- Improved definition of the diurnal cycle of convection and the phasing of convection and easterly waves;
- Development of a chlorophyll-based parameterization of solar transmission which has been implemented in the NCAR Community Climate Model;
- Development of a new formula for representing cloud-based drizzle;
- Discovery that evaporating drizzle drives low-albedo patches of open cellular cloud in aerosol-poor air masses.

The field phase of the Kuroshio Extension System Study (KESS) starts in 2004. The goal of KESS is to identify and quantify the dynamic and thermodynamic processes governing the variability of and the interaction between the Kuroshio Extension and the recirculation gyre.

A workshop on the low frequency behaviour of ENSO was hosted by Dr J. Picaut in Toulouse, France in September 2003. Three working groups addressed the following issues: i) data analyses: historical and proxies, ii) ENSO decadal variability and subtropical/tropical interactions, and iii) self sustained low-frequency variability in the tropics. Each group tackled specific questions and provided recommendations. The final report, including all presentations and working group conclusions, should be published in early March 2004.

Strong links were developing between the Pacific Panel and CLIVAR modelling working groups. Two activities with the WGOMD were focused on allowing easy comparison of the behaviour of ocean models. The first was to provide a common suite of diagnostics of ocean reanalyses. The second was a comparison of the low frequency behaviour of forced ocean models and the ocean component of coupled models. A

compilation of such information would provide an improved framework for comparison and interpretation of observations.

A major new initiative was a joint activity of the Pacific Panel and the Working Group on Seasonal to Interannual Prediction (WGSIP) aimed at improving the representation of ocean processes in models of the tropical Pacific used in seasonal prediction. The first focus would be on mixing (both vertical and lateral). A workshop was being considered which would be tasked with identifying deficiencies and planning model experiments and observational studies. In this context, the US CLIVAR Pacific Upwelling and Mixing Physics (PUMP) was relevant. PUMP is a proposed process study to examine the mechanisms by which upwelled waters in the equatorial Pacific are transformed by mixing and how this upwelling influences the heat balance of the coupled ocean-atmosphere system. PUMP was still in its planning stages.

Low Latitude Western Boundary Currents (LLWBCs) provide a link between the sub-tropics and tropics, and in the north Pacific a link with the Indonesian Through Flow. Ways of monitoring the LLWBCs were being explored, initially through an IOC WESTPAC meeting. It was hoped to have plans for a pilot study by the end of the year.

The sparse number of observations in the South Pacific continues to be of concern, though the situation was improving, particularly with regard to the coverage of the Argo array. A US process study on Sub-Antarctic Mixed Layers, Fluxes and Overturning Circulation, newly funded to run from 2004-10 would greatly improve observations in the Southeast Pacific, where data sparsity was an acute problem.

The planning and execution of process studies targeted at elements of the climate system were being hampered by lack of funding from national agencies. One way forward was to engage with other programmes. For example, the aims of the proposed study on tropical mixing (which includes PUMP) were relevant to both the Surface Ocean - Lower Atmosphere Study (SOLAS) and IMBER. Ways to promote such collaboration needed to be sought.

Two relevant workshops, planned for 2004, were a regional workshop on interannual/interdecadal variability, in September in Chile, which would highlight the regional applications of ENSO research, and a joint CLIVAR/PICES Workshop, in October, in Hawaii. The latter was focused on the impact of climate variability on marine ecosystems and biochemistry, and fisheries, with particular regard given to scale interactions.

5.2.3 The Southern Ocean

The Southern Ocean (SO) panel held its second meeting in September 2003 in Bremerhaven, Germany in the context of a “Southern Ocean Science Week”. The meeting was held in conjunction with the WCRP International Programme for Antarctic Buoys (IPAB), the international Antarctic Zone SCOR affiliated programme (iAnZone), the Antarctic Sea-Ice Processes and Climate project within the SCAR Global Change Programme (ASPeCt), Ice Station POLastern (ISPOL) and the multinational GOODHOPE project (a large multinational project proposed to study the ‘’choke point’’ south of Africa).

The panel has strengthened its links with other programmes and projects interested in SO research as well as provided guidance for the GOODHOPE project and support for other proposed studies such as Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES), Subantarctic Mixed Layers, Fluxes and Overturning Circulation (SAMFLOC), and Southern Ocean air-sea CO_2 exchange study (GASEX).

A major theme of discussion during the last panel meeting was the proposed International Polar Year (IPY) in 2007/8. As a result of this the panel submitted a white paper to the IPY committee, entitled “Role of the high latitude oceans in the global water cycle”. The panel was also working in concert with OOPC to produce a list of climate indices based on SO phenomena, and a white paper on time series sites.

SCAR was interested in raising the profile of ocean/climate issues. Rather than forming a new, separate SCAR panel or working group, the suggestion has been made for SCAR to co-sponsor the SO CLIVAR/CliC panel. The additional monetary support and links into SCAR would be welcome, provided the panel’s brief remains SO climate and additional overheads are low. Resources and champions for time series sites were still required. There was also the need to maintain the push for SO Argo (including under sea ice technology).

5.2.4 The Indian Ocean

Encouraged by the outputs from the Workshop on Sustained Observations of Climate in the Indian Ocean (Mauritius, November 2002), which WCRP co-sponsored, a joint IOC/CLIVAR Indian Ocean Panel was established during the year. It held its first meeting alongside CLIVAR's Asian Australian Monsoon Panel (AAMP), to which it reports, in Pune, India, from 18-20 February 2004. The panel will provide scientific and technical oversight and develop, coordinate and implement a plan for a sustained Indian Ocean Observing System (IOOS), to (a) meet the common requirement of CLIVAR research themes and regional initiatives, particularly those identified by AAMP and VACS and the CLIVAR modelling panels, (b) satisfy the common requirements of GOOS and its modules, and (c) coordinate implementation activities in collaboration with relevant regional and global bodies and Indian Ocean GOOS(IOGOOS) and JCOMM in particular.

The JSC acknowledged that the emerging needs for WGOMD to develop closer liaison with the CLIVAR ocean basin panels created the need for activities well beyond, and different from, its original tasks in serving WGCM. The JSC decided that WGOMD should continue as a joint WGCM/CLIVAR group but that a review of its ToR, membership and reporting structure should be part of the overall review of CLIVAR (see also *9.2.5*).

5.3 Studies of monsoons and regional climate variability

The regional foci for the seasonal-interannual elements of CLIVAR are the Americas, areas influenced by the Asian-Australasian monsoon and Africa. The last two are closely related and there is collaboration between all three on monsoon modelling issues. CLIVAR has science panels for each of these areas.

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 monsoon systems over North and South America, respectively. These projects are collaborative with GEWEX and perform modelling and empirical studies and enhance the monitoring infrastructure. Deliverables include fine resolution precipitation products, as well as an improved understanding of orographic and land surface processes, and of the regional water budgets. A new project, the VAMOS Ocean-Clouds-Atmosphere-Land Studies (VOCALS) has started. VOCALS addresses the better understanding and simulation of how marine boundary layer cloud systems surrounding the Americas interact with the coupled ocean-atmosphere-land system on diurnal to interannual timescales.The activities in all projects rely heavily on multinational scientific collaboration.

VAMOS was conceived as a unified programme, albeit covering two distinct monsoon systems. This unity was predicated on the conviction that the comparative study of monsoon systems with many differences in their time and space scales would facilitate progress on the understanding of the fundamental components. It was felt, therefore, that the programme's unity should be preserved despite inevitable differences in resources of the regions involved.

A VAMOS International Project Office has been established for support of its field programmes under the guidance of the VAMOS Science Working Group (SWG) and of the agency Programme Manager(s). The Project Office has participated in the planning and field implementation of the South American Low Level Jet Experiment (SALLJEX), which took place in the period November 2002-March 2003. This participation, which contributed greatly to the success of SALLJEX, included the planning and field implementation of the experiment and also the coordination, management, and implementation of all activities such as meetings, workshops, outreach programmes, training, etc. The Project Office directly supported the efforts of the SWG Data Management Sub-Group by addressing facets of data management, including data collection, validation, quality control, and archiving. The Office was actively involved in the implementation of the field phase of the NAME project, as well as the realization of the meetings of the MESA and VOCALS projects. VAMOS was pleased with the relations it had established with the GEWEX SSG and its Hydrometeorology Panel (GHP). These links would be of great help in the research plans of both NAME and MESA. There was general agreement that increased connections with the GEWEX modelling panels would be very beneficial to VAMOS modelling programmes.

The most challenging issue to VAMOS has been the establishment of collaborations with operational hydrometeorological centres in the realization of field campaigns. NAME was making a big effort to

anticipate these difficulties in their forthcoming field experiment, and appeared to be succeeding at least for the centres in North America. SALLJEX found that it was difficult to achieve such a collaboration with the hydrometeorological centres in a multi-country region. Overall, VAMOS feels that mechanisms to address the collaboration between operational centres and WCRP in field campaigns of research programmes were not clearly defined.

North American Monsoon Experiment (NAME)

NAME has organized workshops on Ocean Processes and Data Assimilation. The latter resulted in a Modelling and Data Assimilation Strategy Document. This provided a strategy for accelerating progress on the fundamental modelling issues pertaining to the NAME science objectives, and emphasizes activities that bring observationalists, modellers and physical parameterization experts together to focus on key physical processes that were deficient in coupled models. NAME had also started a programme for assessment of North American monsoon simulations using both regional and global models. The NAME SWG had continued the preparations for the NAME 2004 enhanced observations field programme. A NAME Forecast Operations Centre had been established jointly by US and Mexican National Weather Services in support of NAME 2004 and longer-term efforts, and exchange visits have been carried out.

Monsoon Experiment in South America (MESA)

Ongoing post-SALLJEX activities using the data gathered during the field experiment include quality control, analysis and diagnostic studies. A coordinated set of model experiments had been performed. Work with the data and model results were discussed at a SALLJEX Data Workshop, held in Buenos Aires, Argentina, 10-12 December 2003.

MESA also comprises the Science Study Group (SSG) on the climatology and hydrology of La Plata Basin (PLATIN SSG) which was encouraging the establishment of a research programme. The long-term goal was to improve understanding and prediction of the La Plata Basin's climate and hydrology based on their unique regional features and sensitivity to the variability of remote climates. This was motivated by the need to find answers to the the following questions: 1) How predictable are the regional weather and climate variability and what is the impact of these on hydrological, agricultural and social systems of the basin?, 2) How are droughts and floods in the basin characterized from a climatological and hydrological point of view? and 3) What is the role of global climate change and land use change on regional weather, climate, hydrology and agriculture?

An important activity and major success of the PLATIN SSG in 2003 was the participation with the United Nations Environmental Programme (UNEP), Organization of American States (OAS) and the Intergovernmental Coordinating Committee for La Plata Basin (CIC) in a request for funds to the Global Environmental Facility (GEF). The funds are for support of the planning and implementation of strategic actions to be taken by the governments of countries in the La Plata Basin for the environmentally and socially sustainable economic development of the basin. Areas specifically targeted were protection and integrated management of water resources and adaptation to climatic change and variability. Leverage of CLIVAR research through the PLATIN SSG was a key component in the successful outcome of the request and funds have been allocated for the planning stage. In this stage, PLATIN has been selected to coordinate one of the key activities: "Predicting the Impacts of Climatic Variability and Change on the Hydrology of the La Plata Basin''. The goal of this activity is to enhance the capacity of the five countries in La Plata Basin to predict the likely impacts of climatic change and hydrologic variability through the identification and coordination of common concerns, strategies, and procedures. Areas specifically targeted in the UNEP/OAS/CIC multi-national project are protection and integrated management of water resources, energy production, agriculture, and adaptation to climatic change and variability. The interaction between PLATIN and the GEF is new ground for CLIVAR.

The JSC congratulated the PLATIN Science Study Group for its part in the successful bid for significant funding from the Global Environmental Facility, which broke new ground for CLIVAR and provided an important, much-needed and timely opportunity to link VAMOS basic research directly to operationally-based applications within several WMO Member States. Strong liaison and partnership between WCRP and other WMO-sponsored programmes, in particular Hydrology and Water Resources, will be critical to the success of this new endeavour and the Director, WCRP, should keep WMO fully appraised of this.

The VAMOS Ocean-Clouds-Atmosphere-Land-Studies (VOCALS)

VOCALS addresses the time and space scales of interactions among cloud-topped boundary layers

and continents. Particular emphasis was given to regional seasonal/interannual feedbacks between stratocumulus clouds, surface winds, upwelling, coastal currents and SST in the Eastern Pacific. VOCALS also addresses the feedbacks of Eastern Pacific cloud topped boundary layer properties on overall tropical circulation and ENSO, and the climatic importance of aerosol-cloud interactions. The project strategy is based on global and mesoscale model evaluation and improvement (e.g parameterization development) using multiscale data sets, and model sensitivity studies to refine hypotheses and target observations. The science approach is based on the synthesis/use of existing data sets, enhancement through targeted instrument procurement, algorithm evaluation and development, and enhanced observation periods. Co-ordination has been established with oceanographic, aerosol, cloud process communities, including US CLIVAR Climate Process Teams (CPTs), CLOUDSAT, etc. One of the first activities of VOCALS was the augmentation of the instruments in San Felix Island (off the Chilean coast at 26^{o}S, 77^{o}W) with a wind profiler, radiation, microwave liquid water path instrumentation, and an aerosol sampler. The VOCALS data set will be developed through the distributed satellite/model/in situ data archive at JOSS.

5.3.2 Asian-Australian Monsoon

CLIVAR's Asian-Australian Monsoon Panel (AAMP) met in Pune, India, 18-20 February 2004. Since the previous panel meeting in Atlanta, (AAMP5, 25-27 February 2003), advances have been made (i) towards a sustained Indian Ocean Observing System (IOOS) through the formation of an Indian Ocean Panel (IOP - see 5.2.4 above) and the continued implementation of Argo, (ii) with the joint GEWEX/CLIVAR CEOP Inter-monsoon Model Study (CIMS), (iii) in planning for an international workshop on 'The Role of Indian Ocean in Climate Variability over India' (INDOCLIM) and (iv) in the field of applications of monsoon studies. AAMP endorsed the concept of the INDOCLIM international workshop which took place in Pune, India from 23-27 February 2004, following the AAMP meeting. The aim of this workshop was to facilitate synthesis of the available information on Indian Ocean variability and its impact on the climate of the region. About 80 experts reported on recent advances in various aspects of oceanography, air-sea interaction, and meteorology with specific focus on the Indian Ocean. Both observational and modelling studies of the various facets of the role of the Indian Ocean in the climate variability and change over India were discussed at the meeting. A detailed report of the meeting would be prepared.

Argo floats are a core element of the ocean observing system in the Indian Ocean, which will ultimately improve predictability of the monsoons. The Argo float programme has progressed in the Indian Ocean, with ~200 floats sending temperature/salinity profiles every 10 days at the present time. The IOP will plan a unified approach integrating the ongoing XBT, drifter and sea level measurements with the new mooring and Argo observations. At AAMP5 the panel discussed observation simulation experiments aimed at providing guidance on how best to deploy Argo floats in order to monitor intra-seasonal oscillations (ISOs) in the tropical Indian Ocean. Communication on this topic with the Argo Science Team has been established. Open questions remain as to where and how often to sample the upper ocean. The task was to aid the design for an Argo float array in the Indian Ocean by inferring information from Observing System Simulation Experiments (OSSEs). Some preliminary results from activities undertaken in India, the USA and Australia suggest that capturing variability on intraseasonal-to-seasonal scales in the Indian Ocean requires a spatial sampling with approximately $x \leq 500$km and $y \leq 100$km. Intraseasonal variability requires a temporal sampling of 5 days or less (current sampling period is typically 10 days).

Climate Forecasting Applications in Bangladesh (CFAB), which one of the panel co-chairs helped to establish was continuing to promote applications of monsoon forecasts in agriculture in Bangladesh. In particular, applications to flood prediction were being made. AAMP was represented at the first planning meeting of the START Integrated Regional Study (IRS) for Monsoon Asia, a 10-year project aimed at assessing vulnerability and impacts due to environmental/climate changes in the monsoon regions. Further planning within 3 sub-groups was under way. AAMP would provide input as appropriate.

The JSC acknowledged CLIVAR concern that the CEOP Inter-Monsoon Studies (CIMS) did not include the full and proper input and participation of the CLIVAR Asian-Australian Monsoon Panel (AAMP). It re-iterated the request that CLIVAR and GEWEX review their monsoon-related activities with a view to achieving better coordination and collaboration and to reducing the number of monsoon-related panels, and develop a pan-WCRP monsoon modelling strategy. Particular attention should be given to requirements and actions needed in connection with the Asian-Australian monsoon. CliC should be brought into the deliberations where appropriate. A preliminary report should be made to the WCRP Officers, Chairs and Directors Meeting, in September 2004, with a full report and proposal(s) to JSC-XXVI, March 2005. The JSC requested that "WCRP Monsoon Research" be a specific agenda item at JSC-XXVI, March 2005.

5.3.3 Variability of the African Climate System (VACS)

CLIVAR-Africa was the subject of a double issue of CLIVAR Exchanges published in September 2003. The issue highlighted the breadth of interest in climate research relating to Africa, including the following key items being pursued by the VACS Panel.

African Monsoon Multidisciplinary Analysis (AMMA)

The interannual and interdecadal variability of the West African monsoon (WAM) has important consequences for sustainability, land degradation, and food and water security in the region. AMMA is a coordinated international project to improve our knowledge and understanding of the WAM and its variability with an emphasis on daily-to-interannual timescales. The initial science plan of AMMA was produced by the French research community in 2001 (http://medias.obs-mip.fr/amma/index_en.html). Since then there have been several workshops in Europe, Africa and USA during 2002/2003 and now scientists from 15 countries were involved in AMMA. Both CLIVAR and GEWEX have given their endorsements to the project and VACS and the CLIVAR Atlantic Panel were active in AMMA planning.

The observational strategy would associate operational observations with long term observations concentrated in a sub-regional window and obtained from various ongoing research projects and intensive multi-disciplinary observations during specific periods focusing on the understanding of key processes. The utility of the enhanced observations would be tested using modelling and assimilation systems. AMMA is planned as a multi-year project. Satellite observations would contribute strongly to the objectives of the project by providing key variables of the surface-atmosphere system. The project would provide a unique set of integrated ground observations for validation. It would also provide the framework to build a reliable monitoring strategy combining satellite and in situ networks, to make up for the low density of routine observations in Africa. Particular attention would be given to evaluation and improvement of numerical prediction of weather and climate over the West African region. In West Africa a network of scientists, called AMMANET (http://www.ird.ne/ammanet/), has been formed in order to encourage scientific collaborations and contribute to AMMA. Initial financial support to AMMANET proposals are provided by IRD-France, ICSU, the Agency of French Speaking Countries and ACMAD-FIRMA.In Europe efforts are under way to help mobilize EU funding as well as national funding in France, Germany and the UK. In the USA a scientific steering group that represents US interests in AMMA has been formed. A US science plan is available at http://www.joss.ucar.edu/amma.

Atlas of African Climate Variability

A major goal of this atlas is to stimulate and promote research activity on African climate variability. It will achieve this by providing global and regional diagnostics along with text that highlights key scientific issues. An initial version of the Atlas web page was made available to a VACS subgroup for comments (http://www.geog.ox.ac.uk/~arnaud/ClimateAtlasNew/ClimatologyIndex.html).

Decadal Variability Review

Recognizing the importance of decadal variability for the African continent, a review document on this subject was being developed for publication in a peer-reviewed journal.

PIRATA SE Extension

A one-year study supported by the Benguela Current Large Marine Ecosystem (BCLME) programme has addressed the issues related to the scientific rationale and implementation feasibility of a PIRATA array extension at key locations in the tropical SE Atlantic region. BCLME was reviewing the document and initial response seems favourable in supporting the PIRATA extension.

Research Agenda for Eastern Africa

As recommended by the CLIVAR SSG in 2002 the VACS panel has initiated plans for a research initiative in Eastern Africa. The first draft of a white paper was produced in November 2003 and distributed to the VACS panel members. The agenda, which includes the VACS Great Lakes Project consists of 7 potential projects to be discussed in detail at the next VACS meeting in summer 2004.

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. 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 involve a combination of activities including

encouraging collaboration through international projects like AMMA, international workshops and capacity building.

The JSC acknowledged that the major challenge for VACS and its community was to mobilize adequate resources for research related to African climate variability. The JSC re-affirmed support for the development of AMMA as a joint CLIVAR-GEWEX experiment and as a focus and test-bed for mobilizing the resources, both in Africa and elsewhere, needed to study African climate variability.

5.4 Modelling activities in support of CLIVAR

5.4.1 JSC/CLIVAR Working Group on Coupled Modelling (see section 9.2)

5.4.2 Seasonal to interannual prediction modelling

The CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP) met in Honolulu, USA in November 2003 in association with the Workshop on Seasonal Prediction, which was organized by the WCRP COPES Task Force on Seasonal Prediction.

WGSIP's Seasonal Prediction Model Intercomparison Project (SMIP-2) was aimed at determination of potential predictability on seasonal timescales given perfect knowledge of global surface boundary conditions. SMIP-2 has now been extended to investigate actual 1-season forecast skill. The extended activity is called SMIP-2/HFP (historical forecast projects) and has been conceived to encompass a range of initial conditions reflecting the range of research and operational approaches to seasonal prediction being used and investigated by the community. The project was proceeding although participation was not at the expected level. Options for data management, including aspects of data collection at PCMDI, were being reviewed. Further details of the experiment 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 Commission for Basic Systems (CBS) report on verification of long lead forecasts which they endorsed, regarding it as an excellent starting point if 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. However, the ICPO did not have either the resources or the expertise to develop and manage this. This was hampering progress. In the meantime intermediate plans for start up implementation were being explored.

GEWEX/GLACE, the GEWEX Global Land-Atmosphere Coupling Experiment, is now a joint co-sponsored activity between GEWEX GLASS (the GEWEX Global Land-Atmosphere System Study) and WGSIP. GLACE is seeking participation in a multi-model intercomparison experiment focusing on the ability of land surface state to affect rainfall generation and other atmospheric processes. The experiment aims to quantify the strength of land-atmosphere coupling in the different global atmospheric models used for weather and climate studies. It aims to develop a table of 'coupling strengths' to aid in the interpretation of land-atmosphere studies. GLACE has some 15 centres participating. For each AGCM, three 16-member ensembles of 3 month simulations are being generated, a control and two others in which: (a) all of the land surface variables are reset at each time step to land surface conditions generated during one of the control runs (randomly chosen from one of the participating models) and (b) some land surface variables are allowed to vary freely but others (the soil moisture contents associated with the rooting depth and below) are reset.

A Workshop on Ensemble Methods would be held at the Met Office,UK 18-21 October 2004. WGSIP would meet back-to-back with this event. WGSIP in collaboration with the Pacific Panel was developing a strawman proposal for an experimental strategy for improving our ability to simulate the tropical ocean, e.g. via improved treatment of mixing processes. A closer interaction between both panels was envisaged. Other new activities were expected through the COPES Task Force on Seasonal Prediction.

At its last meeting, WGSIP had a particular concern that the Commission for Climatology (CCl) is seeking to establish a group in order to define an internationally accepted index of El Niño. Following the meeting the group prepared a revision of the position paper presented in detail in the CLIVAR report to JSC-XXIV proposing the use of NINO3.4 as a robust index for ENSO. The revised paper has been forwarded to the CCl for consideration.

WGSIP noted that there is some common ground with aspects of the START programme and expressed some hope for more interaction in the future. Since the group is dealing with seasonal prediction,

a topic closely related to applications, it is natural that they look into issues like forecast products, feedback from end users, etc. There is clear relevance of WGSIP to the WMO CLIPS (Climate Information and Prediction Services) programme and to wider seasonal forecast services for a variety of applications and end users. These need to be fostered and developed.

As one of the first activities under the Coordinated Observation and Prediction of the Earth System (COPES) strategic framework, WGSIP and the recently formed Task Force for Seasonal Prediction (TFSP) held a workshop on Seasonal Prediction immediately following the working group meeting. A report of this meeting was presented to the JSC by Professor B. Kirtman. Recognizing that the JSC had recommended that WGSIP lead the TFSP, WGSIP should expand its terms of reference to include sub-seasonal (i.e., weeks) time scales and include consideration of decadal time scales to the extent that they affect prediction and predictability on time scales of weeks to interannual. Decadal prediction and predictability itself was beyond the scope of WGSIP and they recommend that it should remain within the remit of WGCM. Moreover, given WGSIP's leadership of the COPES TFSP as recommended by the JSC, it was suggested that WGSIP report directly to the JSC on matters directly related to the limited-term TFSP. Regarding all ongoing CLIVAR related projects and new initiatives, WGSIP should continue to report to the CLIVAR SSG.

The JSC supported the concern of WGSIP that the WMO Commission for Climatology (CCl) was seeking to establish a group in order to define an internationally accepted index of El Niño for operational use and guidance. The JSC noted that in direct response to a request to WCRP from the President, CCl, WGSIP had already submitted a position paper to CCl for consideration proposing the use of NINO3.4 as a robust index for ENSO. The JSC requested that Director, WCRP, convey the JSC's concerns to WMO.

5.5 Joint CCI-CLIVAR Expert Team on Climate Change Detection (ET/CCD)

The ET/CCD is the successor to the joint WCRP/CCl Working Group on Climate Change Detection (WGCCD). The team consists of four CCl and four CLIVAR representatives. It is chaired jointly by Dr A. Mokssit (CCl) and Dr F Zwiers (CLIVAR). The first Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI) meeting was held in Norwich, UK in November 2003. It reviewed recent progress in the field of Climate Change Detection Monitoring and Indices (CCDMI), made a working plan for regional workshops in 2004-2005 and discussed development of marine/oceanic aspects of CCDMI. Details are in the meeting report available at http://www.clivar.org/organization/etccd/index.htm/.

Future regional workshops that would help to further global assessment for climate extremes and changes were being planned, building on the successes of the Caribbean and Casablanca workshops organised by the WGCCD. The first is a workshop in South Africa, which would take place in Cape Town in June 2004 in association with the 9th International Meeting on Statistical Climatology. All countries in Africa would be eligible to participate but priority would be given to those countries that were not covered by the Casablanca workshop (2001). The workshop would further help fill in the large data-blank area in Southern Africa in global climate analyses. Specifically it would accomplish an analysis of indices calculated from daily meteorological data in the region and increase regional research synergies by sharing insights and improved analyses between neighbouring countries.

A number of international projects/collaborations directly related to the interests of the ET were under way. These included:

- The European Climate Assessment (ECA) which was providing a comprehensive assessment of observed daily precipitation and temperature extremes based on homogenized data and a range of indices (http://www.knmi.nl/samenw/eca)
- Modelling the Impacts of Climate Extremes (MICE) and STatistical And Regional Dynamical Downscaling of EXtremes for Europe (STARDEX), which were making extensive use of indices of climate extremes that had previously been developed in coordination with the WGCCD (details are available at http://www.cru.uea.ac.uk/projects/).
- The development of high resolution global / regional SST and sea level pressure data sets, especially within I-COADS and the EU project European and North Atlantic daily to MULtidecadal ClimATE variability (EMULATE).
- The USGCRP-funded international "Ad Hoc" detection and attribution group (IDAG), in which two ET members were involved.

An ET website was being developed at the web domain of the University of Victoria, Canada, led by Drs. X Zhang and F Zwiers. It will be focused on indices, and contain information (or links), on software for calculating indices, post-processed peer-reviewed indices (downloadable), workshop reports and follow-up activities, homogenized daily data (or links) where available, post-workshop indices and an updated list of

references. Eventually marine indices would also be included. In addition a GCOS/ETCCDMI web site was being designed to update indices of climate change and variability in near real time and planned for implementation later in 2004. This may be jointly developed by the Hadley Centre, Met Office, UK and the Australian Bureau of Meteorology and have the needs of IPCC particularly in mind.

Workshops on climate change indices for data sparse regions

In planning for additional workshops, priority was being given to South America and southern Asia. Such workshops are designed to enhance the capacity of developing world scientists to quality control their climate data and to contribute indices computed from those data to global and regional detection studies.

IPCC AR4 input

The ET would make a considerable contribution to the IPCC report. Specifically, the outputs of the regional workshops would fill geographical gaps in observations of climate change for the AR4's Chapter 3 (Atmospheric and Surface Observations). The team may also be able to contribute to Chapters 4 and 5 (Cryosphere and Ocean). There are potential impacts of the ET's work on other chapters, given the role of indices in global and regional model assessment (Chapters 8 and 11), climate change detection and attribution (Chapter 9) and assessment of global and regional projections (Chapters 10 and 11). The team recognized that in practical terms, the IPCC activities could serve as a driving force for its activities and has adjusted its working plan to the IPCC time line. A key deadline is December 2005, when all material referenced should be in press or published.

Climate of the 20th Century Project (C20C) (see also section 9)

Recognising that anthropogenic climate change is a cross-cutting subject in the CLIVAR programme, the team was requesting that appropriate CLIVAR panels and working groups should report to the ET on developments concerned with the improvement and extension back in time of global historical data sets including data archaeology, use of proxy data, and the homogeneous extension of such data sets into the future sometimes using new (e.g. satellite technology). In particular the ET was looking to develop links with CLIVAR basin panels in order to promote marine and oceanic aspects of CCDMI across the CLIVAR community. This would require extra coordination efforts with the help of the ICPO.

5.6 CLIVAR/ Past Global Changes (PAGES) intersection

CLIVAR/PAGES Intersection focus aims to improve the understanding of decadal to century scale climate variability, especially as relevant to improving predictability, through the use of high resolution paleoclimatic data. The activities within this focus are overseen by a joint working group shared between CLIVAR and PAGES, a core project of the IGBP. The group last met in July 2001 and was being reconstituted with new chairs appointed and revised membership under active discussion. In general research within this area focused on the detection of interannual to long-term climate signals (e.g. monsoons, ENSO, and NAO) in the past millennium using multiproxy data sources and modelling, as well as issues related to rapid climate change and variations which extend the remit of the panel back to the last ice age.

Two workshops were organised under the auspices of the panel during 2003:

- A Euroconference on 'Achieving Climate Predictability from Paleoclimate Data, San Feliu de Guixols, Spain, 11-16 October 2003
- A workshop (co-sponsored by IPCC), 'A Multi-millennia Perspective on Drought and Implications for the Future', 18-21 November 2003, Tucson, Arizona. The workshop was aimed at investigating a full range of past drought variability revealed by paleoclimate data and studies of the future drought conditions associated with global warming. Although globally drought areas increased more than 50% during the 20th century, paleo studies show dramatic changes in drought over the world and suggest that the serious drought situations such as observed in the Sahel since the 1960s were not uncommon. Further unanticipated droughts could be expected to feature in the near future climate, particularly given continued global warming. Further CLIVAR/PAGES joint studies of paleo data and modelling would help lessen the uncertainties in the present knowledge.

A key related activity is PMIP, the Paleo Model Intercomparison Project. A new phase of PMIP was launched in late 2003 with five components as follows:

1. 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 (P. Braconnot, LSCE, France).
2. Coupled ocean-atmosphere (OAGCM) and ocean-atmosphere-vegetation (OAVGCM) simulations of the response to glacial conditions (C. Hewitt, Hadley Centre, UK).
3. Early Holocene (10 ka BP) simulations of the climate response to insolation changes in combination with ice sheet changes (P. Valdes, Reading).
4. Early glacial (115 ka BP) simulations designed to understand the processes underlying glacial inception (G. Ramstein, LSCE, France).
5. Prescribed freshwater fluxes experiment (R. Stouffer, GFDL, USA), (jointly with CMIP).

Contributions to this activity were being assembled.

5.7 International CLIVAR Project Office (ICPO)

The ICPO continued to be hosted by the UK with current (February 2004) confirmed financial contributions from UK and the USA. A contribution from France had also been awarded by the French IOC Committee but there have been difficulties over the past year and more in actual receipt of the funds at the ICPO through the French ministry system. Valuable contributions have also been made towards publication of CLIVAR Exchanges by Canada, which, through the good offices of the Canadian Climate Centre, paid for the production and costs of mailing of a double issue of Exchanges during the year, and by the China Meteorological Administration who were paying the production costs of Exchanges for the December 2003 issue and follow-on issues.

Funding of the ICPO continued to be problematic with the overall downward trend continuing. The present UK commitment of support for the ICPO comes to an end at 31 March 2005. An application for renewed funding of the ICPO beyond this date was being made to the UK Natural Environment Research Council who provide the present UK funding.

The development and maintenance of a high quality web site together with a searchable database of CLIVAR projects and appropriate data management and information pages have been, and will remain, a high ICPO priority. Indeed, the CLIVAR data management and information pages have been further developed and brought more to the fore over the year and the ICPO has been active in scoping the 1st CLIVAR (Ocean Observations) Data Planning Workshop. 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 continued to expand 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. Of late the number of papers received has been more than we can publish as part of the printed copy and we have moved to publication of some contributions on the web only.

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 sixteenth session of the GEWEX Scientific Steering Group kindly hosted by the University of Marrakesh and the French Institute for Research and Development, were presented by Professor S. Sorooshian, Chair of the GEWEX Scientific Steering Group, and Dr R. Lawford, Director, International GEWEX Project Office. Milestones for 2003 were:

- The first CEOP full annual cycle of observations and data gathering scheduled to last until the end of 2004, with the joint commitment of the Continental Scale Experiments (CSEs), the space agencies and the global modelling community.
- An increased coordination of CSEs with the development of joint studies and the approbation of the La Plata Basin as a new CSE.
- The reorganization of global data sets under a common umbrella and the initiation of a GEWEX working group on data management and analysis.
- The completion of a first boundary layer model intercomparison study by the newly formed GABLS project.
- The approval by IGOS Partners of the IGOS Water Cycle theme report, in which GEWEX has a leading role.

Dialogue between GEWEX projects and panels was being encouraged as part of the organization of "cross-cutting" activities in the following areas: observation, modelling and forecast of precipitation, global closure of the water and energy budget (global WEBS), data management and analysis, and the initiation of a specific activity on the diurnal cycle.

Closer interactions between GEWEX and the other WCRP components have been pursued. The interaction with CLIVAR was particularly strengthened by joint participation in CEOP with a significant monsoon component and by the evolution of continental scale experiments towards dual CLIVAR-GEWEX sponsorship. The interaction with CliC, which takes place regularly through the CSEs, was developing particularly in precipitation-related activities and as part of CEOP. WGNE remains a key partner of GEWEX through joint activities with the GEWEX Modelling and Prediction Panel (GMPP), however uncertainties on the funding of AMIP have slowed down the intercomparison of global atmospheric models. WGCM was represented at the GEWEX SSG this year, with the scope of increasing interaction in the domain of cloud-radiative feedbacks and in the representation of physical processes including the diurnal cycle.

The positioning of GEWEX with programmes outside WCRP was also considered as a major item. Coordination with the new IGBP components was building up; this concerned mainly the integrated Land Ecosystem Atmosphere Processes Study (iLEAPS), which would benefit from joint membership with GMPP in its scientific committee. The need to maintain close contacts with IPCC on water-related topics was confirmed by the SSG, as the preparation of the 2007 report is under way. The relations with GCOS have been reinforced during the year following the activity of the WCRP Satellite Working Group, and with the proposal for the Baseline Surface Radiation Network (BSRN) to be adopted as a joint GCOS/WCRP Baseline Surface Radiation Network.

It was important to note that, within WMO, there was continuing coordination with the Hydrology and Water Resources Department on the management of water resources (joint support of WRAP, Water Resources Application Project), and also cooperation with the Atmospheric Research and Environment Programme (AREP) on two aspects: aerosols and radiative flux measurements involving BSRN and GAW (Global Atmospheric Watch) and the preparation of THORPEX with common interests in the fields of water cycle data and process studies.

There was a continuing effort to maintain a close relationship with space agencies, with the participation at SSG of ESA, JAXA and NOAA, and frequent contacts during the year with NASA and EUMETSAT. A major involvement of GEWEX in the activities of the WCRP Satellite WG helped to initiate relations with the space agencies of Canada, France, India and Russia. In this respect the leading role of GEWEX in the IGOS-Partners water theme should also be noted. Relationship with the main modelling centres was maintained on a continuous basis, as part of the modelling activity of GMPP and as part of CEOP. The dialogue with UNESCO had also developed during the year in hydrological observations and applications. With the IAEA (International Atomic Energy Agency), a new cooperative project was developing, taking advantage of isotope measurements as tracers of the water cycle.

Although CEOP has now acquired a WCRP-wide status, it retains its scientific roots in GEWEX and its advances were presented and discussed at the SSG. The data collection phase was progressing well, but the continuous support of funding agencies is required to get full benefit of the work done up to now, in order to support a research phase after 2004 and to possibly extend CEOP in view of the establishment of a long term global water cycle observation system. CEOP should naturally be considered as a demonstration experiment for COPES and its possible extension as a WCRP contribution to the Group on Earth Observations (GEO) process.

A brochure collecting the main results of phase I of GEWEX has been prepared by the IGPO, and a brochure describing phase II orientations is planned. A more comprehensive paper covering phase I achievements is intended to be written as part of the WCRP 25th anniversary book, with a possible separate publication to be submitted to the Bulletin of the American Meteorological Society (BAMS).

6.1 Overview and main recommendations from the GEWEX SSG

A mid-year report was issued in July 2003 and a strategy meeting with the main GEWEX officers was held in Tucson in August 2003, in order to review the main orientations of the project and to improve the response to JSC and SSG recommendations. At the SSG, in order to assess this evolution and to provide guidance for future actions, members were specifically asked to evaluate progress made relative to the five guiding goals of GEWEX phase II, to reflect on a GEWEX roadmap and the participation of GEWEX to the COPES initiative.

6.1.1 COPES and general WCRP strategy

The roadmap under preparation and the organization of cross-cutting activities within GEWEX could be considered as preparatory work in the COPES perspective. Concerning a possible "sunset date" for GEWEX, it was felt that a key date for the achievement of phase II could be set at 2012. With respect to WCRP cross-cutting activities, GEWEX could provide a major input in the fields of tropical convection, global precipitation and data management, domains where a significant interaction with other projects already exists. The modelling activity of GEWEX should be considered as an important contribution to the overall WCRP objectives, with advances foreseen in the parameterization of physical processes and a potential for a stronger involvement in AGCM and CGCM experimentation and validation. Its "data" expertise should allow GEWEX to develop a key role in the future Working Group on Observations and Assimilation. It was suggested that the development of homogeneous climate products for the period 1979-present by using available Earth Observation and in situ data be considered as a first major task for the WGOA.

Concerning the specific objectives outlined as part of COPES, GEWEX is able to particularly contribute to:

- Climate research for arid and desert regions: the expert workshop which was envisioned to take place in Marrakesh jointly with the SSG had to be postponed and was now planned for early autumn 2004 in Cairo with a strong UNESCO participation.
- Task Force on Seasonal Prediction: the main contribution of GEWEX up to now to this activity was the experimentation of the effect of land surface fluxes on seasonal predictability as carried out within the GLASS project. The SSG recommended a better use of global data sets for model boundary conditions and validation, and a stronger involvement of CSE modelling teams for regional simulations.
- Monsoon activities: the main contribution of GEWEX is channelled through the CEOP Monsoon Studies Working Group, with the aim to assess, validate and improve the capabilities of climate models in simulating physical processes in monsoon regions. A broad support on this topic was noticeable at the Berlin planning meeting in April 2003, followed by a specialised workshop on issues related to the Himalayas.

6.1.2 Evaluation of GEWEX phase II advances

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

- **The focus on objective 1**, "the production of consistent descriptions of the Earth's energy budget and watercycle and their variability and trends, and data sets for the validation of models", remains valid and a major asset of GEWEX. Significant progress on the closure of the water budget at global and regional scale was expected from the CEOP data set and the use of global reanalyses, among them the ECMWF ERA-40 made widely available since 2003. The availability of global data sets for periods of around 20 years was felt to be a major achievement, and those data are used extensively for developing parameterization schemes and for model validation. The question of variability and trends was still open, and should be the object of special attention in new developments. The accuracy of precipitation data remained a major challenge. A major gap remains due to the lack of data sets for evolving surface properties and surface fluxes over land.

- **Objective 2**,"enhancing the understanding of how energy and water cycle processes contribute to climate feedbacks", has been the object of specific attention since the November 2002 Atlanta workshop organised jointly with WGCM. It was felt this objective should be refocused to take into account what is really feasible with available data and state of the art models. A first step would be to diagnose causes of observed variability of the energy and water cycle for the past 15-25 years, and to partition this variability between internal variability and response to external forcing. A new workshop on this topic would be scheduled jointly with GCM modellers.

- **Objective 3**, "developing improved parameterizations encapsulating these processes and feed-backs for atmospheric circulation models". GMPP is the main contributor to this objective and the approach underlined by its three components, cloud systems, boundary layers and land surface processes, combining one-column, 3-D eddy-resolving models and GCM validation, is directly aimed at improving parameterizations. A good participation of GCM modellers to workshops organised by these groups was noticeable. In addition, the GEWEX Cloud System Study (GCSS) group was involved in the development of new advanced parameterization techniques, making use of a "multi-scale modelling framework", that is, embedding a cloud resolving model at each grid point.

The nomination of a new GCSS Chair with GCM experience should also be noted. However it appears that a specific effort would be needed to use the expertise of the other GEWEX panels in this domain, and the question of an overall parameterization cross-cutting activity at the WCRP level remains open.

- **Objective 4**, "interacting with the wider WCRP community in determining the predictability of energy and water cycles". The increasing interaction with CLIVAR should be noted, particularly in the perspective of the COPES initiative. This was noticeable in the evolution of CSEs, which tend to combine water cycle aspects with studies of climate variability and change, and with the development of joint GEWEX-CLIVAR expertise in monsoon studies. If one considers the various regional experiments, GEWEX Americas Prediction Project (GAPP) is a partner in the North American Monsoon Experiment NAME, AMMA endorsed last year by both GEWEX and CLIVAR 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, the newly approved PLATIN (La Plata Basin experiment) also involves both communities. In Asia, as GEWEX Asian Monsoon Experiment (GAME**)** was ending next year, a new regional project aimed at the modelling and prediction of monsoons, water cycle and water resources was being envisioned, possibly under a joint CLIVAR-GEWEX umbrella. CEOP remains an important field of cooperation, now that the main observation period was under way, and with the first scientific results coming up. The monsoon working group mentioned above has been fairly active during the year with the design of strategy for experimentation and validation of a range of models, from cloud resolving to regional and global.

  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. Joint efforts were on-going for the evaluation of precipitation measurements. A clear interest has been shown by CliC on the reanalysis of climate data sets, as proposed by the satellite working group, particularly with respect to clouds and land surfaces. A specific reflection was needed to take advantage of the International Polar year for the development of joint research themes.

  The interaction with SPARC has not evolved substantially during the year. A natural interaction exists with the GEWEX radiation panel for the development of radiative data sets and the evaluation of water vapour and aerosol effects. As it was the case for CliC, it was expected that the new initiative proposed for climate data sets would revive the cooperation.

- **Objective 5,** "interacting with the water resource and applications communities to ensure the usefulness of GEWEX results". This objective was carried out mainly by the Water Resources and Applications Project (WRAP), which has organised a series of workshops with hydrologists, including two in 2003. The effort of publication and outreach of the group is important. Two main new initiatives include the development of water resource assessment "indicators" and a joint project with the hydrology community for hydrological ensemble forecasting. The interaction with both the WMO Hydrology and Water Resources Department and UNESCO has been significant and a white paper under circulation provides a good basis for future developments.

6.1.3 Specific issues for JSC:

In addition to the overview of GEWEX activities and orientations presented above, the GEWEX SSG Chair raised the following issues for formal endorsement by JSC:

- GEWEX SSG has supported the proposal for BSRN to become a joint WCRP-GCOS baseline surface radiation network. JSC's approval was now sought.
- GEWEX SSG is proposing that the new Working Group on Observations and Assimilation takes over the activities of the WCRP Satellite Working Group, ensuring the continuation of the relationships with space agencies.
- Given the importance of parameterization issues, this topic was proposed for consideration as a pan-WCRP activity.
- The prolongation of the International Satellite Cloud Climatology Project (ISCCP), the Global Aerosol Climatology Project (GACP), and the Surface Radiation Budget (SRB) project, for which funding is not secured after 2005, was submitted for approval to JSC.
- JSC was invited to support the continuation of CEOP, with the establishment of a research phase after 2004 and the principle of the extension of CEOP as a contribution to a long term global water cycle observation system.

In immediate response, the JSC welcomed and approved the proposal that the BSRN should be designated as the GCOS global baseline surface radiation network and that this be formally implemented through the submitted, "Agreement between the Global Climate Observing System and the World Climate Research Programme regarding the Baseline Surface Radiation Network". The BSRN will remain institutionally and organizationally within WCRP/GEWEX and will be identified in all GCOS documentation and distributions as the WCRP/GEWEX BSRN, or spelled out as necessary.

The JSC endorsed the proposal of the GEWEX SSG that the activities of the WCRP Satellite WG be part of the remit of the proposed WCRP WGOA, including the need to maintain and develop further close and strong working relationships with space agencies.

The JSC noted the proposal by the GEWEX SSG that "parameterization" should be the subject of a WCRP workshop, but decided this was too broad a topic per se. The JSC recommended that consideration be given by GEWEX (and other WCRP activities) to proposals for workshops on more specific and focused climate-related processes and their parameterization in models.

The remaining points raised by Professor Sorooshian are dealt with under section 6.3 (CEOP) and section 6.4.2 (Global data sets and satellite projects).

6.2 Hydrometeorology

6.2.1 Overview

The hydrometeorology activity of GEWEX is coordinated by the GEWEX Hydrometeorology Panel (GHP). GHP presently coordinates the following regional Continental Scale Experiments (CSEs): the Mackenzie GEWEX Study (MAGS), GEWEX Americas Prediction Project (GAPP), the Large-Scale Biosphere-Atmosphere Study in Amazonia (LBA), the Baltic Sea Experiment (BALTEX), the GEWEX Asian Monsoon Experiment (GAME), the Murray Darling Basin (MDB). In addition, the La Plata Basin (LPB) was endorsed as a new CSE by the 16th SSG in Marrakech. The GHP is also following jointly with CLIVAR the AMMA project, which is considered as an affiliated CSE. It also has an advisory role with respect to GEWEX interests in a few hydrometeorologically relevant activities such as those of Global Runoff Data Centre (GRDC), the International Satellite Land Surface Climatology Project (ISLSCP), the Global Precipitation Climatology Centre (GPCC), as well as in the International Association of Hydrologic Sciences (IAHS) and the International Atomic Energy Agency (IAEA). The Coordinated Enhanced Observing Period (CEOP), which originated in GEWEX, also reports to GHP. Besides providing a hydrometeorological focus for the GEWEX CSEs and affiliated global projects, organizations, and agencies, the GHP has formed various working groups to focus on specific issues, including: Water and Energy Budget Synthesis (WEBS), Water Resources Application Project (WRAP), Data Management (DM), Sources and Cycling of Water (SCW), Extremes, Predictability Working Group (PWG), and Transferability Working Group (TWG).

The GHP held its annual meeting at Lüneburg, Germany, where the GHP CSEs, affiliated experiments, global projects, organizations, and agencies reported on their progress and contributions to GHP goals. Also during the past year, a review article led by Dr R. Lawford and summarising the past 8 years of GHP activities has been submitted to BAMS for publication.

The main developments for the past year are summarised as follows:

- All CSEs mentioned above have been active during the year and, except the few more recent ones, have published at least one review article. BALTEX would go through a major review at a Conference to be held in May 2004, and some new orientations were being envisioned as part of European climate research. LBA has now entered a mature phase and some of its objectives may have to be revised in the near future. MAGS would normally end in 2005 and its possible prolongation was not decided. GAME was also going to end in 2005, and a new regional project was under preparation. AMMA was pursuing its plan for a formal beginning in 2005 and intensive periods scheduled for 2006. Finally, as mentioned above, the La Plata Basin experiment has been approved as a new CSE.
- A specific reflection was being carried out to take into account the orientations of GEWEX phase II and the growing cooperation with CLIVAR in the requirements for and objectives of the CSE. Increased integration was required as well as the development of horizontal activities, mainly in the domains of the various working groups mentioned above.
- The interaction with other GEWEX components was already developing mainly in the domains of the closure of water and energy budgets, and data management and analysis. It was starting in the cross-cutting precipitation activity and intended in the diurnal cycle activity. SSG has recommended

a stronger involvement of CSE modelling teams in the general GEWEX modelling activity and a more visible participation in regional climate research along with other modelling groups.

- The future of ISLSCP has been discussed. There was a definite interest in the potential use of phase II products just released or to be released very soon. The plan for an ISLSCP potential phase III needs a thorough review in order to ascertain if it fits with the requirements of GEWEX.
- The contributions of GPCC and GRDC to gather data for GEWEX use are widely acknowledged, including their specific capabilities with respect to quality control and quantification of uncertainties. A continuing effort was needed to improve delivery of data to those centres.
- IAHS provides a venue for GHP hydrologic science efforts to interact with the broader science community. In that regard, IAHS has been encouraging various groups to become involved in its Prediction of Ungauged Basins (PUB) 10-year initiative and intends to interact with WRAP to better utilize GEWEX products for various applications. The IAHS was also interested in helping CEOP to become more relevant to various catchments.
- The IAEA has an Isotope Hydrology Programme, which not only provides the international standards for making isotope measurements, but also collects and analyzes global isotope measurements in precipitation and streamflow. The IAEA would be working with and helping to coordinate GHP/SCW efforts to develop models capable of simulating and predicting these isotope measurements.
- The SSG has endorsed the proposal by Dr J. Shaake of a HEPEX (Hydrological Ensemble Prediction Experiment) workshop to be held under joint sponsorship of the WMO Hydrology and Water Resources Department at ECMWF in March 2004.
- The next GHP meeting will take place in Montevideo, 6-10 September 2004, giving the opportunity to create new links with the La Plata Basin community.

6.2.2 Updates on Continental Scale Experiments

The Baltic Sea Experiment (BALTEX)

Major BALTEX activities in 2003 included: 1) a science plan for BALTEX phase II drafted and approved; 2) exploration of observational data taken during the BALTEX/BRIDGE EOP (1999 to 2002) continued; 3) a major EU-funded BALTEX project (CLIWA-NET: BALTEX Cloud Liquid Water Network) successfully concluded; 4) two major coupled model systems established and model runs for the BALTEX region conducted; 5) CEOP contributions to 4 reference sites and the development of Model Output Location Time Series (MOLTS) data archive at MPI Hamburg); 6) planning for 4th Study Conference for May 2004 on Bornholm, Denmark, and 7) mid-term assessment of the contributions from the DEKLIM (the national German Climate Research Funding Programme funded by the German Federal Ministry of Education and Research) to the BALTEX.

Major research contributions to BALTEX originating from several projects within the DEKLIM programme include modelling soil frost and snow as well as regional evaporation at grid and pixel scale over heterogeneous land surfaces, analysis and simulation of hydrological and ecological variability in the last 1000 years, development of a soil moisture analysis and accurate areal precipitation measurements over land and sea.

GEWEX Asian Monsoon Experiment (GAME)

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. The International Symposium on the Climate System of Asian Monsoon and its Interaction with Society was held 11-13 November 2003 in Khon Kaen, Thailand. A CD –ROM is available with main GAME data and results. The 2nd International Workshop on Regional Modelling for Monsoon System was held on 4-6 March 2003, co-sponsored by GAME-ISP (International Science Panel) and FRSGC (Frontier Research System for Global Change). The International Asian Monsoon Symposium (IASM) would be held in 18-20 February 2004, Honolulu, USA. The Seventh Workshop on GCM Simulations of East Asia Climate (EAC) and the Third Workshop on Regional Climate Modelling would be held in conjunction with IASM.

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

GAPP, a follow-on to the GEWEX Continental-scale International Project (GCIP), was being supported to “demonstrate the capability to predict changes in water cycle variables (e.g. precipitation, soil

moisture) on times scales up to seasonal and interannual through better understanding and model representation of land surface and boundary layer processes." GAPP would support, in conjunction with CLIVAR Pan American Climate Studies (PACS), the 2004 North American Monsoon Experiment (NAME) field campaign. GAPP also plans to have another field campaign in the western Cordillera towards meeting the water resources needs of the western USA. In addition, significant efforts would continue to be directed at land memory processes, predictability studies, water resource application studies, and the development of prediction systems. GAPP continues to support and contribute to CEOP.

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

Over 200 investigators are involved in about 85 studies in the LBA related to physical climate, atmospheric chemistry and composition, carbon storage and exchange, biogeochemical cycles, land-surface hydrology and water chemistry, and land use and land cover changes. Special issues of Journal of Geophysical Research, Theoretical and Applied Climatology, Global Biogeochemical Cycles and Acta Amazonica have been or will be published in 2003 or 2004. The Third LBA Science Conference would take place in Brasilia in 2004.

In 2002 and the first half of 2003, several activities took place, including the installation of the measurement and monitoring components at the LBA research sites. The second major field campaign was the SALLJEX-Brazil that took place during the austral summer of 2003. This is a Brazilian component of the SALLJEX initiative from the CLIVAR-VAMOS programme on the South American monsoon, and represents collaboration between GEWEX and CLIVAR. One of the major activities of LBA Phase II would be the Regional Atmospheric Carbon Budget in Amazonia– BARCA. Major field campaigns as part of BARCA/LBA are planned for May 2004 (biomass burning) and October 2004 (towers with continuous monitoring).

The Mackenzie River GEWEX study (MAGS)

The MAGS scientific programme was on or ahead of schedule in meeting its objectives. The establishment of strong linkages between stakeholders and scientists was becoming a key element of ongoing activities. MAGS research in 2003 has been focused on model developments and includes completion of development and initial evaluations of intermediate-level coupled models and finalizing development of the fully-coupled atmospheric-surface-hydrologic model. Highlights of the MAGS scientific activities during the first half of 2003 have been completion of a CAnadian Gewex Enhanced Study (CAGES) special issue in J. Hydrometeorology (in press), publication of journal article summarizing achievements of MAGS phase I in BAMS, the MAGS Modelling Workshop (Ottawa, March 2003), a MAGS Session at the Canadian Meteorological and Oceanographic Society (CMOS) Congress (Ottawa, June 2003), and release of 1994/95 Water Year Study dataset CDROM. MAGS also continued its strong contribution to GHP initiatives as well as its interaction at national and international levels with other organizations and agencies with common interests (e.g. GAME-Siberia, CEOP, and CliC).

The Murray-Darling Basin Water Balance Project (MDBWP)

The major objectives of MDB are to: 1) Monitor and predict the daily water budget, 2) Develop real-time products for water agencies, 3) Observe, understand and model processes controlling soil moisture, 4) Improve the representation of land surface processes in weather and climate models, which can assist in the prediction of land salinization and water resource management, 5) Estimate carbon and moisture exchanges between the atmosphere and the land surface in the MDB, with an emphasis on emissions from salinity affected areas.

During 2003, progress included: 1) a study to monitor and predict the mean areal daily rainfall over the MBD has been initiated and a study using naturally occurring radioactive and stable isotopes together with nuclear techniques characterising key processes driving cycles of interaction between the land surface and the atmosphere boundary layer on diurnal and seasonal timescales has been initiated, 2) development of real-time products for water agencies including a project to provide an irrigation authority with forecasts of rainfall and evaporation has been started, 3) maintaining the network of 18 soil moisture sites situated in the Murrumbidgee Catchment, 4) a study applying isotopic techniques to water balance studies in regional basins has been initiated under the GNIR (Global Network for Isotopes in Rivers) Project, 5) forcing data for the Viterbo and Beljaars Land Surface Scheme (VB95) have been compiled and used to evaluate the VB95 Scheme, and 6) the Isotope Project for Intercomparison of Land-Surface Parameterisation Schemes (IPILPS) has been initiated under the auspices of GLASS.

La Plata Basin (LPB)

LPB, recently approved as a CSE at GEWEX SSG-16, is coordinated by the PLATIN Science Study Group (SSG), which is co-chaired by C.R. Mechoso representing CLIVAR/VAMOS and P.L. Silva Dias representing the GHP. CLIVAR and GEWEX formed the PLATIN SSG in recognition that LPB is a climate-hydrology system with components that are potentially predictable with useful skill from seasons in advance, and whose variability has important impacts on human activities. See section 5.3.1 MESA, for details.

African Monsoon Multi-disciplinary Analysis (AMMA) (affiliate)

AMMA is a multidisciplinary and international project, building on projects such as Coupling Tropical Atmosphere and Hydrologic Cycle (CATCH, a GEWEX Continental Scale Affiliate (CSA)) and West African Monsoon Project (WAMP), a European modelling project. AMMA is built around four main components: observing system, modelling activities, satellite component, training programme. Currently the main effort is on organising the Enhanced Observing Period (EOP) and the related modelling and satellite activities. One major issue in this respect was to secure the operation of the existing radio sounding network over West Africa and, possibly, to reinforce it where needed, especially around a selected monsoon window. The EOP, planned for 2005-2006, is designed to document the annual cycle of the surface conditions and atmosphere, and to study the surface memory effects at the seasonal scale. Special Observing Periods, scheduled in 2006, would focus on detailed observations of weather systems at three key stages of the rainy season.

The JSC re-affirmed support for the development of AMMA as a joint CLIVAR-GEWEX experiment and as a focus and test-bed for mobilizing the resources, both in Africa and elsewhere, needed to study African climate variability. See also section 5.3.3, AMMA.

6.2.3 Other projects and activities

International Satellite Land Surface Climatology Project (ISLSCP)

ISLSCP Initiative I produced the first interdisciplinary Earth Science data collection. Initiative I included two years of monthly surface meteorology, vegetation, soils, surface routeing and runoff, atmospheric radiation data and clouds. An effort was funded by NASA's hydrology programme to produce the ISLSCP Initiative II collection, a ten-year global collection spanning 1986 to 1995, with some data sets spanning a 17-year period, 1982-1998. 2001 land cover and albedo data sets from MODIS were also included. Initiative II added new carbon data to support specific carbon cycling issues, new state-of-the art data sets for soils, precipitation, runoff, land cover, and topography as well as human dimension data to study the human footprint on the environment. The Initiative II collection, consisting of 48 individual data series, was nearing completion, with 46 of the 48 data sets received. Its evaluation would focus on: (1) consistency across data series, (2) internal consistency within data series, (3) validation against ground measures, (4) impact of data quality on global scientific analyses, and (5) sensitivity analyses.

A number of WCRP and IGBP initiatives leveraged on ISLSCP II were already beginning to use completed portions of the collection, including the GEWEX Global Soil Wetness Project (GWSP), the Global Carbon Observing System, NASA's Interdisciplinary Science Projects (IDS), NASA's Seasonal to Interannual Prediction Project (NSIPP), the GEWEX Global Land Atmosphere System Study (GLASS).

Data Management Working Group (DMWG)

DMWG develops coordinated hydrometeorological data sets from all of the CSEs, affiliated GHP projects, and other GEWEX projects. During the 2002-2003 period, the DMWG membership worked on maintaining the DMWG World Wide Web: http://www.joss.ucar.edu/ghp/, incorporating data from the GEWEX CSEs into this archive, continuing discussion with the CLIVAR and CliC programmes to coordinate data activities, managing CEOP data collection data from the various CSEs, developing a prototype “composite” data set from CEOP’s first Enhanced Observing Period (EOP-1), July through September 2001, using data from 16 Reference Sites located around the world (http://www.joss.ucar.edu/ghp/ceopdm/refdata_report/), continuing discussions to coordinate GHP data management activities with the other GEWEX Projects (i.e. GEWEX Radiation Panel (GRP), GLASS, and Assistance for Land- surface Modelling Activities (ALMA)) and preparation of data format verification software to be used to check submitted data sets.

Water and Energy Balance Study (WEBS)

The objective of WEBS is to develop the "best available" global and regional synthesis of water and energy variables and processes from global and regional observations and analyses for the 1997-2001 time period. A number of global and regional GEWEX data sets have slowly become available and they now need to come together in order to enable to develop a full global land (and perhaps ocean also) water and energy budget synthesis from GEWEX and CSE observations. At the 2003/07 IUGG Workshop, it was decided to first develop an atlas, which will later be distilled for publication in a refereed journal. In particular, annual and seasonal means (DJF, MAM, JJA, SON) would be developed for the period July 1996-June 2001.

Water Resources Applications Project (WRAP)

WRAP is designed to engage in a dialogue with the hydrological modelling community and operational environmental services, demonstrate skill in predicting changes in water resources and soil moisture on time scales up to seasonal and annual, and to develop collaboration with water resources agencies to develop better hydrometeorological predictions. WRAP held a workshop in conjunction with the 9th Annual GHP meeting in Lüneburg, Germany (22-26 September 2003). The primary activities have been to develop a website, organization of workshops to establish a dialogue with the water resource planning and management community, preparation of articles for the GEWEX and IAHS newsletters, participation in planning exercises and consultation with other programmes and agencies, collaboration with the World Water Applications Project (WWAP) on scientific indicators for global water resources assessment, and initiation of a "white paper" on the application of GEWEX-related science to water resource issues. A proposal for a workshop entitled Transferring Hydrological Data across Spatial and Temporal Scales was submitted to IAHS. A proposal for an international workshop on hydrological ensemble forecasting was developed by Dr J. Schaake and a subsequent discussion of a potential "predictability" working group was led by Dr J. Marengo.

Transferability Working Group (TWG)

The TWG will provide a framework for systematic evaluation of simulations of dynamical and climate processes arising from different climatic regions. An important aspect of this intercomparison is to evaluate transferability of regional climate models and their components, for example the extent to which a model developed to study one region can be applied to other regions. Since several models will be used for each regional domain, the TWG will perform an intercomparison by examining individual and ensemble performance between domains as well as on particular domains. Anchored by coordinated observations from CSEs, modelling studies under TWG will examine influences of physical parameterization choices (clouds, convection, precipitation, surface processes), resolution and nesting dependencies, modelling choices (grid point, spectral, stretched grid), and boundary condition influences on the quality of predictions.

Extremes Working Group

The Extremes Working Group is under development and would examine feedback mechanisms affecting the water cycle and how these influence wet and dry periods. Although some work on extremes has been conducted within the various components of GHP, a collective effort has not yet been established. At the 2002 GHP meeting, the need to consider extremes in a collective manner was raised again and an initial, short workshop was held in conjunction with the 2003 meeting. The main objectives of the workshop were to review individual activities within the CSEs and to consider future, collective efforts on this issue within GHP.

6.3 Coordinated Enhanced Observing Period (CEOP)

CEOP was seeking to achieve a database of common measurements from both in situ and satellite remote sensing measurements, as well as matching model output that includes Model Located Time Series (MOLTS) data along with four-dimensional data analyses (4DDA; including global and regional reanalyzes) for a specified period. In this context, carefully selected reference stations are linked closely with the existing network of observing sites involved in the GEWEX CSEs, which are distributed around the world. The observational component of CEOP would continue at least through the end of 2004 and has already begun to support research in the existing projects and sub-activities in CEOP. An on-going process of coordination and review of work in CEOP has been undertaken, through regular monthly teleconference calls. A major milestone was met when the Second International CEOP Implementation Planning meeting was held in Berlin, Germany, 2-4 April 2003.

A CEOP session was recently convened at the 2003 Fall AGU meeting by J. Roads and R. Lawford. The session provided an overview of the data and scientific aspects of the CEOP initiative as well as links

with climate programmes. Even while CEOP continues its observational phase, these papers provide early scientific results, using CEOP's initial dataset (EOP1), that show the direction the CEOP research phase will take. A Science Steering Committee (SSC) has been established to guide the scientific work of the five main CEOP working groups (Water and Energy Simulation and Prediction, Monsoon Systems Studies, Satellite Data Integration, Data Management and Model Output Implementation). The activation process of the CEOP Advisory and Oversight Committee (AOC) was completed. The AOC would have representatives from CNES, ESA, EUMETSAT, JMA, JAXA, NASA and the IGOS-P Water Theme who would meet in a parallel session at the Third CEOP Implementation Planning Meeting, 10-12 March 2004. The AOC would provide additional oversight and connections to the main supporting agencies.

The main implementation phase of CEOP was 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 (CIMS) activities within CEOP. Information concerning the characteristics of the CEOP reference sites has been made available in the CEOP Reference Site Table at: http://www.joss.ucar.edu/ghp/ceopdm/rsite.html. An initial (seasonal) CEOP dataset, designated EOP-1, was also available at that site. The implementation of the CEOP annual cycle datasets that would form the key deliverables of CEOP was moving forward. Two of these, EOP-3 and EOP-4 cover the period from 1 October 2002 up to the end of 2004.

A major international CEOP Monsoon Systems Studies Workshop focused on the Himalayas CEOP Reference Site Region was held 7-8 April 2003, Milan, Italy. The summary report of the workshop findings is being published in BAMS. CEOP/WESP has developed 3 main working groups: (1) Water and Energy Budget Studies; (2) Land Data Assimilation Systems; (3) Transferability Experiments. A WESP major activities plan has also been produced. A number of specific studies and proposals have begun to mature under WESP.

The Third CEOP Implementation Planning meeting would take place 10-12 March 2004 at Irvine, California, USA. CEOP EOP-3 data sets (October 2002 to September 2003) should be completed by the end of 2004. Centralized Archive Centres for the CEOP in-situ and model data sets at UCAR/JOSS and MPI respectively should reach proto-type development levels by the end of 2004. A CEOP Satellite Data Archive and Integration System would be demonstrated in 2004. A number of studies using CEOP data to validate models and satellite data algorithms would be advanced in 2004. Efforts would also begin to apply these predictions for water resource applications. There will be another CEOP Monsoon Systems Studies Workshop in 2004. The meeting will be a joint CEOP/VAMOS Workshop and will be held in conjunction with the 2004 GHP meeting (September 2004, Montevideo, Argentina).

In addition to the finalisation of the data integration phase, main issues for CEOP concern progress of the research components and the use of the momentum acquired up to now for the benefit of the hydrology and climate communities. A research phase is obviously needed after 2004 with adequate support by funding agencies, and its planning will be prepared at the Irvine meeting with contributions from the existing working groups, and with guidance from the SSC and AOC. On the observation and data side, a reflection has been initiated on how to take full benefit from CEOP in the preparation of a sustainable global water cycle observation system. The proposal of a Coordinated Enhanced Hydrology Data Collection Period was being studied with the participation of a network of reference sites. In addition a specific project on the hydrology of cold regions was envisioned with joint participation of CliC and GEWEX scientists.

The JSC acknowledged the continuing successful implementation of the CEOP observational phases and that CEOP-generated data and products are already being used within the research and operational modelling communities. The JSC supported the continuation of CEOP, with the establishment of a research phase after 2004 and the principle of the extension of CEOP as a contribution to a long-term global water cycle observation system. It requested that CEOP draft a research plan, to include criteria for measuring progress and a statement of resource requirements, to be considered at WCRP Officers, Chairs and Directors Meeting, in September 2004, and at JSC-XXVI, March 2005.

6.4 Radiation Panel and GEWEX Climatological Global Data Sets

6.4.1 Overview

The 2003 GEWEX Radiation Panel (GRP) meeting was held in Victoria, Canada, on 10-12 November 2003. The meeting was followed by a Workshop on 3-D Clouds and Radiation on 13-14 November 2003. Both meetings were hosted by the Cloud Physics Research Division of the Meteorological Service of Canada. The GRP reviewed the status and accomplishments of all its projects and decided how best to proceed towards its goals.

Main issues can be summarised as follows:

- Most of the commitments by agencies to support current satellite data products end in 2005, thus requiring a recommendation at the JSC level to seek the extension of those projects through the period 2006-2010.
- Present data sets will be assessed by 2005 and it is recommended to ensure that this assessment be considered as input to the new IPCC report.
- All of the GRP project data management groups (for GPCP, ISCCP, GACP and SRB with representation from BSRN and GPCC) were merged into a single WG on Data Management and Analysis (WGDMA); the members of the group represent each participating data centre in these projects. The first meeting of this group was held 12-16 May 2003, hosted by NCDC in Asheville, North Carolina. It is intended that this group become the nucleus for a GEWEX data management and analysis group with possible extension to the WCRP level.
- A number of GRP initiatives, including the SeaFlux project and the Feedback study, have coalesced into the preparation and analysis of a comprehensive collection of satellite-based global datasets. It is suggested that this activity be coordinated as the Global Water and Energy Budget Study (GWEBS).
- GRP has been the driving force within the WCRP satellite working group and it is recommended that the proposal for the development of homogeneous data products, making use of all available satellite and in situ data for the last 20-30 years, be adopted at the WCRP level, as a contribution to COPES.
- The status and achievements of BSRN have been reviewed and GRP supports the proposal of BSRN becoming a joint WCRP-GCOS baseline surface radiation network.
- Following the success of GRP in addressing global radiation budget issues, new developments are envisioned with respect to the observation of aerosols and clouds. They require a multidisciplinary approach with other GEWEX components. The WCRP strategy with respect to aerosols should be updated.
- A specific effort is needed for the development of adequate data sets for evolving surface properties and surface fluxes. This issue should be considered as a priority either in a new phase of ISLSCP or be taken up by GRP.

Within GRP, concerns have been raised with regard to a number of issues concerning satellite missions under way or under preparation: (1) The possible early termination of TRMM, precluding the absolutely unique opportunity to observe precipitation with TRMM and CloudSat, (2) the threat to MeghaTropiques and EarthCare from funding shortfalls, (3) the possible gap in coverage by afternoon polar orbiting weather satellites before the first launch of NPOESS, and (4) the reversal of the decision to fly the spare CERES instrument on NPOESS Preparatory Program (NPP) to reduce the risk of a gap in Earth Radiation Budget coverage later this decade. The GRP welcomed the approval of Soil Moisture and Ocean Salinity (SMOS) and expressed strong support for the European contribution to the Global Precipitation Measurement (EGPM) mission plans to put significant effort into snowfall measurement and for the JAXA GoSat missions. A major cause for concern to the whole GEWEX programme is the possible early termination of TRMM operations next year that NASA is considering. This would not only preclude the unique opportunity of operating two differing-sensitivity precipitation radars at the same time, when CloudSat is launched in early 2005, but would eliminate any chance that TRMM could operate until replaced by Global Precipitation Measurement (GPM) mission.

In the coming year the GRP will organize workshops on comparisons of satellite-based data products for aerosols, water vapour, clouds, precipitation and radiative fluxes, develop a comprehensive on-line GCM radiative transfer code test kit in collaboration with the Atmospheric Radiation Measurement (ARM) programme, organize workshops on radiative transfer codes for application to lidar and active/passive microwave observations, produce a comprehensive collection of global, long-term datasets describing the variations of the global energy and water cycle, and formulate an integrated clouds-aerosol-precipitation-radiation research strategy.

The next meeting of the GRP in October 2004 will be hosted by Dr T. Hayasaka at the University of Kyoto.

6.4.2 Global data sets and satellite projects

International Satellite Cloud Climatology Project (ISCCP)

ISCCP completed its 20th year of data collection on 30 June 2003. Radiances from all operating meteorological satellites, with the exception of FY-2B, are being routinely collected by the cognizant Sector Processing Centres (SPC) and delivered to the Global Processing Center (GPC) and International Archives

Center (ICA) in accordance with project requirements. All project datasets are now being delivered via Internet except for the DX product. Currently operating satellites are NOAA-16, NOAA-17, GOES-9, GOES-10, GOES-12, METEOSAT-5 and METEOSAT-7 with METEOSAT-6 and GOES-11 in reserve. GOES-12 replaced GOES-8 on 1 April 2003. METEOSAT-5 is located at 63°E longitude, providing coverage of the Indian Ocean - Asia sector since July 1998. MSG-1 was launched in 2002 and was going through an extensive commissioning phase; it was not planned to be fully operational until 2005. At that time, METEOSAT-6 would be moved to provide coverage of Asia. METOP-1 launch was planned for 2005. GOES-9 was now located at 155°E longitude, replacing GMS-5 on 22 May 2003. The launch of MTSAT-1R was now scheduled for early 2004. China successfully launched FY-1D (polar orbiter) in 2002 and plans to introduce a much more advanced polar orbiter, FY-3, in 2005. ADEOS-2 data are available for approximately six months in 2003.

GEWEX Global Aerosol Climatology Project (GACP)

Following the completion of Stage DX, D1 and D2 ISCCP data for July 1983 through September 2001 (18.25 years), the GACP aerosol product has been derived and was available for the same period. An error in the processing of the Snow/Ice (SI) product was discovered that may affect the ISCCP D-data products for 1998 onwards. After these data have been re-processed, the significance of this error on the aerosol product would be analyzed. The expected delay in the processing of the ISCCP D-data beyond September 2001 would similarly delay the GACP aerosol products. The current estimate of the processing schedule was as follows: (1) Complete and deliver GACP datasets for October 2001 through March (or June) 2003 by August 2004, 2) Deliver GACP data products through December 2003 by January 2005.

Surface Radiation Budget (SRB)

The WCRP/GEWEX Surface Radiation Budget (SRB) project has produced a 12+ year (148 months) data set spanning July 1983 to October 1995 for the GEWEX SW, SW Quality Check (QC), GEWEX LW and LW QC flux algorithms. Monthly and daily averaged data from three of these data sets are archived at the NASA Langley Atmospheric Sciences Data Center (ASDC) and available to the public. Concurrently, with the data processing, activities in validation and analysis of the data sets are being pursued. The project has been selected by NASA Headquarters to continue through April 2006. The level of funding is such that nearly all proposed upgrades, validation, processing and archival activities will continue. SRB uses satellite data from ISCCP, meteorological data from the NASA Global Modelling and Assimilation Office and ozone data from TOMS and TOVS when needed. All data required for SRB Release 2 have been obtained. All data are archived at the NASA Langley ASDC. All ISCCP data are also archived at ASDC, which will act as the data source for continued processing. The SRB project will collect other data inputs as needed.

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-hourly product is being planned. TRMM data have provided a very useful input for the validation and improvement of algorithms. All GPCP data processing centres have approval to operate through 2005 and are operating normally, except the Sounder Research Team (SRT) continues to re-build their TOVS processing software system due to a computer replacement. As a result, the GPCP Merge Development Centre (GMDC) was awaiting TOVS input to compute the final monthly and daily precipitation estimates for November 2002 forward, and the Climate Prediction Centre (CPC) is awaiting final Version 2 Satellite-Gauge (SG) fields to compute the pentad estimates for November 2002 forward. The SRT was currently doing end-to-end testing. All intermediate data products are available from the respective producers some 1-2 months after the end of the data-month; all such products are current except for TOVS, which currently ends with October 2002. The Version 2 SG monthly is available over the period January 1979-October 2002 in final form and over November 2002-July 2003 in provisional form. The pentad product is available over the period January 1979-October 2002. The 1DD product is available over the period January 1979-October 2002 in final form and over November 2002-July 2003 in provisional form.

Baseline Surface Radiation Network (BSRN)

The BSRN collection system consists of approximately 35 surface sites collecting at a minimum the downwelling solar and thermal infrared hemispheric irradiances. Basic meteorological variables and routine upper air soundings are also made at most of the sites. Additional observations of upwelling irradiances, spectral atmospheric transmission (for aerosol optical depth), UVB and ozone are made at some of the sites as resources and conditions allow. Several new candidate sites are being proposed. Although the original intent of the BSRN was to provide direct observations of surface irradiances at globally remote and regionally

representative sites, interests and demands of the project have expanded that mission. BSRN continues to expand observations by analyzing the current measurement capabilities and proceeding by establishing specifications for measurement systems that will supply data of the necessary quality. The procedures for implementing network-wide aerosol optical depth measurements were being established and the evaluation of Ultraviolet-B (UVB) and Photosynthetically-Active Radiation (PAR) measurement capabilities were under way. New methods for determining cloud base height were being investigated and future measurements of spectral irradiance and non-radiative heat fluxes were being considered. Such relatively sophisticated and costly measurements could only be done if the necessary funding can be obtained.

The JSC strongly endorsed continuation of projects dealing with producing global data sets of clouds, aerosols, radiation and precipitation (i.e. ISCCP, GACP, SRB, GPCP), but urged that due attention should also be given to the validation and intercomparison of such data sets, and to encouraging reprocessing of the data sets to fully take advantage of new algorithms and corrections for satellite drift and other sources of error. In particular, any such reprocessing should be done with a view to improving records on decadal timescales and trend estimates for the next IPCC assessment (AR4), and also to fulfilling the needs for the evaluation and improvement of climate models. Where necessary and appropriate, WMO's support should be sought to inform appropriate national funding sources of the need and value of such projects and their products, with a view to appealing for and securing further funding.

Whilst recognizing the potential value of global data sets generated by GEWEX, the JSC queried whether or not these were being fully exploited, especially by the climate (and NWP) modelling community. The JSC welcomed and supported the intention of GEWEX to assess the quality, use and value of its major data sets by 2005. It requested that all core WCRP activities be involved in this assessment. Consideration should be given to holding an expert workshop or wider scientific conference that would bring together the producers and providers of critical global data sets with their corresponding actual and potential users.

The JSC noted that precipitation remained a key cross-cutting issue and that a WCRP strategy to ensure co-ordination of activities may be warranted. The JSC requested that GEWEX and CliC SSGs should consider this matter in the first instance, liaising with other projects, WGOA and AOPC as appropriate, and that a report and/or recommendation should be made to the next JSC session.

6.5 Modelling and prediction

6.5.1 Overview

The aim of the GEWEX Modelling and Prediction Panel (GMPP) is to improve the numerical representation of the processes linked to the water and energy cycle in the climatic system and develop conceptual models, which allow simulations of small-scale processes in global models. Attempts were under way to create pan-GMPP activities which would intensify the interactions between the working groups on cloud processes (The GEWEX Cloud System Study, GCSS), on land surface processes (The Global Land/Atmosphere System Study, GLASS) and on the planetary boundary layers (The GEWEX Atmospheric Boundary Layer Study GABLS). These activities will be presented here while the achievements of each of the panels are discussed in the following sections. The proposed cross-cut activities within GMPP are a common theme for the analysis of models and the selection of a common site for model inter-comparisons.

The diurnal cycle has been proposed as the common theme for the analysis of model inter-comparisons. This choice will guide activities in all three groups and encourage a closer study of the couplings which exist between them. Through collaboration with AMIP, the theme will also strengthen the link with global climate models. Although a number of studies have already been carried out on the ability of general circulation models to represent the diurnal cycle, there was still a lack of systematic analysis, which would identify the regions and processes where problems are most common in GCMs.

GMPP proposes to evaluate the ability of models to represent the diurnal cycle using model inter-comparisons as it has proven its value in previous GMPP activities. The strategy envisaged is to diagnose the diurnal cycle in parallel in the processes with which GMPP deals and on the global climate scale before moving onto the analysis of the interactions between clouds, the atmospheric boundary layer and land-surfaces. This plan was submitted and accepted by the 3 panels and was also well received by WGNE, which proposes to call this a common GMPP/WGNE theme. In collaboration with WGNE the analysis of the diurnal cycle could be extended to NWP models. It was proposed that the interactions with WGNE on the diurnal cycle theme would be as follows: 1) At the joint WGNE/GMPP meetings NWP centres would report on problems they encountered with the diurnal cycle in their models, 2) this could trigger research within GMPP. Ideally the NWP centres would propose case studies based on data they have

available or on regions, which they have identified as critical, and 3) GMPP can request specific diagnostics from NWP centres, which should enable a better understanding of the problems encountered in the models.

It is hoped that tackling the diurnal cycle theme and the interactions it will trigger will help overcome the "implementation bottleneck" which exists between GMPP developments and their implementation in large-scale models. The diurnal cycle theme also offers some opportunities for collaboration between GMPP and CEOP. With the first data sets available through CEOP the ability of some NWP models to reproduce the diurnal cycle on the locations chosen for MOLTS was evaluated. As these areas are covered by a large set of in-situ observations they would be ideally suited for more in-depth analysis through GMPP model inter-comparisons.

Another opportunity to encourage pan-GMPP collaborations and work on the coupling of cloud, land-surface and Planetary Boundary Layer (PBL) processes could be achieved if a common site for model inter-comparisons could be found. Because of the very different needs in the 3 groups, the choice of a common site could prove difficult. A pre-selection of possible common sites will be submitted to the GMPP panels in 2004 and by the end of the year the best candidate with the corresponding scientific questions could be selected. The coming year will see the implementation of the diurnal cycle theme. This should result in first results on the systematic errors of cloud-resolving models (CRMs), cloud parameterizations and land-surface models in their representation of the diurnal cycle. The various candidates for the common site for GCSS, GLASS and GABLS will be studied. For the next WGNE/GMPP meeting a proposal needs to be tabled for the continuation of AMIP. The preparation of this proposal will involve GMPP and its panels.

Specific issues raised at the SSG were the following:

- The proposal for a diurnal cycle theme has been approved
- The nomination of Dr C. Jacob as new GCSS Chair has been approved, Dr S. Krueger pursuing his involvement as deputy
- GMPP recommended a closer interaction with the modelling teams of the CSEs in order to contribute to the improvement of regional models
- A stronger involvement of North American scientists in GABLS is recommended.

6.5.2 GEWEX Cloud System Study (GCSS)

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

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

6.5.3 GEWEX Global Land-Atmosphere Study (GLASS)

The GLASS project was progressing through the various actions which were defined in the implementation plan. Within GLASS, the Project to Intercompare Land-surface Parameterization Schemes (PILPS) operates the off-line intercomparisons. The goal of PILPS is to contribute improved understanding of continental surface and near-surface processes through international intercomparison of current state-of the-art parameterizations employed in coupled climate, atmospheric and earth system models. Since the early 1990s PILPS has evaluated the parameterization of energy and water fluxes to/from the land-atmosphere interface. In 2002 carbon fluxes were included in this land-surface MIP (Viovy, 2002). In 2004/5 it is planned to incorporate stable water isotopes in a new phase of PILPS: Isotopes in PILPS (IPILPS). Two rare but naturally occurring isotopes of water, $^{1}H_{2}{}^{18}O$ and $^{1}H^{2}H^{16}O$, will be exploited in IPILPS

as part of the overall GEWEX push into the use of isotopes in modelling and monitoring the global water cycle.

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

6.5.4 The Global Soil Wetness Project 2 (GSWP-2)

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

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

6.5.5 GEWEX Atmospheric Boundary Layer Study (GABLS)

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

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

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

The Chairman of the ACSYS/CliC Scientific Steering Group, Dr B. Goodison, and the Director of CliC International Project Office, Dr C. Dick, reported on the concluding actions of the ACSYS project and

unrolling activities of CliC, as well as on the status of the two associated polar buoy programmes, in the Arctic and Antarctic, and the planned International Polar Year 2007/08.

7.1 *Completion of ACSYS*

ACSYS (http://acsys.npolar.no) is the third WCRP core project to finish. It started its main observational phase on 1 January 1994 and finished on 31 December 2003.

ACSYS Final Science Conference

The conference took place on 11-14 November 2003 in the Arctic and Antarctic Research Institute (AARI) of the Russian Federal Service for Hydrometeorology and Monitoring of the Environment (Roshydromet), St Petersburg, Russia. It was co-chaired by Professor Thierry Fichefet and Dr Ivan Frolov and was supported by AARI, the European Science Foundation through its Standing Committee on Life and Environmental Sciences, the International ACSYS/CliC Project Office, the Norwegian Polar Institute, and the WCRP. There were approximately 242 participants (40 young scientists) from 19 countries in the 4-day meeting, 217 abstracts were submitted, 40 oral presentations were complemented by 161 posters. The findings of the ACSYS project, as reflected by the deliberations at the Final Conference, will be summarised in a monograph.

The aim of the conference (http://acsys.npolar.no/meetings/final/conf.htm) was to summarize the major improvements in the knowledge of the Arctic climate system during the ACSYS decade, drawing together advances in the understanding of each of the individual elements of the Arctic climate system and, more particularly, the understanding of the interactions between them. The conference also sought to examine the challenges for future research on the Arctic climate system.

The most important scientific highlights of the conference were:

- The Arctic experienced very strong warming in concert with the global trend during the last three decades. However, variations in Arctic climate over the past century do not track global variations, suggesting a complex relationship to global climate, which should remain the focus of ongoing study and debate.
- Although no convincing evidence of any significant slowdown of the Atlantic meridional overturning circulation (MOC) is yet found, there is some evidence that the recent freshening of the subarctic seas might not be a localized Atlantic event but the strong local expression of a change in the global water cycle. Freshening has been observed in high latitudes of both the Atlantic and Pacific Oceans, while low latitude oceans seem to become more saline.
- Satellite passive microwave data reveal that the Arctic sea ice extent has decreased by 0.30×10^6 km^2 (i.e., 2.5%) per decade since 1972. All months have negative trends, and the magnitude of the trend is largest in September, the month of minimum ice extent. The lowest levels were reached in September 2002 and 2003.
- The Arctic sea ice has been reported to have thinned substantially over the last 20 to 40 years in most of the deep water areas, especially during summertime. However, sea ice exhibits a pronounced interannual variability in thickness, making it more difficult to interpret the spatially and temporally sparse record. This interannual variability is reasonably well captured by current high resolution sea ice–ocean general circulation models forced by reanalysis atmospheric data, but there is still much work to be done to fully understand the mass balance of Arctic sea ice and its influence on atmospheric and oceanic circulations.
- In 2002, the Greenland ice sheet experienced the most extensive melt since satellite observations began in 1980. A model study suggests that the greenhouse gas-induced increase in freshwater flux from this ice sheet by the end of the 21st century might be sufficient to induce an abrupt weakening of the Atlantic MOC, with a subsequent cooling of eastern Greenland and the northern North Atlantic.
- Analysis of hydrological data shows that the river runoff into the Arctic Ocean has significantly increased during recent decades and that the seasonal freezing of those rivers has diminished in length.
- Proxy data point to a northward movement of the Arctic tree line since the late 1950s. This shift is largest in north-western Canada and eastern and coastal Siberia. Furthermore, satellite-derived vegetation indices suggest a “greening” of Alaska in the past few decades.

Taken individually, each of these changes seems to be indicative of warming in the Arctic region during the last decades of the 20th century. However, high variability over a number of time scales still makes it difficult to draw conclusions about the causes of the changes. Despite considerable progress in understanding during the ACSYS decade, there are still many gaps, which are summarised below.

- Arctic climate feedback mechanisms are not known well enough. The associated spatial and temporal scales are connected with the "carriers" of the feedbacks, e.g. sea ice, snow, clouds, etc., giving a complex range of possible climate cycles. An important issue is the extent to which these feedbacks are represented in models, and the fidelity of this representation.
- The difficulties of making measurements in the Arctic are compounded by the fact that the existing observing systems were generally established to help guide short-term weather and water resource management, rather than to look at long-term climate and environmental change. Although the satellite observing system has made remarkable advances, many aspects of the Arctic climate system remain inaccessible to space-borne instruments. There is still a strong need for *in-situ* measurements to provide long-term records of many variables. This must form part of a coordinated and dedicated international effort to improve the Arctic climate observing system, using both *in-situ* and remote sensing techniques. Current positive examples include development of under-ice technology to supplement Argo ocean observations and the long-term support for the North Pole Environmental Observatory. The Earth Observation Summit and initiatives such as formation of the Group on Earth Observations (GEO) provide an opportunity to influence the development of enhanced observing systems.
- The ACSYS project has provided a valuable legacy of data sets vital to the study of Arctic climate and processes. The challenge is to foster international collaboration in the future. In particular, we must facilitate data sharing through international archives using all available tools, e.g. the World Wide Web.
- Despite improvements in the ability of global climate models to reproduce many features of the observed climate and its historical variability, numerous uncertainties remain. The use of data assimilation in models has been very successful in improving the data sets for atmospheric climate research, and this is something that should be pursued more vigorously in the future for both the ocean and the cryosphere. In addition, models should be used to assist in the development and deployment of observing systems or design of field campaigns.

The predictability of Arctic climate is still not well characterised, and should be given elevated importance as part of the developing WCRP COPES strategic framework.

Completion of ACSYS

After the formal end of ACSYS in the year 2003, the WCRP is not curtailing its studies of the Arctic climate system. The ACSYS website located at http://acsys.npolar.no remains available to users. The Data Management and Information Panel of CliC supported by the CliC International Project Office will prepare datasets relevant to studies of Arctic climate and publish the collection on a CD-ROM and/or the Internet. This will be accomplished primarily via the ACSYS Data and Information Service. The CliC Numerical Experimentation Group (NEG) and Observation Products Panel (OPP) will maintain their interest in modelling and observations of the Arctic. CliC supports an important project on the Arctic System Reanalysis. The full transition of all relevant ACSYS activities to CliC will be achieved through their inclusion in studies undertaken under the CliC Project Areas.

The JSC congratulated and thanked all those concerned with the development and implementation of ACSYS and for its successful final science conference. The JSC recognised that ACSYS achievements included: creation of a basis for improved numerical simulations and reanalysis of the complex system involving polar atmosphere, oceans, sea-ice, and land; provision of a framework for active deployment of drifting buoys by the IABP, declassification of submarine observations, deployment of moored sonars, intensification of ship-based studies, generation of new satellite products, and collection and upgrading of circumpolar data sets; providing a rationale for monitoring meteorological networks in remote locations; stimulation of enhanced regional (Arctic) process studies; intercomparison projects which have led to advances in modelling of the polar environment and created a better basis for projections of amplified impact of the climate change in the polar region.

CliC Panel on the Arctic

The fourth session of the ACSYS/CliC SSG (St. Petersburg, Russia, 15-18 November 2003) established a CliC Panel on the Arctic. The Chair is Dr Cecilie Mauritzen (Norway). CliC would continue co-ordination of WCRP Arctic research in the former areas of ACSYS interest (Arctic Ocean circulation, sea ice, atmosphere, hydrological cycle, processes through which the Arctic acts as a player in the global climate system) through its existing panels and the new Arctic panel. The full scope of the Panel activities was being developed, but it was likely that the panel would have a marine emphasis, including associated atmosphere-ice-ocean interactions and freshwater runoff from land. The geographic scope would be the Arctic and

connecting seas, including the Nordic Seas, Hudson Bay and the Canadian Archipelago, areas not considered by ACSYS. The Panel would intensively collaborate with other important coordination mechanisms in the Arctic, e.g. the International Arctic Science Council, Arctic Ocean Science Board, and other groups. It would have strong links to CLIVAR. Dr A. Busalacchi, speaking on behalf of CLIVAR, supported the establishment of the panel by CliC and expressed readiness of CLIVAR to support it. Dr S. Gulev opined that surface fluxes and precipitation should be given attention by the panel.

The JSC welcomed the confirmation that Arctic research studies would continue to feature strongly within CliC and endorsed the proposal for a CliC Panel on the Arctic.

7.2 *Development of CliC*

CliC (http://clic.npolar.no) was endorsed as a WCRP project by the JSC-XXI (Tokyo, Japan, 13-17 March 2000). The fourth ACSYS/CliC SSG (St. Petersburg, Russia, 15-18 November 2003) resolved that the expected lifetime of CliC would be approximately 15 years.

The current stage of CliC development requires actions to:

- Achieve broad acceptance of the project scientific goals and objectives and to finalise its implementation strategy including corresponding documentation.
- Define, initiate and guide CliC observational and modelling activities for determining the role of the cryosphere in the global climate system and its realistic representation in models.
- Stimulate national, regional, corporate and individual contributions to CliC scientific and observational activities.
- Continue developing strategies for co-ordination of CliC national and regional initiatives, including establishment of partnerships with other scientific organizations, societies, and international committees.
- Strengthen links with other WCRP projects and relevant research and observational programmes outside WCRP.

CliC expects to gain momentum through the determination of a clear and efficient implementation strategy. An important milestone in promoting and refining the project science goals and objectives, stimulating corresponding commitments, establishing partnerships, and making the project more widely known would be the First CliC Science Conference. The CliC project is fortunate to have its active growth stage coinciding with the development of the International Polar Year (IPY) proposal. CliC was expected to contribute to IPY and to benefit from the activities associated with it.

7.2.1 Clic Implementation Strategy

The project science goals and objectives are summarised in the Science and Coordination Plan (Allison et al., 2001). An initial version of the CliC Initial Implementation Plan was made available to the general science community during the first half of 2002. In August 2002, following limited feedback, a meeting of the project leadership proposed a modified approach to implementing the project. Planning the project implementation well in advance was recognised to be too prescriptive, so it was decided to develop first a shortened 'Implementation Strategy' for the whole project, which would include the concept of CliC Project Areas (CPAs). The current titles of the CPAS are:

- The terrestrial cryosphere and hydrometeorology of cold regions
- Glaciers, ice caps and ice sheets, and their relation to sea level
- High latitude oceans and the marine cryosphere
- Linkages between the cryosphere and global climate

Activities within each of the areas should be streamlined towards fulfilling CliC goals and answering the main CliC science questions. This would allow for developing more specific implementation plans for each of the CPAs. 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 CPAs, a framework for management of the programme and collaboration, recommended methodology, and data management strategy.

National committees for CliC have been established by China, Japan, and the Russian Federation and are being considered or developed by a number of other nations, including Australia, Canada, Germany, 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.

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. These plans have yet to be practically implemented.

The International ACSYS and CliC Project Office, now CIPO (CliC IPO) 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. The staff of two located at the office in Tromsø, Norway, (Dr C. Dick, Director; Ms T. Villinger, Office Coordinator) has been supplemented since 1 April 2003 with a staff scientist/data manager Bernard Miville, located at the Canadian Centre for Climate Modelling and Analysis (CCCma), Victoria, Canada. There is still a need for more long-term staff to be employed, preferably at the main office in the Norwegian Polar Institute in Tromsø, Norway.

With the addition of a Staff Scientist/Data Manager to the staff, it has been possible to carry out the necessary website development for the ACSYS and CliC projects and the CIPO. The sites have been completely overhauled, along with the ACSYS Data and Information Service (ADIS). All pages now have a consistent 'look', and menus remain the same on moving from one part of the website to another. Databases for ACSYS data sets, links, papers, reports, etc. have been upgraded, and now contain far more information and are fully searchable. Similar development is now being carried out with the new Data and Information Service for CliC (DISC), under the guidance of the Data Management and Information Panel.

The JSC renamed the ACSYS/CliC SSG as the CliC SSG, with effect from 1 January 2004, and the supporting project office, the CliC International Project Office (CIPO).

First CliC Science Conference

Following the kind invitation of the Permanent Representative of China with the World Meteorological Organization and a member of the ACSYS/CliC SSG, Professor Qin Dahe, the Fourth ACSYS/CliC SSG session resolved to hold the First CliC Science Conference in 2005 in China. Subsequent consultations between the JPS WCRP and the China Meteorological Administration established 11-15 April 2005 as the Conference dates and Beijing, China, as the venue.

The goals of the conference are to:

- Critically review the level of observations and research on cryosphere and climate and to demonstrate their role in climate change detection, understanding and projection.
- Highlight existing findings showing the crucial role of the cryosphere for the future of the Earth in a changing environment and to find ways to fill the gaps in observations, research and projections that generate significant uncertainties in decision making support information.
- Contribute to understanding by national and regional governments, local authorities, funding agencies, media, and decision makers of the role of systematic observations of the cryosphere and research on cryosphere and climate.
- Generate contributions by scientists, groups, organizations and nations to activities of cryospheric observations, process studies, and modelling.
- Establish links between groups and institutions active in observations and research on interaction between climate and cryosphere.
- Seek new methods and new collaborative arrangements for carrying out cryosphere/climate research.

The conference is intended for scientists, managers, representatives of national and local governments, media, and funding organizations and will provide an opportunity to discuss co-operation between various groups and initiatives, such as the International Polar Year 2007/08. All projects active in research on cryosphere and climate will be invited to take part in the conference. The format of the conference will include keynote and invited talks, and posters including a poster session devoted to national CliC activities. The content of the sessions will correspond to the CliC Project Areas. Current sponsors of the conference are the China Meteorological Administration, the Chinese Academy of Sciences, the CliC

International Project Office, and the World Climate Research Programme. Other sponsors are being sought. The work of the Science Organising Committee will be led by three Co-chairs: Dr Ian Allison (Australia), Professor Peter Lemke (Germany), and Professor Qin Dahe (China). Conference organization will be coordinated by the CliC International Project Office and a local organising committee.

The JSC welcomed the news that the First CliC Science Conference would be held 11-15 April 2005, Beijing, China, at the invitation of Professor Qin Dahe, Permanent Representative of China with WMO, and a member of the CliC SSG.

7.2.2 CliC Project highlights

A joint meeting of the Joint ACSYS/CliC Panels was held in Victoria, Canada, on 14-17 October 2003.

Data and Information Management

The Data Management and Information Panel (DMIP) discussed the general approach to be taken to address the diversity of data management activities that are possible during CliC. It concluded that the following key activities were important to assuring the long-term success of the project:

- developed and thoroughly maintained Data and Information Service for CliC (DISC);
- coordinated data management related activities with other WCRP projects;
- links with global data centres responsible for cryospheric data and information;
- use of new capabilities in data archive exchange and interoperability including metadata standards, GIS, search tools and World Wide Web capabilities.

Major new DISC capabilities include query and search of references, datasets and publications. All information has been updated where possible to include a complete record of reports, meeting summaries and links to project related web sites. The key next steps for CliC DISC development were summarised. The actions are to:

- establish key contacts in each of the international data centres where cryospheric data are managed and establish WWW links to the DISC;
- develop a list of researchers, organizations etc. that create and/or use cryospheric data;
- provide a forum for CliC data providers, operators/managers and researchers on DISC to exchange ideas and discuss issues;
- facilitate getting CliC relevant data to data centres;
- continue development of the metadata archive for datasets in DISC;
- prepare an inventory of journals focusing on the cryosphere.

These activities will require continuing input from the science and monitoring community as well as staff effort to maintain a complete set of information. An important principle is that DISC development must be user driven.

The Panel considered, with assistance from international experts, some immediate steps to help develop a better understanding of the diversity of CliC data and information. There are several proposed and ongoing efforts to improve broad community understanding of cryospheric processes and access to related data and information. The list includes:

- development of longer time series datasets and forcing datasets for analysis/re-analysis;
- preparation, archival and distribution of global runoff and precipitation datasets by GRDC and GPCC;
- establishment of a WCRP precipitation working group for *in-situ* measurements with representation of individuals working on specific projects and interested nations.

DMIP also decided to develop a dynamic table and more detailed report of the state of data management for CliC components (e.g. permafrost, glacier, sea ice, etc.). It would include an assessment of a component's importance to CliC, whether the component is observed, modelled or derived, status of the corresponding data archive, information on distribution of and access to data and information about that component. It will be complemented by a world map of cryospheric components with source locations, and impacts on a national scale. It will be possible to use it for looking for information on the cryosphere. As part of this activity, DMIP considers preparation of a global inventory of remote sensing datasets relevant to the cryosphere. Chronology and coverage by various sensors would be a key objective. These plans will be implemented using a GIS global/regional map interface. Sparse information and data on the Southern

Hemisphere were noted as a significant gap for CliC. To resolve this, work with Australian colleagues and others to link better to regional data and inventories is needed.

In April 2003, Mr B. Miville (Environment Canada) joined part-time the CliC International Project Office as the data manager and staff scientist working remotely from Victoria, Canada. He took over the task of improving the management of metadata for CliC. Mr Miville processed all the information in CliC related datasets in order to properly create their metadata. The WMO Core Metadata Profile was used as the basis for structuring the metadata. This standard used the official ISO 19115 standard for geographic metadata. Using an ISO standard will facilitate the exchange of information with other standard compliant data portals. The metadata were then entered into a relational database and a web interface was created for the administration of the metadata and doing queries through a search engine. The web interface has been called Data and Information Service for CliC (DISC). DISC contains not only metadata from CliC related datasets but also CliC/WCRP reports, links of interest to the CliC community and the CliC Newsletter. The maintenance of DISC is an ongoing project and a pro-active method is used to find and publicise CliC related datasets. Mr Miville is constantly searching for cryosphere data by directly asking the researchers. At the same time a database of specialists working in the Cryosphere Sciences was being developed and would become fully searchable as a web interface in the near future. Mr Miville is currently developing a data exploration mapping system, where the user will be able to view on a world map the location of the CliC related datasets and zoom in and out or click on a location to obtain more information. The same system will be used as an educational tool to give users a general idea of where the cryosphere is located on Earth. CliC is also monitoring the media for news items related to the cryosphere. Mr Miville created an automated system to monitor on a daily basis several worldwide news agencies for articles of interest to the CliC community. Direct links to the articles are provided and an archive is also maintained. The expertise developed by Mr Miville for CliC may be useful for the WCRP project activities as well.

The JSC was impressed by the achievements during the past year in the development of a new Data and Information Service for CliC (DISC), due mainly to the part-time addition of Mr B. Miville (Environment Canada) to the CIPO team. The JSC expressed concern that resources were not available to maintain this support on behalf of WCRP beyond 2004. The JSC requested the Director, WCRP, to explore prospects for finding such resources.

ACSYS/CliC Numerical Experimentation Activities

Progress on the various ongoing projects is summarized below:

- SIMIP2: The sea-ice model intercomparison project, phase 2, involves simulation of the thermodynamic evolution of multi-year sea ice over an annual cycle. Participating models are forced with observations obtained from the Surface HEat Budget of the Arctic Ocean (SHEBA) field experiment (Beaufort Sea, October 1997-October 1998). Information is available at http://acsys.seos.uvic.ca/acsys/simip2/. A one-day workshop was held on 20 October 2003 in Victoria, Canada. Results obtained so far were presented and discussed, and plans for further model experiments and final evaluation were made. The objective was to prepare a multi-authored paper summarising the project's results within the coming year.
- AOMIP: The Arctic Ocean Model Intercomparison Project has been under way for several years. It is comprised of an active group of co-investigators and is funded in part by the International Arctic Research Center in Alaska. The objective is to evaluate and improve models of the Arctic Ocean and its ice cover, and it makes use of historical atmospheric data spanning the period 1948-2002. The AOMIP participants held their 6th meeting May 12-16, 2003 in Woods Hole, USA. More details are available at http://fish.cims.nyu.edu/project_aomip/overview.html.
- ARCMIP: The Arctic Regional Climate Model Intercomparison Project is a joint initiative of the NEG and the GEWEX Cloud System Studies Working Group on Polar Clouds. Eight modelling groups are participating and simulations over a smaller Beaufort Sea domain and a larger pan-Arctic domain span the 1997-98 SHEBA year. Most of the groups have completed the required model runs and the output analysis is currently under way. More information is available at http://paos.colorado.edu/~curryja/arcmip/index.html.

- ISMINT: A new initiative of the ACSYS/CliC NEG, the Ice Sheet Model Intercomparison Project is aimed at evaluating several aspects of contemporary ice sheet models. It follows on from the successful European Ice Sheet Modelling Initiative (EISMINT) project. A workshop was held in Brussels, Belgium in June 2003, and participants laid out five topic areas: polar ice sheets and greenhouse warming; benchmark experiments for higher-order models; Heinrich event intercomparison; intercomparison of the Last Glacial Maximum Northern Hemisphere ice sheets; and an update of EISMINT Phase II experiments.

The International Commission on Snow and Ice (ICSI) Working Group on Snow and Climate has initiated a project SnowMIP-2 aimed at an intercomparison representing snow-vegetation interaction models. A workshop on permafrost modelling to be held at the University of Alaska, Fairbanks (USA) in October 2004 was being organised. There are plans to coordinate an intercomparison of ice-shelf models.

ACSYS/CliC coordination of cryospheric observations

The main activities of the Observations Product Panel (OPP) panel in the past year were an expanded observational product review relevant for model validation and verification to the global scale, with emphasis on Southern Hemisphere and mid-latitudes. These included the review of observational products from *in-situ* and remote sensing sources for snow surfaces, including terrestrial and oceanic, the review of ice sheet observational products relevant for model validation and verification, including Greenland and Antarctica, and the discussion of strategies for future cryospheric observations in support of model evaluation and process studies.

The panel discussed how to coordinate with space agencies on the requirements of space-borne interferometry for ice sheet and climate studies. The rationale for this effort is that synthetic aperture radar (SAR) does not operate like other satellite sensors – it has a high data rate and a high cost of archiving the associated data volume. Thus, SAR sensors are not operated unless planned – it is an on-demand sensor. Therefore, mapping of the polar regions requires a coordinated programme that includes the commitment of space agencies and directions by scientific working groups. This is the only approach to produce the desired plans that will allow the most effective use of available resources.

Measurements of albedo (reflectivity of solar radiation) are essential for climate change and Earth's energy budget studies. Surface albedo can be estimated using shortwave, broadband or multi-spectral images from satellite sensors such as Advanced Very High Resolution Radiometer (AVHRR), Moderate Resolution Imaging Spectroradiometer (MODIS), Landsat, and Satellite pour l'Observation de la Terre (SPOT). The accurate assessment of albedo is a key factor in the ice-ocean-albedo feedback that is expected to cause amplification of climate signals in the polar regions. The panel concluded that overall, satellite data have the potential of providing good and at least acceptable data on large scale albedo and surface temperatures in the polar regions. They provide spatial details on a global scale that cannot be obtained by any other means. Combined with surface data, they can be used in conjunction with physical models to gain insights into the changing Arctic climate system.

Key to any assessment of future sea-level change is the mass balance of the Greenland and Antarctic ice sheets: are they increasing or decreasing in volume? Currently, the uncertainty in their mass-balance estimates is approximately equivalent to the observed global sea-level rise. The Programme for Arctic Regional Climate Assessment (PARCA) is a NASA project with the prime goal of addressing this issue for Greenland. The prime result is an order-of-magnitude improvement in our estimates for the mass balance of the entire ice sheet, with quite detailed assessments of the behaviour of smaller regions within the ice sheet. Other significant progress has also been made both in the development of new techniques for glaciological research, and in process studies. Taken as a whole, results from PARCA represent a significant advance in our knowledge and understanding of the mass balance of the Greenland ice sheet, and they form a baseline set of measurements for comparison with precise surface-elevation measurements to be acquired by NASA's Geoscience Laser Altimeter System (GLAS) aboard ICESAT, which has been launched in January 2002. Major research emphasis is now on the observation and monitoring of surface melt in the ablation regions, the ice motion of certain out-let glaciers, and the modelling of surface processes to reduce uncertainties in the mass balance. These measurements are crucial given the observational evidence that glaciers have increased their flow speed by as much as 40% within the past three years as a dynamic response to increased surface melting caused by warmer summer temperatures.

A team of CliC specialists is involved in preparing a proposal for the Integrated Global Observing Strategy (IGOS) Partnership to consider a new Theme on Cryosphere. Observations of the Cryosphere should comprise an important part of the activities of the intergovernmental ad hoc Group on Earth Observations (GEO), in which the WCRP is a participant. Preparing a comprehensive document on an IGOS Cryosphere Theme should facilitate the development of a cryospheric observing system as part of the GEO activities, as well as of GCOS, GTOS and GOOS.

The JSC endorsed that CliC should pursue discussions for facilities for downloading SAR information in data sparse regions, particularly Russia. The JSC encouraged CliC, on behalf of WCRP, to explore further, with other partners, the value and viability of developing an IGOS-P Cryosphere Theme.

Polar Re-analysis

The work over the last few years has focused on developing momentum for an Arctic System Reanalysis (ASR) to be conducted under the USA Study of Environmental Arctic Change (SEARCH) programme and on validation of output from the ERA-40 reanalysis. The multi-agency SEARCH programme will now embark on generating a dedicated ASR. As part of its commitment to the SEARCH programme, NOAA has provided seed funding intended to lay the groundwork for ASR development. This funding is directed at two primary activities. First is evaluation of the ECMWF ERA-40 reanalysis and the National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis (NARR). The objective is to assess the present "state-of-the-art" of reanalysis depictions in the Arctic region and set performance benchmarks that should be beaten by the ASR. The second activity is to develop a prototype ASR. ERA-40 and NARR evaluation is proceeding. As a step toward meeting the second goal, a workshop was held in Fairbanks, USA from 8-10 November 2003. As outlined at the workshop, the planned ASR will be based on the NCEP Weather Research and Forecasting (WRF) system. WRF represents a new direction for NCEP, and will include a family of models. The ASR will be developed for the region north of 45°N at a horizontal resolution of 25-30 km and with high vertical resolution. A 3dVAR assimilation system will be adopted. Ideally, the ASR will be run for the period 1957-present.

The ASR must make optimal use of satellite data. The workshop participants readily acknowledged the need for improved assimilation of TOVS data. Sub-optimal cloud clearing in the Arctic was identified as a key issue. The general view was that assimilation of retrieved properties (temperature and humidity profiles) would be a better approach than the direct assimilation of radiances. MODIS cloud-track winds from NASA's TERRA and AQUA satellites represent a potentially valuable data source for recent years. Results from test cases showed that while assimilation of TERRA winds improved high-latitude forecast skill, assimilation of AQUA winds degraded skill. Resolving this problem was identified as a key research issue. The workshop also identified the requirements for better soil, sea ice concentration and ocean data sets, and the need to explore how the NCAR/NCEP/ECMWF "Big Merge" assimilation data set might be supplemented through data mining efforts.

A subsequent meeting was held at the SEARCH Open Science Conference, Seattle, Washington, USA (27-30 October 2003) to formulate a coherent strategy for ASR development. Given the limited NOAA funding, it was decided to perform an initial test run for the period 1987-1998 with a prototype ASR. The prototype would be based on the transfer to WRF of optimized polar physics that reside in the latest-generation polar MM5 model (Pennsylvania State University/NCAR Fifth Generation Mesoscale Model). The test period was chosen due to the availability of a fairly robust database for evaluation (including data from the SHEBA experiment). Given problems that still need to be addressed in the use of TOVS and MODIS, the prototype will not include assimilation of satellite data. As the ASR prototype is being developed and tested, parallel efforts will be needed for the optimization of TOVS and MODIS retrievals and further refinement of model physics (e.g. a better snow model and sea ice treatment). These improvements would then be included and evaluated in the ASR through an iterative approach.

The NOAA seed funding is only sufficient to develop the prototype ASR and is intended as a "proof of concept". Additional funding will be sought through research proposals to different agencies. International participation will be key to the success of the project. ECMWF will likely play a role as an "interested observer" but more formal collaboration should be pursued. It is envisioned that Russia and China can play roles in data rescue. Japan (JMA, JAMSTEC, NASDA) could contribute through IARC and in the development of satellite data sets. Canada could contribute Radarsat and snow data. CliC should coordinate the ASR development.

The JSC encouraged CliC to continue their reanalysis activities and to seek funding opportunities and partnerships, such as with SEARCH to conduct an Arctic System Reanalysis.

Joint CliC panel project on "observed changes in the global cryosphere during the 20th century"

At the joint panel meeting in Victoria, Canada (14-17 October 2003), a project to review observed changes in the cryosphere was initiated. The purpose of this project is to assemble published information on changes in all cryospheric elements covering as much of the globe as possible, and representing as long a portion of the 20th century as possible. The objective is to provide a synthesis of historical change in the cryosphere that will contribute to the upcoming IPCC Fourth Assessment Report. Dr G. Flato (Environment Canada) is leading this effort.

Arctic Ocean Observing System

CliC was putting forward an initiative to develop an Arctic Ocean Observing System (AOOS) as a regional component of the Global Ocean Observing System (GOOS). The initial proposal includes the "physical" domain of the AOOS only. The goal of AOOS would be to monitor the Arctic Ocean in sustained mode with contributions and in cooperation with existing international oceanographic projects in the Arctic and Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) of the WMO and IOC. The AOOS has to strengthen the polar (Arctic, sea-ice) dimension in global ocean observations and operational oceanography. AOOS can become one of the IPY initiatives. The CliC Arctic Panel is expected to contribute to the AOOS development.

The Arctic - Subarctic Ocean Flux (ASOF) programme aims to monitor and understand the oceanic fluxes of heat, salt and freshwater at high northern latitudes and their effect on global ocean circulation and climate. The ACSYS/CliC SSG, at its session in St. Petersburg, Russia, in November 2003, endorsed ASOF as an important contributor to CliC goals.

Hydrological Programme

Cold region hydrology is one of the central topics in CliC Project Area 1 and requires increased attention if we are to advance our understanding of the climate system and associated environmental science and impacts. Climate models need to include not only hydrological processes, but also their interaction with, for example, dynamical vegetation, the carbon cycle, permafrost and seasonally frozen ground. Initial steps in this direction have been made, and much more remains to be done particularly using the CPA1 as a framework. The PILPS-2e Arctic Hydrology Model Intercomparison, a joint ACSYS/CliC and GEWEX project has been completed in the Torne-Kalix River Basin. Follow-on intercomparisons are to be finalised and the scope of land surface / vegetation / hydrological models needs to be extended. A workshop (March 2004) planned by northern circumpolar hydrologists on the Synthesis of Water Balance Data from Northern Experimental Watersheds is a major step in developing a comprehensive understanding of circumpolar hydrology.

Quantification of cold region precipitation is one of the critical issues that remain to be addressed by CliC. This has to be done in concert with other WCRP projects as collectively we strive for the quantification of global precipitation. The need for a WCRP working group or panel on precipitation remains. CliC is proceeding with some of the activities recommended in its implementation plan. It is pleased that an intercomparison site has been established and operated at Barrow, Alaska, to provide a test site in a windy, cold Arctic environment through the co-operation of the Japanese Frontier Institute, University of Alaska and IARC. The results will build on the knowledge gained from the earlier WMO Solid Precipitation Intercomparison. CliC will establish a working group to deal with precipitation measurement in cold regions. CliC will work with GPCP on the development of data sets, adjusted for known systematic errors, suitable for hydrological and climate modelling. CliC will also identify how it can contribute to the development of the GPM mission, and particularly in the development and evaluation of precipitation products for high latitudes, particularly snowfall. Development and assessment of new technologies for precipitation measurement in cold climate regions are essential if the hydrological programme is to be successful.

CliC has also proposed and promoted the development of "supersites" in different climate regions. Scaling of cryospheric variables and the associated land surface processes and models is a high priority task for CliC terrestrial studies and has been identified as a common theme deserving special attention. The proper scaling (scale down climate parameters; scale up cryospheric processes) and verification of the scaling procedure are essential in the development of land surface process models and their link to hydrological models and incorporation into climate models. Scaling and sub-grid variability are issues for all of the terrestrial components, and are especially important to advance the hydrological programme. Long-term field experiment sites must be established or maintained if they exist. These supersites would complement and build upon other study areas, e.g. CEOP. The CliC Implementation Plan provides additional information on these sites, and this concept could be extended to serve all of WCRP and provide a bridging mechanism between observations and modelling within COPES.

Since 2001, 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 Arctic Monitoring and Assessment Programme (AMAP). Co-ordination with WMO Hydrology and Water Resources Department and Global Terrestrial Network for Hydrology is also needed. 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. This work should be done with involvement of the Global Run-off Data Centre (GRDC).

The JSC noted with interest the concept of supersites introduced by CliC. The link to CEOP was recognized. Further discussion among the projects and with the WGOA and GCOS was encouraged to further define the benefits and feasibility of supersites within COPES.

7.2.3. Coordination of CliC activities with major international research programmes

CliC is not a funded or funding research project. It is an umbrella mechanism stimulating research in areas of importance for climate science and a means to coordinate such research. It is expected that many of the CliC scientific questions will require contributions of other projects and programmes, including national research. For example, a number of Antarctic and Artic regional projects contribute scientifically to the goals of CliC. CliC has contacts to many of them through members of its panels and groups.

A Memorandum of Understanding was signed in 2003 with the International Study of Environmental Arctic Change (SEARCH). SEARCH and CliC share common goals in trying to understand recent Arctic environmental and climate change and variability. Cooperation has been significantly strengthened with the International Permafrost Association (IPA). CliC has established stronger links with the International Commission of Snow and Ice (ICSI) of the International Association of Hydrological Sciences (International Union of Geodesy and Geophysics), which initiated a proposal to attain the status of an Association within IUGG. ICSI offered its national focal points to CliC for establishing initial contacts with many countries. An important partner, with goals similar to CliC but with regional focus, is the Northern Eurasia Earth Science Partnership Initiative (NEESPI) aimed at developing a better understanding of the interactions between the ecosystem, atmosphere, and human dynamics in northern Eurasia. The CliC SSG Chairman, Dr B. Goodison, is on the Steering Committee of the Second International Conference on Arctic Research Planning (ICARP II). CliC has begun to establish direct linkages with IGBP and its projects including PAGES.

CliC has contributed to the draft plans of the Global Water System Project (GWSP) in all its aspects connected to cold region hydrology. The need to consider cryospheric components in the GWSP was acknowledged. CliC plans to maintain links with the Mountain Research initiative(MRI). The MRI is a new multidisciplinary scientific organization that addresses global change issues in mountain regions around the world. MRI is endorsed by IGBP, IHDP, Global Terrestrial Observing System (GTOS), and UNESCO's Man and the Biosphere Programme (UNESCO MAB). An initial contact was recently established. CliC is mandated to contribute to observation and monitoring of the cryosphere in the three global observing systems (GCOS, GTOS and GOOS). The CLIVAR/CliC Southern Ocean Panel, CliC Arctic Panel and the Arctic Ocean Observing System initiative form the basis of CliC's contribution to GOOS.

CliC and other WCRP cross-cutting activities

Several of the WCRP cross-cutting themes involve CliC. Global precipitation, monsoons, performance of models in high latitudes, transport of water, energy and ozone in high latitudes, radiation, and climate-chemistry coupling are all topics where CliC would have an interest. One key cross-cutting issue is sea level rise. The contribution of the cryosphere to changes in sea level is one of the CliC Project Areas. Activities related to this include the initiation of the ISMINT, involvement in the PARCA, and the planning of a workshop on a global assessment of glacial contribution to sea level rise for early 2005. The intention is for this last activity to form the basis for a CliC contribution to a more wide-ranging assessment of factors affecting sea-level.

The JSC noted with interest the opportunity to develop a regional COPES activity for the Arctic region through the International Arctic Science Committee (IASC)/ Second International Conference for Arctic Research Planning (ICARPII) and the possibility of co-operating with a similar activity within THORPEX. The JSC wishes to be kept informed of this opportunity as ICARPII progresses.

CliC and CLIVAR

Apart from the activities of the joint CLIVAR/CliC Southern Ocean Panel, enhancement of joint activities in the Atlantic sector was being sought. This should be achieved through the activities of the Arctic Climate Panel. Some other projects and activities would be invited to cooperate with the Panel. Other areas of joint CliC – CLIVAR interest may include cooperation with ASOF, SEARCH, the Arctic Ocean Observing System, PAGES, links between CliC NEG activities and the JSC/CLIVAR Working Groups on Coupled

Modelling and Ocean Model Development. Potential joint interest between CliC and CLIVAR exists in studies of the Asian-Australian Monsoon in relation to the role of the Tibetan Plateau. Both project have links to GEWEX/CEOP. As recommended by the Southern Ocean Panel, both projects should be keen to ensure full coordination of their data management approaches.

CliC and GEWEX

Current co-operation with GEWEX includes contribution of CliC to the Co-ordinated Enhanced Observing Period (CEOP) with a CliC SSG member on the CEOP SSC to bring special attention to cold climate modelling, remote sensing and *in-situ* measurement issues. CliC would support an extension of CEOP as it would provide at least one more winter season of data collection. Among GEWEX projects, the GEWEX Asia Monsoon Experiment (GAME), the Mackenzie GEWEX Study (MAGS), and the Baltic Sea Experiment (BALTEX) have cryospheric components. Arctic-HYCOS is a topic of mutual concern that should be discussed further to ensure its effective implementation. The GRDC, GPCC and PILPS are part of GEWEX, but are critical for CliC activities. The CliC theme on terrestrial cryosphere and hydrometeorology of cold regions has many initiatives that link to and require good collaboration with GEWEX.

Discussions have been initiated between the GEWEX Radiation Panel and the CliC Observational Products Panel on a joint workshop on clouds and radiation issues. Precipitation remote sensing, another area of common interest with the GRP, still presents significant challenges, and there was a need for activity to compare methods of snow/ice remote sensing to field data. This included not just snow on the ground, but solid precipitation. With current field and modelling projects (e.g. BALTEX, MAGS, GAME-Siberia, and other "supersites") and new proposed satellite systems that make up the GPM and the EGPM, there are areas of mutual interest that could benefit from contributions of both groups.

CliC and SPARC

One important area of coordination, which CliC should strive to ensure, is adequate representation of stratospheric layers in the Arctic System Reanalysis. Another area of potentially strong interest is the role of the polar stratosphere (and sudden stratospheric warmings) in tropospheric predictability. CliC can potentially contribute to this research through studies on the Northern Annular Mode/Arctic Oscillation. The CliC Arctic Panel can serve as contact in this area.

7.3 WCRP and sea-ice buoy programmes

7.3.1 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. The 13th Meeting of IABP Participants took place on 4-6 June 2003 in Tromsø, Norway, hosted by the Norwegian Polar Institute (NPI) and the International ACSYS/CliC Project Office (IACPO). Drifting buoys in the Arctic Ocean, contributed by 18 organizations 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 Ocean providing surface air pressure and surface air temperature to the GTS. Monthly buoy maps and status sheets can be accessed on the IABP web site. The suite of monthly maps was expanded in 2003.

IABP data were fundamental to Walsh et al. (1996) showing negative trends of atmospheric pressure over the Arctic, Rigor et al. (2000) showing positive air temperatures trends, and to Proshutinsky and Johnson (1997); Steele and Boyd, (1998); Kwok, (2000); and Rigor et al. (2002) showing that the clockwise circulation of sea ice and the ocean has weakened. All these results relied heavily on IABP data. In addition to supporting these studies of climate change, the IABP observations are also used to validate satellite retrievals of environmental variables, to force, validate and initialize numerical models, and to forecast weather and ice conditions.

The JSC expressed its gratitude to IABP participants for the very successful conduct of the programme. It called on IABP to spare no effort in trying to make its data available in real-time mode on the WMO GTS.

7.3.2 The WCRP International Programme for Antarctic Buoys (IPAB)

The WCRP International Programme for Antarctic Buoys (IPAB) started in 1995. It co-ordinates drifter deployments in the Antarctic sea-ice zone, optimises buoy distribution over this region and aims 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. A fourth meeting of the IPAB participants was held during the Southern Ocean Science Week (5-7 September 2003, Bremerhaven, Germany). The status of the Programme was reviewed.

Throughout its life, IPAB has lacked strong support from operational meteorological agencies, and the majority of IPAB buoy deployments are made as part of 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). The WCRP, through the WMO Executive Council Working Group on Antarctic Meteorology, solicited a WMO Executive Council Resolution 15 (EC-LV) “Maintenance of, and support to, the International Programme for Antarctic Buoys of the World Climate Research Programme” (Geneva, May 2003). It called for active participation in the IPAB, strengthening coordination of the buoy deployments, ensuring that the observations are reported through the WMO GTS.

The JSC agreed with the participants in the 4th IPAB meeting that IPAB required considerable strengthening and more attention from meteorological services, and programme coordination needed to be improved.

7.4. WCRP participation in the 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. The Fourteenth WMO Congress adopted a resolution 34 (Cg-XIV) “Holding a third International Polar Year in 2007-2008”. ICSU established an ICSU Planning Group on IPY, which presented its recommendation to the ICSU Executive Board to work on the IPY jointly with the WMO. The Executive Board in February 2004 accepted that proposal.

The JSC-XXIV decided that CliC would coordinate WCRP participation in IPY 2007-08 and represent WCRP at meetings and bodies involved in the preparations for IPY. The CliC International Project Office and project leadership contacted WCRP projects and working groups and collected their views and proposals on IPY. A discussion paper on WCRP’s contribution to IPY was prepared and submitted to the ICSU IPY Planning Group. The WCRP participation in the IPY is welcomed both by the WMO and ICSU. CliC plans to continue the preparations on behalf of the whole WCRP. WCRP projects and working groups are invited to actively express their needs and wishes on how their activities may benefit from WCRP participation in the IPY.

Dr D. Carson added to the discussion a concise overview of the relevant WMO activities.

The JSC noted the lead role played by CliC, on behalf of WCRP, in the development of plans for the implementation of an IPY 2007-08, now under the joint sponsorship of WMO and ICSU. It requested CliC to continue playing this role for WCRP, keeping all other relevant parts of WCRP informed and involved as appropriate, with particular regard to involving WCRP-related modelling activities.

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

The Co-chairs of the SPARC Scientific Steering Group, Professor A. O'Neill and Dr A. Ravishankara, as well as the Director of the SPARC International Project Office, Professor M.-L.Chanin, presented SPARC activities and the principal recommendations from the eleventh session of the SPARC Scientific Steering Group held in Frankfurt am Main, Germany, 22-25 September 2003.

8.1 Recent significant results

Recent SPARC activities have been concerned with stratospheric indicators of climate change, study of stratospheric processes, development of modelling, various assessments and development of data assimilation. The recent deliverables have been: an assessment report "Stratospheric temperature trends: observations and model simulations" (paper awarded the international Norbert Gerbier-MUMM International

Award, 2003); a stratospheric reference climatology report; and the 2002 WMO/UNEP Assessment of Ozone Depletion.

8.2. Future directions

The JSC, at its 2003 meeting in Reading, UK, requested SPARC: to lead collaboration with IGBP/IGAC on chemistry-climate interactions; to focus on issues raised by recent studies of the Arctic Oscillation; to liaise with the Scientific Committee On Solar-TErrestrial Physics (SCOSTEP) on solar radiative forcing and temperature trends; to work with WMO GAW on ultra-violet radiation penetration; and to contribute to international assessments and mission planning.

In response, SPARC refined its main directions and proposed three themes for future SPARC research. They are directed at detection, attribution, and prediction of stratospheric changes, stratospheric chemistry and climate, and stratosphere – troposphere coupling. The main science questions for each of these three themes include:

Detection, Attribution and Prediction of Stratospheric Changes:

- What are the past changes and variations in the stratosphere?
- How well can we explain past changes in terms of natural and anthropogenic effects?
- How do we expect the stratosphere to evolve in the future, and what confidence do we have in those predictions?

Stratospheric Chemistry - Climate Interactions

- How will stratospheric ozone and other constituents evolve in a changing climate?
- How will changes in stratospheric composition affect climate?
- What are the links between changes in stratospheric ozone, UV radiation and tropospheric chemistry and vice-versa?

Stratosphere-Troposphere Coupling

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

These three themes are highly cross-cutting and many future activities will fall under more than one theme. For example, the stratosphere chemistry-climate interactions components will have a major emphasis on model-model/model-observations comparisons under a new activity, which will encompass all three themes. A draft of a new implementation plan is under development. In the process, SPARC will specifically examine how the above three themes fit into the WCRP's COPES strategic framework. The cross-cutting interactions between the different WCRP projects and working groups, in the context of COPES and otherwise, are of special importance.

Expected deliverables by SPARC in the near future will be:

- a temperature trend assessment report,
- an aerosol assessment report,
- a review on Arctic Oscillation / North Atlantic Oscillation for stratosphere - troposphere system,
- a review of gravity-wave parameterizations,
- a review of scientific issues in the domain of chemistry and climate,
- a review on global circulation models / chemical transport models with focus on ozone and predictions of mid-latitude ozone,
- contribution to IPCC process: comprehensive calculation of the radiative forcing of HFC134a, a substitute for CFCs,
- a comprehensive review / assessment of polar stratospheric cloud climatology (is being initiated as a SPARC activity; results from this activity are expected in the next couple of years).

8.3 Status of the three main streams of SPARC activities

8.3.1. Detection, attribution and prediction of stratospheric changes

From the viewpoint of observations, two important issues are the continuity of stratospheric temperature data sets and data on stratospheric water vapour changes. Changes in meteorological analysis procedures or in data characteristics strongly influence current stratospheric data sets. There are significant uncertainties in all analyses associated with the change of data source from TOVS to ATOVS products. This will affect future assessments. For subsequent studies it is important to recognise the inherent observational uncertainties. SPARC will encourage efforts to improve the observational record in the future. There must be work on a more integrated understanding of past changes, which would involve studies of trends in ozone, temperature and water vapour trends as well as aerosol assessments. Modelling results should be more widely used to explain and verify the trends. These ideas were discussed at a one-day workshop, which was held in Silver Spring, USA, on 5 November 2003, in conjunction with the Dr J.K. Angell 80th Birthday Symposium. The workshop delineated future directions of studying stratospheric trends. In particular, it was shown at the workshop that using regression analysis between different data sources for different years it was possible in principle to generate a more uniformly continuous data set.

"Understanding the past and prediction of the future" will be a major new theme in SPARC. In this context, it is expected that the current GCM-Reality Intercomparison Project for SPARC (GRIPS) will merge seamlessly with the larger theme of "climate – chemistry interactions". Successful implementation of these tasks would open the way for predictive experiments. It will be essential to use in such experiments credible atmospheric global circulation models with full troposphere, robust radiation codes, parameterizations for hydrological cycle and other physical factors and with upper boundaries in the mesosphere.

An important scientific issue for SPARC is the understanding of cause for positive trends of water vapour in the lower stratosphere. The role of the tropical tropopause layer in determining the water vapour abundance of the stratosphere will be examined. A future activity in this area is envisioned. Such an activity will be timely and is likely to be bolstered by anticipated field measurements activities. The SPARC-sponsored tropopause workshop of 2001 laid the groundwork for examining the essential elements of such an activity.

8.3.2 Stratospheric chemistry – climate Interactions

Atmospheric composition changes are caused by both natural phenomena (e.g. volcanic emissions) and anthropogenic activity (e.g. pollution, emissions, land use etc.). They result in changes in surface spectral reflectance, the composition of trace gases and aerosol, which are both chemically and radiatively active, radiation, cloud cover, precipitation rates, i.e., weather (short term), and climate (in the medium and long term). Nonlinearity of the system further enhances the complexity in feedbacks. Therefore, the important issues are the extent and non-linearity of the coupling and interaction between the chemistry, weather, and climate, and the attribution of the natural and anthropogenic contributions to changing and variable atmospheric composition and conditions. Emphasis needs to be focused on regional air quality, long-range transport and transformation of pollutants, the atmospheric lifetime and turnover of greenhouse gases and aerosol.

For the stratosphere the questions are as follows. Will ozone recover from chlorine driven depletion as predicted? What is the role of changes in tropopause height on ozone trends and on climate and chemistry interactions? What is the role of bromine? Will the dynamics and circulation remain stable and what will be the impact of a changing circulation on the chemical composition?

Additional scientific questions arise in connection with the mesosphere. Are the mesospheric composition changes a potential early warning signal for climate change? Is a change of occurrence of noctilucent clouds an indication of change of water vapour concentration and/or temperature? To what extent is the mesosphere a source NO_x for the stratosphere? Do we understand well enough all the processes involved in inter-conversion between O_2 and O_3 in the mesosphere?

Some of these questions will be addressed by modelling and some by forthcoming satellite missions. The goal of the satellite studies will be to estimate the mean noise-induced error on geophysical parameters. Data for this exercise are expected to come from the MIPAS, GOME, GOME-2, GOMOS and SCIAMACHY instruments. New observing remote sensing methods are being developed. Recent progress was reviewed at the first International UV/Vis Limb Scattering Workshop organised by SPARC and IGAC in Bremen, Germany, 14-15 April 2003.

The current state of climate-chemistry interactions and an accounting of the planned studies were reviewed and assessed at a joint SPARC-IGAC Workshop on Climate-Chemistry Interactions held in Giens, France, 3-6 April 2003. A joint programme of research on these issues is a natural progression of current activities. The discussions at the workshop highlighted five major topics: aerosols and climate; water vapour and clouds; stratospheric ozone and climate; tropospheric chemically active greenhouse gases;stratosphere -troposphere interactions.

The following topics are indicative of priorities for collaboration between SPARC and IGAC:

- The role of UTLS (upper troposphere - lower stratosphere) aerosol and clouds in chemistry, in climate, and in their interactions: understanding and representing microphysical, chemical and radiative processes in numerical models.
- The role of convection (both deep and warm) in controlling UTLS water and chemical constituents.
- Tropical tropopause layer and climate-chemistry interactions.
- The extent and role of stratosphere-troposphere exchange in controlling the abundances of ozone and other species in the upper troposphere and lower stratosphere and, specifically, an accurate quantification of the stratosphere-troposphere exchange contribution to tropospheric and upper-tropospheric ozone budget.
- The use of tracers and their variability in observations and in models to identify and diagnose roles and contributions of processes, an assessment of the role of inter-annual variability in the circulation patterns affecting the distribution of chemical constituents in the stratosphere and troposphere.
- The role of lightning in the production and distribution of nitrogen oxides.
- Determination of the fundamental parameters in kinetics, heterogeneous chemistry (specifically aerosols and ice in upper troposphere), photolytic processes, spectroscopy, and optical properties via laboratory studies.
- Satellite observations of trace species and meteorological parameters in the troposphere and lower stratosphere, assimilation of satellite observations, evaluation of models by using satellite data.

A workshop on "Process-oriented validation of coupled chemistry-climate models" was held in Garmisch – Partenkirchen / Grainau, Germany, 17-19 November 2003 with approximately 80 participants in attendance. It was held under the auspices of the Institute for Atmospheric Physics of the German Aerospace Centre (DLR), the EU research cluster OCLI (Ozone CLimate Interactions), and SPARC. Chemistry-climate models and chemical transport models communities, as well as various measurement groups, discussed key model processes and attempted to identify specific diagnostics and datasets that could be used to validate those processes. The discussion was based on other model validation activities, such as GRIPS, EU-TRADEOFF, NASA Models and Measurements-II initiative, and the Programme for Climate Model Diagnosis and Intercomparison (PCMDI). The lasting impact and the full benefit from the workshop will come from the concerted validation activity. It is hoped that such activity unfolds over the next couple of years and receives major support of the modelling community. The list of key validation processes, associated diagnostics, relevant datasets, based on the contributions and discussions at the workshop will be open for discussion by the whole community and will be adjusted to take into account received proposals and comments. The evolving list with diagnostics, developing ideas and a list of contacts for individual aspects of the validation activity can be found at http://www.pa.op.dlr.de/workshops/ccm2003. A working group on observational needs is being organized and is expected to be active in the near future.

The JSC expressed strong satisfaction with the progress reported in the joint IGBP/WCRP initiative on “Atmospheric Chemistry and Climate”. It recognised that the WCRP expertise required in this field extended beyond the traditional remit of SPARC; this should probably evolve into a major new project in due course. In the meantime, the JSC supported the view that SPARC, on behalf of WCRP, should continue to develop this topic jointly with IGAC/IGBP, informing and involving other WCRP projects and activities as appropriate. It requested SPARC to inform all other WCRP projects and activities about the current status of this topic, soliciting views, expressions of interest and potential contributions.

8.3.3 Stratosphere – troposphere dynamical coupling

A workshop “The Role of the Stratosphere in Tropospheric Climate” took place in Whistler, British Columbia, Canada, on 29 April – 2 May 2003. The purpose of the workshop was to bring together researchers and students with the goal of improving the understanding of the role of the stratosphere in tropospheric climate on sub-seasonal to multi-annual timescales. The focus was on understanding the dynamical mechanisms that link the variability in these two regions. A summary of the discussions at the workshop contains, inter alia, the following conclusions:

- Together with the tropical troposphere, the stratosphere is a player in determining the memory of the climate system.
- The influence is mainly during northern winter and southern spring.
- The stratosphere may play an important role in climate variations through downward coupling to SSTs, sea ice, and the high-latitude oceans.
- The most pressing issue is to better understand the dynamical processes by which the tropospheric circulation responds to changes in the stratosphere.

There are observations depicting stratosphere – troposphere interactions that favour the concept of an important role of stratosphere in variations extending through both stratosphere and troposphere, such as variations triggered by stratospheric warmings. In addition there are some model results indicating that without an account of stratospheric variability, the time scale of autocorrelation of daily surface Arctic Oscillation Index was significantly shorter. A link to the strength of the circumpolar vortex was also traced. This may lead the research into an area where changes in the circulation due to ozone loss and/or greenhouse gas concentration are considered. Current conclusions by SPARC scientists on the issue of stratosphere – troposphere dynamical coupling are as follows:

- Persistence and predictability of the Arctic Oscillation depend in part on the long timescale of large circulation anomalies in the lowermost stratosphere.
- The most pressing issue in stratosphere and troposphere coupling is to better understand the dynamical processes by which the tropospheric circulation responds to changes in the stratosphere.
- This understanding may help to better predict not only the weather on monthly and seasonal time scales, but also the climatic effects of greenhouse gas increases, stratospheric ozone depletion, solar changes and volcanoes.

The studies of stratosphere – troposphere coupling receive considerable attention and are supported sufficiently well by funding agencies. Professor A. O'Neill and Dr A. Ravishankara think that there is need to strengthen the connections to the tropospheric science community including IPCC. A targeted workshop as a follow-on from the SPARC Assembly may be required. It could well be organised as a SPARC-WCRP workshop and would cover a range of time scales from seasonal to long-term ones. The question is how SPARC should link this theme to related activities in the WCRP (in particular, in CLIVAR). A JSC member (Professor Ramaswamy) will convene a special session (Session A08) at the 2004 CGU-AGU-SEG- EEGS Joint Assembly, Montreal - Canada, 17-21 May 2004, entitled "Forcing of the high-latitude climate system by the stratosphere". It will be focused on recent advances in our knowledge of the forcing and response of the high latitude atmosphere-surface system arising due to changes in the stratosphere. Potentially, the SPARC research on dynamical interaction between stratosphere and troposphere can generate valuable contribution to the WCRP COPES.

8.4 Other areas of stratospheric research

Solar radiation and climate

A Gordon Research Conference on Solar Radiation and Climate was held at the Colby-Sawyer College, New Hampshire, USA, 13-18 July 2003, organised and chaired by a JSC member, Professor Ramaswamy. The conference summarised current research on physical and chemical factors in the observed radiative properties and energy budget of the planet and this led to a consideration of how perturbations of the radiative energy budget affect climate variations at several time scales, from seasonal to interannual and decadal.

Data assimilation

Data assimilation requirements for SPARC include:

- Long- term, global data sets for the troposphere and stratosphere, free of artificial trends.
- 3-D velocity fields with reduced data assimilation “noise” at an interval of several hours.
- Estimates of mass fluxes associated with sub grid-scale processes.
- Diabatic heating rates.
- Ozone, tracers and aerosols.
- Attention to bromine in the UTLS region.

To fulfil these requirements is the goal of the SPARC data assimilation initiative. A data assimilation working group has been established, which collects information on stratospheric data sets on meteorology and chemistry (quality, availability, software, etc.); undertakes process-focused quality assessments; collects

and documents information on stratospheric data assimilation systems for global circulation models (e.g. DARC/ Met Office, UK, ECMWF, Canadian Meteorological Service), chemical transport models (e.g. KNMI, BIRA-IASB, UPMC, DAO), and coupled systems (e.g. Météo-France). It liaises with space and other agencies on SPARC data needs and tries to anticipate their requirements. In June 2003 SPARC organised two meetings on stratospheric data assimilation, an ASSET/SPARC workshop in Florence, Italy, and an ECMWF/SPARC workshop at ECMWF, Reading, UK. This working group might merge with a complementary activity in the WGNE.

Radiosonde climatology

This SPARC-coordinated activity looks at the climatology of wavelike fluctuations in ultrahigh-resolution radiosonde wind and temperature data. It has involved participants from eleven countries and data at over 200 stations worldwide. Some of the individual participants in the project have submitted papers on analysis of their own national data. There is a question of how much of the original data used in the study can be made available through the SPARC Data Centre. The plan is to contact each of the participants to see if they are willing (and legally able) to send their data to the SPARC Data Centre. It is believed that the SPARC Data Centre is the only location where a substantial collection of the high-resolution balloon data will be conveniently available to the research community.

Darwin Area Wave Experiment (DAWEX)

The DAWEX experiment to examine the middle atmospheric gravity wave field in the Northern Australian region and its relation to tropospheric convection was held October-December 2001. At a small workshop to discuss analysis of results, which was held in Honolulu in December 2002, the participants decided to produce coordinated manuscripts for submission to a special issue of a journal. An overview paper, a paper reviewing the meteorology of the region during DAWEX, a paper on radiosonde observations taken during DAWEX, four papers on airglow imager observations, and two papers on numerical modelling of conditions during DAWEX will be prepared.

Chapman Conference

As discussed at the SPARC SSG meeting in Kyoto in November 2002, the SPARC Gravity Wave Initiative co-chairs had produced a proposal to American Geophysical Union (AGU) to hold a Chapman Conference on Gravity Wave Processes and Parameterization. The conference took place on 10-14 January 2004 at Waikoloa, Hawaii, USA. This was a focused meeting that brought together interested scientists in the middle atmosphere gravity wave community and the global climate modelling community.

Prospects for the Gravity Wave Initiative

Over the year 2004 the main projects that the Gravity Wave Initiative has pursued, namely the radiosonde climatology and the field experiment in Northern Australia, should be essentially completed. At the SSG 2004 it should be possible to give final reports on these projects and to review the Hawaii Chapman Conference. Thus the 2004 SSG meeting might be the logical time to review the overall status of the Gravity Wave initiative and possibly consider its objectives completed. Of course, many uncertainties in the gravity wave problem will still remain, and there may still be a useful role for SPARC in coordinating some research activities. The more "engineering" aspects of the gravity wave parameterization issue may be passed to the GRIPS initiative (and possibly also the data assimilation initiative). An important remaining issue is possible SPARC involvement with future field experiments that includes studies of convective forcing of gravity waves.

Past and future “laboratory” projects

This activity started in 1999, when a peer-reviewed paper on small organic peroxy radicals was published in the J. of Geophysical Research (JGR). In 2002 laboratory data evaluation resulted in updated data for quantum yields for production of $O(^1D)$ in the ultraviolet photolysis of ozone, also published in JGR, 2002. A co-chair of the IPCC Working Group 1, Dr S. Solomon, requested a SPARC sponsored study of the global warming potential of hydrofluorocarbons (HFC) 134a. Five groups of specialists were involved in this activity under the leadership of Dr P. Forster, Reading University. Associated radiative forcings and their uncertainties were estimated, mostly using line-by-line models with account of vertical profile of HFC, clouds, typical temperature profiles inclusive of tropopause. Some discrepancies in the preliminary results were noted. Now, the discrepancies have been resolved and clear sky radiative forcing of 0.16 0.02 Wm-2 ppbv-1

has been established. A paper describing this research was submitted to *Geophysical Research Letters* and was under review.

SPARC Aerosol Assessment

After the kick-off meeting at CNES in November 2001, there have been an informal meeting at Spring AGU, Washington, DC, USA, in May 2002, and lead-author meetings in July 2003 and January 2004. The scope of the prepared report comprises aerosol processes, precursor gases, aerosol instruments and measurements, aerosol records and climatology, trend analysis, and related modelling. The aerosol record will be presented in the coordinates of equivalent latitude and potential temperature. The main data sources for Assessment of Stratospheric Aerosol Properties (ASAP) are measurements by SAGE (Stratospheric Aerosol and Gas Experiment), Halogen Occultation Experiment (HALOE), optical particle counters, and lidar data sets. From primary measurements of extinction, backscatter, size distribution data sets of surface area density (SAD), effective radius, volume/mass were derived. The available data sets are for the period 1979-2003. The following problems of measurements and analysis were noted. Satellite-based SAD tends to underestimate in situ measurements particularly those including small particle sizes. The scale and ubiquity of the problem is not clear. Size-resolved (>= 10 nm) aerosol observations in the stratosphere are therefore needed. The importance of meteorites and smoke is uncertain. There is significant uncertainty in trends, which makes it difficult to even detect their sign. Extinction ratios (size) are inconsistent between models and measurements. Modelled lower stratospheric tropical extinctions are too low for the measured SAD. Work is under way on processing data from major volcanic eruptions. The completion of the assessment is expected in 2004.

8.4 SPARC Data Centre

The aim of the SPARC Data Centre is to provide data to the SPARC scientific communities and their major programmes . The web site is located at http://www.sparc.sunysb.edu. Dr X.L. Zhou is the centre manager under the leadership of Professor M. Geller. Available data include:

- Cold point tropopause data from ECMWF (1979-1993)
- Temperature field near the tropical tropopause
- Small organic peroxy radicals data
- SPARC Reference Climatology Project data
- US high resolution sounding data for SPARC Gravity Wave Initiative
- GCM Reality Intercomparison Project for SPARC (GRIPS) data
- Stratospheric Aspects of Climate Forcing data
- Water Vapour Assessment (WAVAS) Archive
- Rocket sounding data
- Tropical tropopause, tropospheric and stratospheric climatological radiosonde-derived datasets
- Quantum yields for production of $O(^1D)$ in the ultraviolet photolysis of ozone data

The SPARC FTP Server is located at ftp://atmos.sparc.sunysb.edu, directory: /pub/sparc. There is a link to numerous other data centres. The new acquisitions include daily mean temperatures, geopotential heights, pressures, and saturation mixing ratio of water vapour at the tropical cold point tropopause, derived from ECMWF reanalysis; a data set of temperature field near the tropical tropopause; the US high resolution radiosonde data set, which includes data from 93 stations for 1998-2001 (data for 2002 will be put online when available). The data were obtained from NOAA.

Currently there is only 30 GB of disk space available at the data centre. Some data may be removed from an on-line archive. The SPARC grant period is from February 2002 to January 2005 (inclusive). Work is under way to renew the grant and upgrade the data centre computer. An idea of having a back-up centre in Japan is being considered.

8.5 SPARC General Assembly 2004

The Third General Assembly of SPARC will take place on 1-6 August 2004, in Victoria, Canada. The web site of the Assembly is located at http://sparc.seos.uvic.ca. The scientific programme of the Assembly will cover all the topics of relevance to SPARC, including:

- stratospheric climate and indicators of climate change;
- stratospheric data assimilation; transport and mixing in the stratosphere and between stratosphere and troposphere;
- gravity-wave processes and their parameterization;

- stratospheric and upper tropospheric water vapour;
- chemistry, aerosols, radiation and dynamics in the upper troposphere/lower stratosphere; and
- chemistry-climate modelling of the stratosphere.
-

A particular emphasis for this General Assembly will be chemistry-climate coupling. The programme will commence with invited talks. Then continuation will include a mix of invited and contributed talks, and poster sessions, with each day focused on a particular theme area for SPARC as follows:

- Chemistry-climate coupling
- Extratropical upper troposphere / lower stratosphere
- Stratosphere-troposphere dynamical coupling
- Tropical tropopause layer
- Detection, attribution and prediction

Professor T. Shepherd and Dr A. Ravishankara are the co-Chairs of the Scientific Committee. Dr N. McFarlane is the chair of the Local Organising Committee. Approximately 400 participants are expected.

8.6 SPARC interactions with other programmes and activities

SPARC has well-established links with the Working Group on Numerical Experimentation (WGNE) on data assimilation, Working Group on Coupled Modelling (WGCM) on climate modelling, and GEWEX on studies of aerosols. Closer links are needed with CLIVAR on predictability issues, GEWEX on research on water vapour, hydrological cycle and radiation, CliC on studies of polar regions, and WGSIP on long-term forecasting. In addition to this, SPARC has to strengthen links to IGBP/IGAC on chemistry – climate interactions, SCOSTEP and CAWSES (Climate and Weather of the Sun-Earth System) on various issues, WMO GAW, NDSC, COSPAR, and the Integrated Global Observing Strategy (IGOS) theme on Integrated Global Atmospheric Chemistry Observations (IGACO). SPARC SSG members believe that the lack of a dedicated WCRP project addressing chemistry in the troposphere represents a problem.

8.8 SPARC Project Office and future plans

The SPARC office actively pursued its activities in 2003, namely: contacts with the JPS of WCRP, WCRP projects, IGBP, other partner programmes, with the SPARC community of scientists; organization of SPARC meetings; compiling and editing SPARC Newsletters (2 a year); updating the SPARC mailing list; maintaining the SPARC website; and preparation of SPARC reports for publication. A new SPARC brochure has to be prepared soon. The SPARC SSG session in Frankfurt am Main, Germany, warmly thanked the director, Professor M.-L. Chanin, and also Ms C. Michaut and Dr Y. Koshelkov, for their excellent support. During 2003, Dr Y. Koshelkov retired. A new SPARC scientist was hired for the office. Dr E. Oikonomou started his duties on 1 June 2003 supported by a grant provided by the ESA. Half of his time is for SPARC office activities and the other half for research on the Envisat data. The support received from the ESA is much appreciated by SPARC.

In 2004 the SPARC office is expected to move from Paris, France. After many years of outstanding service, the director, Professor M.-L. Chanin, will pass her duties to a new person in charge of the office. A proposal to move the office to the Department of Physics, University of Toronto, Canada, was submitted by Professor T. Shepherd and Dr N. McFarlane to several Canadian organizations. There will be a transition period during which the operation of the office in Paris, France, will gradually slow down and the activities of the office in Canada will gain pace. Ms C. Michaut will visit the new office in Toronto, Canada, and help speed up the operations there. Additional support during the transition phase will be provided from the WCRP JPS. The complete transition to the new base will take place after the SPARC General Assembly 2004.

The JSC welcomed the news that the SPARC IPO would transfer to the University of Toronto, Canada, during 2004 with funding from Canadian sources secured for five years. The JSC requested the Director, WCRP to thank the Centre National de Recherche Scientifique (CNRS), Centre National d'Etudes Spatiales (CNES) and Météo-France for their support to Professor M-L. Chanin, Director, SPARC IPO. The JSC also expressed grateful appreciation to Professor M-L. Chanin for her dedicated and highly-significant contributions to SPARC in several influential capacities. Dr N. McFarlane would become the new Director, SPARC IPO, in succession to Professor Chanin and on its transfer to Canada.

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. In the absence of Dr J.F.B. Mitchell, Chairman of WGCM, Professor B.J. Hoskins 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.

The JSC recorded its grateful thanks to Dr K. Puri, who had stepped down as the Chairman of WGNE on 31 December 2003 and welcomed Dr M. Miller as his successor.

9.1 Report of Working Group on Numerical Experimentation (WGNE), including THORPEX

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 parameterizations 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 (focused 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 parameterizations, 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 Atmospheric Model Intercomparison Project (AMIP), conducted by the PCMDI at the Lawrence Livermore National Laboratory, USA, with the support of the US Department of Energy has been the most important and far-reaching of the WGNE-sponsored intercomparisons. The second phase of AMIP (AMIP-II) had more than twenty-three modelling groups submitting simulations and much of the data from these runs are available for a wide range of diagnostic sub-projects. Climatological comparisons are available for nearly every standard AMIP model output field, and probably represent the most comprehensive source of the climatologies of atmospheric circulation models. AMIP research is structured round a series of diagnostic sub-projects and a clear view of how models have evolved since AMIP began nearly a decade ago has emerged. Overall, there has been a general improvement both in terms of the "median" model as well as for many of the individual models. The simulation of interannual variability and performance in specific geographical regions, as measured by global climatological statistics, also appear to be more realistic. Regular updates of the overall status of AMIP, model integrations, diagnostic subprojects are posted on the AMIP home page http://www-pcmdi.llnl.gov/amip.

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

In its review of AMIP, WGNE was briefed by Dr P. Gleckler about the recent developments at PCMDI and possible future directions of AMIP. AMIP continues to provide an ongoing benchmark diagnostic for WCRP modelling activities. PCMDI's diagnostic strategy will be towards coordinating WCRP modelling activities. Evaluation of CMIP models will be an overarching theme for PCMDI, but AMIP will continue to be supported as a complementary diagnostic to CMIP. WGNE expressed the view that it would be very useful for the CMIP and AMIP panels to meet jointly in the near future to discuss how this could be achieved. WGNE noted that the AMIP had become a well-defined and useful experimental protocol for testing and intercomparing global atmospheric circulation models. WGNE also noted that AMIP, in view of the powerful capabilities of PCMDI, provides a good infrastructure for handling model integrations, and so effectively facilitating the diagnosis and display of many characteristics of the results. As such WGNE continues to strongly support the continuation of AMIP. However any future planning depends strongly on the level of PCMDI support for the project. WGNE expressed the hope that the official position of PCMDI would be clarified in the near future.

The JSC observed that PCMDI has played an important role in AMIP and requested Director, WCRP, to thank the Director, PCMDI for this support. The JSC noted the understandable increasing involvement of PCMDI in CMIP activities. However, the JSC felt that useful information could still be obtained through AMIP continuing under the CMIP umbrella. Director, WCRP, was requested to seek clarification on PCMDI's plans for AMIP.

"Transpose" AMIP

Results from work at NCAR and PCMDI which has grown out of the earlier WGNE proposal for a transpose AMIP were presented. The NCAR/PCMDI project has been labelled CAPT, the ' Climate Change Prediction Program-Atmospheric Radiation Measurement (CCPP-ARM) Parameterization Test bed'. The goal was to obtain the benefits for climate model development and evaluation that have been realized in weather prediction by applying climate models to weather forecasting, but without the huge costs of developing a complete NWP system. An important point was that the climate models are applied at their relatively low application resolutions and are not expected to make the best weather forecast. The method allowed direct comparison of parameterized variables such as clouds and precipitation with observations from field programmes such as ARM, early in the forecast while the model state was still near that of the atmosphere. This was in contrast to the more traditional climate model statistical analysis based on the model simulated climate balance. In that approach the parameterizations see the erroneous climate model state rather than the true observed state.

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

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

Results were presented from forecast experiments with the Community Atmospheric Model (CAM) resident at NCAR. The land was spun up from 1 January 1997 by interacting with CAM2.0 in which the atmospheric state variables were replaced with ERA-40 interpolated variables every six hours. In fact the initial land moisture at ARM-Cloud and Radiation Testbeds (CART) site is better than expected because two significant errors cancelled each other: the atmosphere rains too much and the land dries too fast. After the land spinup, the forecast latent and sensible heat fluxes are in reasonable agreement with ARM. At least their errors seem second order compared to other errors arising in the forecasts.

Two series of 5-day forecasts with CAM 2.0 from ERA-40 initial conditions were presented. One from the June/July 1997 ARM Intensive Observational Period (IOP), and the other from the April 1997 ARM IOP at the ARM CART site in Central Oklahoma. Examination of traditional skill scores of the forecasts indicate that in both seasons CAM produces reasonable forecasts of the large scale atmosphere. Thus the parameterizations are being driven by realistic fields in the forecasts. Analysis of the summer forecasts indicates that the convective parameterization is invoked too frequently and when it is invoked the model does not maintain the observed atmospheric state. In the April case the CAM forecasts the timing of precipitation events accurately, however, again when the convective parameterization is invoked it does not produce the observed atmospheric state.

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

Comparisons of stratospheric analyses and predictive skill in the stratosphere

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

Analyses for the period from 15 September - 15 October 2002 (Days 0-30 in this study) and forecasts from 20 September - 3 October 2002 (Days 5-18) during the southern hemisphere major sudden warming of 2002 from five current NWP models (the Australian BMRC Atmospheric Model, BAM; the ECMWF IFS; the NCEP MRF; the NRL NOGAPS and the UKMO model) are compared. These models provided forecasts out to 8, 10, 10, 5 and 10 days, respectively. TOMS plots indicate that the vortex started to deform on 20 September, split in two by 24 September and had a single vortex centre again by 30 September. Comparisons of the 30 hPa temperature RMSE between the model 5-10 day forecasts and their respective analyses show that for forecasts initiated on 20-25 September, when the vortex was in the process of splitting, all the models have almost continuously increasing RMSE for any given forecast day. Thus, for example, the error in the 48 hour forecasts initialized on these days gets worse from the 20th to the 25th of September. This implies that over this period there is a steady reduction of forecast skill and that this is an increasingly difficult period for all the models. From initialization days 25-27 September the skill in all the models is seen to improve dramatically. This is found to be true for other fields (geopotential height, zonal and meridional winds) and other levels above 200 hPa, with this characteristic being larger the higher in the upper levels. Can these RMSE difficulties be related to particular days? If this is true then there should be a strong dependence of the RMSE on the verification day. All the models show that the periods 27-28 September and 2 October are dynamical situations which they have difficulty forecasting. These are periods when the split vortex is decaying and when the reformed vortex is moving westward, respectively. All the models show that these errors are generally due to the models creating a final forecast vortex which is smaller, more circular, more poleward and more westerly displaced and with a more easterly orientation, though the latter is not as obvious in the ECMWF model. The creation of a smaller, more circular and more polewardly-displaced vortex indicates that all the models are trying to create weaker and less disturbed vortices. The analyses from all five systems are well correlated over the period of the study when the vortex is quasi-stationary; however these analyses are seen to have larger RMSE differences and become less correlated when the polar vortex is undergoing rapid changes. Also during these active periods the model analyses correlations with TOMS total column ozone decrease dramatically from the very high values found when the vortex is quiescent.

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

International Climate of the Twentieth Century Project (C20C)

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

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

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

9.1.3 Standard climate model diagnostics

Over the past six or so years WGNE has developed two lists of standard diagnostics, one of the mean climate and one of variability. The lists were based on responses from the modelling community to queries concerning what diagnostics they would find useful, and from the diagnostic community as to which diagnostics were appropriate for standard application. The WGNE Standard Diagnostics of the Mean Climate are described at http://www-pcmdi.llnl.gov/amip/OUTPUT/ and the WGNE Standard Diagnostics of Variability are described at http://www.cgd.ucar.edu/cms/mstevens/variability/AMWG/variab.html. These diagnostics were intended to: (1) provide a comprehensive set of diagnostics that the community agrees is useful to characterize a climate model, (2) provide a concise, complete summary of a model's simulation characteristics, (3) provide an indication of the suitability of a model for a variety of applications, and (4) provide information about the simulated state and about the processes maintaining that state. They were also intended to be diagnostics whose utility has been demonstrated and which can be calculated by each group. It was hoped that many modelling groups would adopt such diagnostics for routine model processing so that groups could easily compare the properties of their models with each other during the development phase, rather than waiting for frozen models and formal intercomparisons. To date, the diagnostics have not received wide application. Admittedly, it is nontrivial to implement the complete lists. They have been used as the basis for Community Climate System Model (CCSM) Atmospheric Model Working Group (AMWG) model comparison for selecting atmospheric model components for future versions of CCSM, and they are a component of the “quick-look” diagnostics provided to modelling groups upon submission of their simulations to PCMDI.

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

9.1.4 Developments in numerical approximations

At past meetings WGNE has recognised the value in stripped down versions of atmospheric models with very simplified surface conditions for examining the behaviour of physical parameterizations and the interactions of parameterizations with the dynamical cores. In particular, "aqua-planet" experiments with a basic sea surface temperature distribution offer a useful vehicle in this regard. Thus WGNE has endorsed an intercomparison, the Aqua-Planet Experiment (APE), being led by scientists from the University of Reading, NCAR and PCMDI. The details of the experiment and schedule are available at http://www-pcmdi.llnl.gov/amip/ape/ and http://www.met.reading.ac.uk/~mike/APE/ape_home.html.

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

9.1.5 Regional climate modelling

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

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

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

A joint WGNE/WGCM international Workshop, aiming at promoting better knowledge of the potentials and limitations of RCMs and entitled, "High-resolution climate modelling: Assessment, added value

and applications", will be held in Lund, 29 March-2 April 2004 (https://dvsun2.gkss.de/domino/html/Lund. nsf). The event will be held jointly with a meeting of the Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects (PRUDENCE) WG1 and 2. The focus of the Workshop is on comparing the merits and limitations of various approaches to climate modelling at regional scale, including limited-area nested models, variable-resolution or stretched-grid global models, and uniform high-resolution global models. Contributions were invited on topics such as the role of resolution beyond physiographic details, and on the best strategy to achieve progress in regional-scale climate modelling. While the focus of the Workshop is on climate time scales, some contributions on non-climate applications were also being considered, e.g. Numerical Weather Prediction (NWP), Seasonal to Inter-seasonal Prediction (SIP), and intermediate time scales (e.g. Project to Intercompare Regional Climate Simulations (PIRCS)).

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

The JSC considered that, after the Regional Climate Modelling meeting in Lund, Sweden, WCRP should find a route to communicate its conclusions, in particular through interactions 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. The atmospheric and coupled modelling communities and oceanographers have very strong interest in advancing SURFA, which could provide a good opportunity for real progress in estimating and determining surface fluxes. Some NWP fluxes had already been accumulated at PCMDI; however no further work has been conducted over the past year because of changing priorities at PCMDI. Unfortunately, a committed funding source has yet to be identified for SURFA. Given the importance of this effort for a variety of research communities, efforts are continuing in order to resolve the issue in the near future.

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

The JSC recommended that with the establishment of the WCRP-wide Working Group on Surface Fluxes (WGSF), SURFA should be brought under the purview of WGSF, with due consultation with WGNE.

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

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

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

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

9.1.8 Reanalyses

ECMWF

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

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

NCEP

The preparation of a regional reanalysis (RR) over the USA for the period 1979-2003 provides a long-term consistent data set for the North American domain, superior to the NCEP/NCAR global reanalysis in both resolution and accuracy. The regional reanalysis is based on the Eta model and the Eta data assimilation system (with the global reanalysis used as boundary conditions). Important features include direct assimilation of radiances and assimilation of precipitation (over the USA), as well as recent Eta model developments (refined convective and land-surface parameterizations). A range of data (including all those used in the global reanalysis, various precipitation data sets, TOVS-1B radiances for certain periods, profiler measurements, and lake surface data) has been assembled. Many pilot experiments have been done at 80km resolution. The production resolution is 32 km with 45 layers. The domain covers Greenland, North-eastern Siberia, oceanic areas west of Hawaii and east of Barbados, Central America and the Northern tip of South America.

Precipitation data for the Continental USA, Canada, Mexico and oceanic areas have been gathered. Fits of wind and temperature observations to the analysis and guess fields are generally superior to those of the NCEP/NCAR Global Reanalysis (GR). Biases of 2m temperature and 10m wind speed are also improved over the GR. Precipitation patterns from the analysis cycle, averaged monthly, agree well with observed ones in pilot studies carried out so far. The RR production began in February 2003 and was completed by September 2003 when the computer was removed from service.

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

Japan Meteorological Agency (JMA)

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

Dr Puri reiterated WGNE's strong support for all the reanalysis efforts and reiterated the desirability of setting up a dedicated 'Reanalysis Centre' at a major NWP operational centre. WGNE had also recommended that this concept should be built into COPES and that the JSC should secure funding for such a 'Reanalysis Centre.'

The JSC expressed satisfaction at the continued progress being made in reanalysis activities and expressed gratitude to ECMWF for the successful conclusion of ERA-40 project and for making its products available to user community. The JSC strongly encouraged that this activity be continued and suggested that a staggered strategy be adopted encouraging 2-3 centres carrying out the activity in a collaborative mode.

9.1.9 THORPEX: A Global Atmospheric Research Programme

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

The core research objectives of THORPEX are to:

- Contribute to the design and demonstration of interactive forecast systems that allow information to flow interactively between forecast users, numerical forecast models, data-assimilation systems and observations. Interactive forecast systems include the concept of targeted observations.
- Advance the knowledge of global-to-regional influences on the initiation, evolution, and predictability of high-impact weather.

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

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

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

9.1.10 Model Verification

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

Verification is of considerable importance for both WGNE and WWRP projects. It has therefore been decided to form a Joint Working Group (JWG) on verification. It was recognised that a JWG will be valuable to coordinate efforts and share ideas and results, and will allow the formation of unified approaches to solve common verification problems. Proposed members of the JWG are: Drs B. Brown (chair; National Center for Atmospheric Research (NCAR)); F. Atger (Météo-France); H. Brooks (National Severe Storms Laboratory (NSSL)); B. Casati (U. Reading); U. Damrath (DWD); B. Ebert (BMRC); A. Ghelli (ECMWF); G. Greed (UKMO); P. Nurmi (FMI); D. Stephenson (U. Reading); and L. Wilson (MSC).

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

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- Encourage greater cooperation between users and verifiers of forecasts, to ensure the relevance and integrity of the practice of forecast verification; this includes development of useful, meaningful and statistically sound verification measures, as well as working with both forecast users and developers;
- Encourage the development and application of improved diagnostic verification methods to assess and enable the improvement of the quality of weather forecasts, including forecasts of weather elements and forecasts from numerical weather prediction and climate models; some of the issues

that are of concern include partitioning error according to scale, verification of forecasts of probability distributions, spatial forecast verification, assessing uncertainty in verification statistics, and the use and processing of high resolution remotely sensed observational data for verification;
- Encourage the sharing of observational data for verification purposes;
- Encourage greater awareness in the research community of the importance of verification as a vital part of numerical and field experiments; and
- Encourage collaboration among scientists conducting research on various aspects of forecast verification, and with model developers and forecast providers.

WGNE had welcomed Dr B. Brown, Chair, JWG on Verification who made a presentation on the proposed JWG. WGNE formally approved the formation of the JWG and suggested that Dr P. Bougeault's review paper on Verification could serve as a good starting point for the JWG as most of the points of interest are contained there. WGNE pointed out that ensemble prediction verification is of great interest to the scientific community and should be included in the JWGs plans.

9.2 Report of Working Group on Coupled Modelling (WGCM)

The following paragraphs summarize the principal activities being undertaken by the JSC/CLIVAR Working Group on Coupled Modelling (WGCM) including the main items of interest and recommendations from the seventh session of the group, held in Hamburg, 24-26 September 2003. 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 WGSIP, the WGCM/CLIVAR 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 were 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 is directly addressing many of these issues through specific initiatives (see below).

9.2.2 Coupled Model Intercomparison Project (CMIP)

CMIP (http://www-pcmdi.llnl.gov/cmip/) is one of the most important and long-standing initiatives of WGCM, having been started in 1995. There are 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.
Significant accomplishments of CMIP, during the past year include:

- 20^{th} Century Climate in Coupled Models (20C3M), approved as a CMIP pilot project (October 2002): data collection has begun
- Ocean data from CMIP2+ are now available from PCMDI for analysis of subprojects
- Catalogue of MIPs has been completed with cooperation of WGCM and GAIM, and is now on the CLIVAR web page with link from the CMIP web page (http://www.clivar.org/science/mips.htm)
- CMIP and 20C3M summaries have been published in CLIVAR Exchanges (end of 2002); CMIP Summary published by GAIM (early 2003)
- CMIP subprojects have produced 25 peer-reviewed publications, 6 other publications, 4 PCMDI

publications, as well as significant contributions to IPCC TAR. As of September 2003 there are 28 CMIP2+ subprojects currently active, in addition to 10 completed subprojects from CMIP1 and 22 from CMIP2

- Second CMIP Workshop held 22-23 September 2003, Hamburg. 35 people attended and 25 presentations were provided. Emerging themes were:

    1. Multi-model means give better agreement to observations than single models on regional scales.
    2. There is value in comparing coupled and uncoupled components e.g. CMIP, AMIP, Cloud Feedback Model Intercomparison Project (CFMIP).
    3. Multi-model ensembles can provide probabilistic estimates of future climate change, and quantify nature of errors with estimates of observed sensitivity.
    4. Multi-model output can be used to force embedded models for regional/local change, e.g. hurricanes.
    5. Ocean heat uptake and ocean dynamical response are important for climate system response.
    6. Analysis of extreme events from multi-model experiments.
    7. The sources of uncertainty from parameterizations in climate models can be quantified through parameter-varying experiments.
    8. Preliminary results from first CMIP coordinated experiment for MOC show importance of heat relative to fresh water flux in affecting MOC strength, Earth-system Models of Intermediate Complexity (EMICs) can show roughly comparable responses on global scale but not regional scales, and partial coupling is useful for diagnosing model differences.
    9. Several systematic errors that have been present in nearly all generations of coupled models are proving difficult to eliminate, such as overly strong equatorial Pacific cold tongue and double ITCZ in the Pacific.
    10. The nature of regional responses to increasing CO_2 can cause quite different patterns of temperature change e.g. El Niño -like, AO-like.
    11. PCMDI will continue to play a major role in CMIP, with promotion of network Common Data Form (netCDF), Climate and Forecast (CF) metadata standard and PCMDI-supplied subroutines to provide uniform data structure, with other MIPs standing to gain as well e.g. PMIP.
    12. Climate sensitivity and response must be compared among models for 20th century as well as last 1000 years, and cloud feedback (even the sign) is a major factor.
    13. Most modelling groups have either just recently completed or are in the final stages of completing development of new model versions, with a strong awareness of timing new model versions for upcoming IPCC AR4. Most models have roughly 1.5° to 2.5° resolution in atmosphere, and around 1° – 2° resolution in the ocean often with enhanced resolution in equatorial tropics of around 0.5°. Preliminary indications are that sensitivities of new model versions may be converging near 2°C – 3°C; reasons for this need to be understood (science or sociology?).

CMIP and IPCC

The following community runs for IPCC AR4 have been approved by the Task Group on Scenarios for Climate and Impact Assessment (TGCIA) mid-2003:

1. 20th century simulation to year 2000, with all concentrations then fixed at year 2000 values and run to 2100 (CO_2 ~ 360ppm)
2. 21st century simulation with Special Report on Emissions Scenarios (SRES) A1B to 2100, with all concentrations then fixed at year 2100 values to 2200 (CO_2 ~ 720ppm)
3. 21st century simulation with SRES B1 to 2100, with all concentrations then fixed at year 2100 values to 2200 (CO_2 ~ 550ppm)

   WGCM recommended adding a 4th experiment to ensure continuity with respect to the last assessment and to facilitate intercomparisons.
4. 21st century simulation with SRES A2 to 2100

WGCM made the following comments with respect to relationship to IPCC and the AR4 process:

1. PCMDI will archive a collection of forcing datasets for 20th and 21st century climate simulation. These will include the recent standardized sulphate aerosol concentrations from Dr O. Boucher, one CO_2 and trace gas time series for 20th and each of the 21st century SRES scenarios, as well as the Ammann and Sato volcanic forcing datasets, the two solar forcing datasets (Hoyt and Schatten; Lean), and the NCAR and Hadley Centre ozone dataset for 20th and 21st century for stratospheric and tropospheric ozone. Dr C. Covey will coordinate this in cooperation with the CMIP Panel.

2. PCMDI will collect data from the four community runs for a subset of fields [to be determined from the union of Data Distribution Centre (DDC), 20th Century Climate in Coupled Models (20C3M), and CMIP2 lists and consistent with calculation of Frisch et al. extremes indices]. Additionally, daily data will be collected for periods during the experiments (1960-2000, 2035-2055, 2080-2100, 2180-2200; to be the same as periods in TAR). All data must be submitted in netCDF and CF metadata standard, and using PCMDI-supplied software to facilitate archival of standardized data. This exercise is aimed to assist WG1 scientists. If the DDC wants the data they can contact PCMDI, and PCMDI can send them what has been submitted.

3. WGCM, through the IPCC Liaison Panel, will advertise for volunteers to analyse the multi-model data collected above with a list of suggested topics as well as an open invitation for all analysis topics. The announcement will go to the CMIP email alias and to others in the climate community. Recommended topics for analysis include: ENSO, AA monsoon, NAO and annular modes, extreme events from the Frisch et al. indices, NH and SH thermohaline circulation. It is anticipated that these model runs will begin at some centres this winter, some will be collected summer 2004, and the announcement can be sent out after the next WGCM meeting in autumn 2004 (right after the first IPCC Lead Author (LA) meeting in Trieste). More model simulations will be done over that autumn and winter, with all data collected and analyses completed by spring 2005 and at least preliminary results from the subprojects forwarded to the IPCC LAs. Subproject PIs must commit to this schedule at the outset, since these are time-sensitive analyses of direct relevance to the AR4.

4. WGCM stresses that, to understand model response, the CMIP idealized forcing experiments must be used in conjunction with the scenario simulations. Analyses of scenarios simulations should not be viewed as replacements of analyses of idealized forcing experiments.

5. In response to scientists who advocate a 20th century experiment with common forcings, Dr G. Hegerl will contact the detection/attribution group (Informal Ad-hoc Detection Group (IADG), with copy to Drs S. Solomon and G. Boer) for more details and justification for such an experiment.

6. WGCM endorsed a common radiative forcing diagnostic and recommends calculation of radiative forcing for model intercomparison as follows:

Recommend one requirement and one option:

(1) Required from all groups: For model intercomparison purposes (following the Gordon Conference group recommendation) save 12 two-dimensional fields as the model runs: clear and cloudy sky, net short-wave and net long-wave, at a) top-of-atmosphere, b) 200 hPa, and c) surface. These can be plotted as monthly mean time series to give an estimate of total radiative forcing for the sum of all constituents.

(2) It is strongly recommended that groups calculate the radiative forcing from respective model constituents taking into account stratospheric adjustment. This can be one estimate for CO_2 and GHGs from a $2XCO_2$ equilibrium slab ocean run and scaled in the scenario runs to produce a time series. Aerosol and ozone radiative forcing can be calculated (every 20 years centred at year 2000 as the coupled model runs) with two timestep calls over the diurnal and seasonal cycles and saving the 12 two-dimensional fields in (1) above. The techniques for doing this calculation must be documented (e.g. Tett et al., 2002). Alternatively, an off-line calculation can be performed to derive the radiative forcing from the respective model constituents.

WGCM also recommends that some person or group test the different methods of computing radiative forcing in one model to compare the differences of using various radiative forcing calculations.

Next phase of CMIP (CMIP3)

The next phase of CMIP (CMIP3) will begin in October 2003.This will include requirements as before for CMIP2, with fields collected as decided for the IPCC and other runs comparable to CMIP2:

1. 1% CO_2 run to year 80 where CO_2 doubles at year 70
2. 100 year (minimum) control run including same time period as in 1 above
3. $2XCO_2$ equilibrium with atmosphere-slab ocean
4. $1XCO_2$ control with atmosphere-slab ocean

Strongly recommended:

5. 20C3M simulation
6. participate in AMIP, Ocean Model Intercomparison Project (OMIP), and CFMIP

Recommended idealized stabilization simulations:

7. An additional 150 years after CO_2 doubling with CO_2 fixed at $2XCO_2$
8. 1% CO_2 run to quadrupling with an additional 150 years with CO_2 fixed at $4XCO_2$

9.2.3 Intercomparison of cloud feedbacks in models

The International Cloud Feedback Model Intercomparison Project (CFMIP) was launched at the last session of WGCM. Currently, 12 groups are participating, two subprojects (experimental protocols): Feedback Analysis for GCM Intercomparison and Observation (FANGIO) and SLOM are defined and first results are becoming available. A website and a newsletter will be available in late autumn. A workshop is planned for April 2004 in Exeter, UK. Furthermore, it is planned to contribute to the Climate Sensitivity Workshop, July 2004 in Paris, France. The participation in that project is severely limited by funding. The Institut Pierre-Simon Laplace (IPSL) has been using satellite data to validate the sensitivity of its modelled climate, and has developed a data base which is dedicated to the combined use of data from different instruments. The space-based observatory, AQUA-train, which includes two missions in which the IPSL and the Laboratoire d'Optique Atmosphérique (LOA) (Univ. of Lille) are engaged (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), POLarization and Directionnality of the Earth's Reflectances (POLDER)) will constitute a renewed opportunity to validate cloud feedbacks in climate models.

The JSC encouraged a broad range of GEWEX participation in the April 2004 Cloud Feedback meeting in Exeter, UK.

9.2.4 Decadal variability

Multi-decadal variability and predictability and the stability of the Thermohaline Circulation (THC) in GHG integrations have been investigated with the MPI global climate model ECHAM5/MPI-OM1 (without flux correction). The following experiments have been performed:

- Coupled control run, duration 500 years (Jungclaus et al. 2003)
- El Niño hindcasts, 1970-present (Keenlyside et al. 2003)
- Decadal predictability studies (Pohlmann et al. 2003) (performed in the framework of Mechanisms and Predictability of Decadal Fluctations in Atlantic-European Climate (PREDICATE))
- GHG integrations (1% CO_2), ensemble with 4 members (Latif et al. 2003)
- Paleo (6k) integrations, with and without the effects of vegetation (Schnitzler et al. 2003)

The results of these experiments show that:

- There exists rather strong multi-decadal variability in the North Atlantic region.
- The multi-decadal variability is closely related to variations in the THC.
- The multi-decadal variability appears to be predictable a few decades ahead.
- The multi-decadal variability may mask a potential anthropogenic signal for some time.
- The characteristic SST pattern associated with changes in the THC may serve as a fingerprint to detect anthropogenically induced changes of the THC.

The following questions had been raised at WGCM (by Dr R. Stouffer):

- Is there predictability in the climate system beyond the ENSO timescale based on internal variability of the climate system? (probably yes in the Atlantic)
- Does this predictability extend over continents? (possibly a relatively small signal)
- For climate change predictions, is it important to initialize models from "observed" state of the ocean/ice/land system?

Investigations with the GFDL R30 model that document perfect predictability experiments show decadal scale predictability in North Atlantic (THC and SST). A question is whether or not this is of any atmospheric relevance? Grötzner et al. (1999) had stated, "… the signal to noise ratio of the extra-tropical

atmosphere is generally too low to gain relevant predictive skill from this memory." However recent results with another model (HADCM3) suggest that the answer may be a qualified 'yes'. There are a number of workshops related to this topic, including:

- NASA-CCR-CRCES Workshop on Decadal Climate Variability, 23-26 February 2004, Hawaii,USA
- Predictability Workshop, 19-23 April 2004, Reading, UK
- Workshop on the Variability of the Thermohaline Circulation, 13-16 September 2004, Kiel, Germany.

Ongoing research on predictability on decadal timescales was highlighted (PREDICATE).

The JSC noted the suggestions of some predictability on decadal timescales in the Atlantic and the occurrence of a meeting on this topic in Reading in April 2004 and requested a report on this topic to JSC-XXVI.

9.2.5 Ocean model development

The Working Group on Ocean Model Development (WGOMD) was established in 2000 as a joint working group under WOCE (now replaced by CLIVAR) and WGCM, 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". The membership is comprised of scientists working in both oceanographic and climate centres or departments.

To disseminate and publicize information on the status of ocean models used in climate research, WGOMD provides a Web directory of ocean modelling resources and has published a major review paper in the refereed literature.

Activities since the sixth session of WGCM included:

WGOMD session

The 4th session of WGOMD was held at Villefranche-sur-Mer, 13-15 April 2003, back-to-back with the EGS/AGU conference. Part of the session was held jointly with the CLIVAR Atlantic Implementation Panel. Main themes were:

- review of the pilot study for an Ocean Model Intercomparison Project (P-OMIP): forcing protocol, diagnostic sub-projects, timeline
- parameterization of ocean mixing: interaction with US Climate Process Teams (CPTs)
- planning for an international Ocean Climate Workshop.

P-OMIP

The pilot study is 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 is intended to support CMIP in providing quantitative evaluations of the models participating in the IPCC and other climate assessments. In addition, it is expected that an OMIP will provide a common reference point for investigating sensitivities to model formulation, pool 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 P-OMIP protocol specifies an ERA-15 based forcing data set developed for coupled ocean-ice model integrations. Because some groups had difficulties to strictly comply with all protocol details, the group agreed that modest modifications should be allowed but have to be well documented.Currently there are 6 contributors: LANL/U. Miami with MICOM/HYCOM (C grid, 16 layers), GFDL/IARC with MOM4 (B grid, 50 levels), CCSR (B grid, 40 levels), MRI (B grid, 48 levels), LODYC with OPA (C grid, 31 levels) and MPI with OM1 (C grid). The effort is coordinated by Anne-Marie Treguier at IFREMER, Brest. The first experiments indicate a host of robust behaviour patterns (both positive and negative) and suggest that an OMIP of this type should be feasible and has merit. The main challenges faced by most of the groups include lack of funding, and the costs of doing runs especially for this intercomparison (and not for addressing scientific questions). Before a full blown OMIP can commence, resources to support the coordination and infrastructure need to be identified.

Preliminary results from the pilot phase were presented (by F. Bryan, NCAR) at the ACSYS/CliC NEG meeting 2002, and opportunities were discussed for participation and collaboration in diagnostic "subprojects" focused on the polar regions.

Interaction with CLIVAR basin panels

The CLIVAR-SSG requested WGOMD to cooperate closely with the CLIVAR ocean basin panels, and to investigate the response of ocean models to forcing variations on interannual to decadal time scales.

Atlantic Implementation Panel

Links with this panel were intensified with a joint session of the two groups in Villefranche, 15 April 2003. Main themes were: ocean data reanalysis and assimilation activities (Dr D. Stammer); definition of data sets for testing models, particularly with respect to the Atlantic thermohaline circulation and its variability (Dr D. Wright); development of model experiments to explore THC responses and sensitivities (Dr T. Delworth, leading a subgroup formed by the Atlantic panel). The joint session endorsed plans to hold a CLIVAR Workshop on North Atlantic Thermohaline Circulation Variability which will take place in Kiel, Germany, 13-16 September 2004.

Pacific Implementation Panel

WGOMD panel member Dr H. Hasumi attended the Pacific Panel Implementation meeting on 14-16 July 2003. The group suggested including a number of diagnostics (equatorial thermocline structure, eastern boundary upwelling) in the OMIP. Because of their interest in the low frequency variability in the Pacific, they expressed strong interest in extending the current phase of OMIP by a phase with variable atmospheric forcing.

Ocean Climate Model Workshop: Princeton, 16-18 June 2004

During the latter part of 2003, major climate modelling centres have frozen their coupled models used to address IPCC AR4 questions. Additionally, US CLIVAR has announced the formation of two Climate Process Teams (CPTs) starting October 2003. One CPT is focusing on gravity current entrainment and the other on interactions between meso-scale eddies and the mixed layer. Their goal is to enhance, within 2-3 years, the physical integrity and robustness of the IPCC-class of global ocean models. WGOMD hence considers 2004 to be an opportune time to organize a scientific workshop to evaluate the ocean component for climate studies. The meeting will be held at GFDL, Princeton, 16-18 June 2004 (i.e., the week prior to the CLIVAR Conference in Baltimore); the scientific organization is led by Dr S. Griffies from GFDL. The goal for this workshop is to bring together leading ocean scientists who focus on issues related to global climate as well as high resolution models, process physics, and large-scale observations and to foster a candid and critical evaluation of the state-of-the-art in the ocean models used in the IPCC class of climate models, and to discuss strategies for improving the physical integrity of these models. A particular challenge is how coupled ocean-ice model simulations can be systematically compared addressing questions such as: Can the community coalesce around a protocol, and associated dataset, for running the models, such as within the context of an Ocean Model Intercomparison Project (OMIP)? ; How valuable will an OMIP be for evaluating the ocean and sea ice components of coupled climate models? ; Does OMIP provide a useful venue for comparing model sensitivities to parameterizations arising from the CPTs ? In preparation for the workshop, various groups expressed interest in performing analysis of OMIP output, aiming at the representation of these key processes and phenomena in comparison to observed behaviours and insight from process studies.

The JSC encouraged links between the CLIVAR panels and both WGOMD and CMIP in the diagnosis of variability in the aspects of climate with which they are concerned. The JSC suggested that CLIVAR and WGCM should consider whether a broadening of the membership of WGOMD would be useful in this regard.

9.2.6 Detection and attribution of climate change

WGCM reported that the large-scale temperature signals are detected and distinguished from natural forcing in global scale temperature (e.g. Hegerl et al., 1997; Tett et al., 1999, Allen et al., 2003). Ocean heat content changes could also be detected (Barnett et al., 1999, Reichert et al., 2001; Banks et al.). Regional attribution analysis has been performed in:

- continental scale regions (Eurasia, North America) using boxes to define pattern of change (Zwiers and Zhang)
- 6 continental scale regions (Europe, Asia, Africa, North America, South America, Australia) using sub-regions for patterns (Stott et al.).

Warming due to increasing greenhouse concentrations were detected in all continental regions including North America and Europe, anthropogenic climate change was detected in large scale indices (Karoly et al.).Analyses of paleoclimate simulations were investigated to estimate the solar signal. Results show that:

- in paleo simulations, solar forcing explains ca 30-40% variance (Ammann et al.);
- the effect of solar forcing is not detectable and smaller than simulated in most reconstructions if multiple forcings and long time horizons are considered;
- solar forcing is possibly enhanced in the instrumental record.

The importance of land surface changes is still unclear.

In variables other than large-scale temperature, changes could be detected in:

- tropospheric temperature (Santer et al., 1995, distinguished from natural forcing in Thorne et al., 2002)
- tropopause height (Santer et al., 2003)
- sea level pressure (Gillett et al., 2003).

With respect to detection of changes in "societally relevant" variables such as changes in precipitation and climate extremes, preliminary results show that:

- detection of changes in temperature extremes is quite robustly detectable
- detection of changes in precipitation extremes is very model sensitive
    - The signal is more robust for extreme than the mean change
    - The data are very uncertain, and there is a scaling issue between model data and station data
- evidence for change in width of the frequency distribution in models becoming wider for precipitation, often narrower for temperature.

Daily data are required to make a more comprehensive analysis. Some of the open questions in this area are:

- What is the role of solar forcing and variability?
- What climate sensitivity is consistent with all records?
- Can the observed record be used to constrain future changes in societally relevant variables, e.g. rainfall?
- What is the full range of model uncertainty? A very valuable contribution in this context is from climateprediction.net (http://www.climateprediction.net).
- Can indices of extremes be found that can be compared reasonably well between point processes and model grids? Are the Frich indices suitable?

9.2.7 Paleoclimatic modelling

Recent development was reported in the area of paleoclimate modelling, and in particular the Paleoclimate Modelling Intercomparison Project (PMIP) (http://www-pcmdi.llnl.gov/pmip/). A new phase of PMIP-2, now also using coupled models is starting. The goal of this phase is to study the role of climate feedbacks arising for the different climate subsystems (atmosphere, ocean, land surface, sea ice and land ice) and evaluate the capability of state of the art climate models to reproduce climate states that are radically different from those of today. Results from both coupled ocean-atmosphere models and ocean-atmosphere-vegetation models will be considered in this second phase. The forcing data will become available soon. The main foci are on 6k and 21k BP. See http://www-lsce.cea.fr/pmip2/ for more information.

9.2.8 Simulations of climate of the twentieth century (Atmosphere-only AMIP-type)(see also section 9.1.2)

Since this activity is performed mainly with atmosphere-only AMIP type runs, WGCM had felt that this activity would be better placed under the scope of AMIP. Nevertheless, a coordination of the forcing with the ongoing CMIP activity on (coupled) C20C runs would be useful. Given that AMIP and C20C have a number of common features, WGNE had expressed the view that both projects would gain through closer collaboration. For example:

- C20C could follow AMIP in establishing a tighter experimental protocol
- AMIP should consider using the Hadley SST for any future phases

9.2.9 Regional Climate Modelling (see section 9.1.5)

9.2.10 Future perspectives of WGCM

WGCM reported on an exercise carried out to determine its perspectives and priorities for the next 3-5 years. The emerging topics of major interest were:

- WCRP and IGBP GAIM cooperation (carbon cycle & chemistry)
- Systematic errors
- Climate sensitivity
- Variability and changes of variability
- Long control runs for variability, 1% pa runs for response to increasing greenhouse gases, 20th century climate runs for detection and attribution
- Initialization
- Convergence of model for different time scales
- Parameterizations for high resolution models
- Ensembles (e.g. climateprediction.net results)

10. WORKING GROUP ON SURFACE FLUXES (WGSF) AND SURFACE OCEAN-LOWER ATMOSPHERE STUDY (SOLAS)

Dr S. Gulev introduced the topic to the JSC. The Chairman of the WGSF, Dr C.Fairall reported on the activities being planned under the newly established WCRP Working Group on Surface Fluxes. Professor P. Liss, Chair of the Surface Ocean - Lower Atmosphere Study (SOLAS) SSC updated the JSC on the progress of the project.

10.1 Working Group on Surface Fluxes (WGSF)

This new WCRP working group is a follow-up to a temporary SCOR/WCRP Working Group on Air-Sea Fluxes (WGASF) previously chaired by Dr P. K. Taylor (UK) and Dr S. Gulev (Russia). The new working group is charged with reviewing and coordinating requirements of the various WCRP programmes for air-sea fluxes (initially) and air-land fluxes (in a few years), promoting research in air-sea fluxes, and facilitating communication of research advances. Specific objectives include: developing flux data sets available from different sources (in-situ, remotely sensed, NWP-based); improving measurement technologies, parameterizations and flux field production algorithms; and assessments of sensitivity of climate models and limits of predictability associated with uncertainties in surface fluxes. The WGSF will interact with SOLAS, a core project of IGBP, noting that WCRP is itself a sponsor of SOLAS along with SCOR and the Commission on Atmospheric Chemistry and Global Pollution (CACGP). It should be noted that the WCRP involvement with SOLAS is not restricted to WGSF; being a sponsor, WCRP is directly involved with SOLAS. A major priority will certainly be cooperation with SOLAS. The first step here is to set up some joint memberships. One immediate area of cooperation could be in the form of a joint WGSF/SOLAS workshop to review and discuss the state-of-the-art in parameterization of surface fluxes including momentum, energy, gases and chemical compounds, as well as particles. The WGSF also needs to consider, from WCRP perspective, the future of the SEAFLUX project (http://curry.eas.gatech.edu/SEAFLUX), a NASA-funded GEWEX effort to compile and evaluate in situ and satellite data bases. The funding for this project was expected to expire and its future was in question. Dr C. Fairall concluded his presentation by showing significant differences in latent heat flux data by ERA-15, NCEP reanalysis and Southampton Oceanography Centre (SOC) climatology. They showed significant differences, which illustrated the need to study systematic errors in these fields.

The JSC welcomed the progress report from Dr C. Fairall, Chair of the new WGSF. The JSC recommended that SURFA should be under purview of WGSF (see also 9.1) and that, once formed, WGSF should initiate with SOLAS a major review of biogeochemical surface fluxes. The JSC also requested that WGSF develop a working dialogue with NWP and climate modellers to understand their needs and uses of surface flux measurements and how they relate to modelled surface fluxes.

10.2 The Surface Ocean - Lower Atmosphere Study (SOLAS)

As indicated in 10.1, SOLAS is a joint project of CACGP, IGBP, SCOR and WCRP, and is one of the core projects of the IGBP dealing with the interface between the ocean and atmosphere. WCRP has been cosponsoring SOLAS since 2002. WCRP took part in preparations and the review of the SOLAS Science Plan and, subsequently, the SOLAS Science Plan and Implementation Strategy. The publication on the web of the SOLAS Science Plan and Implementation Strategy in December 2003 marked the end of the start up

phase of SOLAS and a move towards the implementation of the Science Plan. The implementation of SOLAS will be led by three Implementation Groups, one of which has already met and the other two are currently being constituted. In addition, the SOLAS Data Management Task Team will begin the task of mobilising the resources needed to effectively manage SOLAS data. Many countries have SOLAS activities in the planning stages or already under way. With the establishment of an international project office, funded for 5 years by the UK NERC, it can be expected that SOLAS coordination and networking will move forward rapidly over the coming years. The first SOLAS Summer School was organised by Corinne Le Quéré and Veronique Garçon in June 2003. SOLAS is submitting a proposal to run further summer schools in 2005 and 2007.

UK/Canadian/German SOLAS coordination with AMMA and TACE

UK SOLAS will be commencing fieldwork in 2005. At that point both the German SOLAS and the renewed Canadian SOLAS programmes, if successful, will be in a position to mount fieldwork in the Atlantic. The possibility of atmospheric monitoring on the Cape Verde Islands (German), Ascension Island (UK), and the existing facilities on the Canary Islands, combined with the Atlantic Meridional Transect (AMT) and Polarstern meridional transects, present the opportunity for internationally coordinated atmospheric and oceanic field campaigns in the tropical Atlantic. In addition, the plans for the African Monsoon Multidisciplinary Analysis (AMMA) and Tropical Atlantic Climate Experiment (TACE) of CLIVAR, could allow SOLAS programmes to combine their biogeochemical work with intensive physical/climatological campaigns. This offers exciting opportunities for studying the production, evolution and deposition of aeolian dust, the factors affecting pCO_2 and many other SOLAS issues.

Global oceanic CO_2 flux synthesis

At a recent meeting in Tsukuba, organised by the International Ocean Carbon Coordination Project (IOCCP), it was agreed that SOLAS Implementation Group 3, led by Dr T.Johannessen, would coordinate and carry out global integration of pCO_2 data (building on the work of regional groups, such as Carbon in the Atlantic (CARINA) and North Pacific Marine Science Organization (PICES) WG 17). A future product of SOLAS will thus be the production of global pCO_2 datasets.

SOLAS Science 2004, the first open science conference to present the results of SOLAS, will run from 13-16 October 2004 in Halifax, Canada. This is being organised by the Canadian SOLAS Secretariat and will provide a forum for further community building and networking within the SOLAS field. There will be a travel fund available for young scientists from developing countries to attend SOLAS Science 2004. This money has been provided by SCOR and Inter American Institute (IAI) and funds have been applied for from the Asia-Pacific Network for Global Change Research (APN). The main capacity building activity of SOLAS is the biennial SOLAS Summer School. Ten young scientists from developing countries attended the 2003 school, supported by the IOC of UNESCO.

The JSC encouraged direct links between CLIVAR, GEWEX, and other appropriate WCRP activities, and SOLAS. In particular, the GEWEX Atmospheric Boundary Layer Study (GABLS) should be of direct interest and value to SOLAS and, in return, GEWEX should consider the need and value of direct interaction with SOLAS Focus 1, 'Biogeochemical Interactions and Feedbacks between Ocean and Atmosphere', in relation to aerosols.

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

11.1 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) were 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.

A joint session with the Scientific Committee of the IGBP (SC-IGBP) on 5 March 2004 was a highlight of this year's JSC session. The session included overviews by Professor P. Lemke, Chairman, JSC, and Professor G. Brasseur, Chairman, SC-IGBP, followed by discussions on ESSP joint projects, Earth System analysis and modelling, observation, data assimilation, predictability, regional aspects, capacity building, Integrated Regional Studies, and START issues. It was hoped that the need for a global view in the joint ESSP projects would reinforce WCRP/IGBP co-operation.

11.2 ESSP joint projects

11.2.1 Global Carbon Project (GCP)

Dr J.G. Canadell, Executive Director, GCP, reported on the progress of the ESSP Global Carbon Project (GCP), which was launched fully in 2003. This was attested by the level of activity that the GCP carried out during the past year and the numerous products published or in press. In addition, the first networks around specific activities were established (e.g. carbon management into the development strategies of cities in the Asia Pacific and the Americas), and critical partnerships resulted in specific activities and products (e.g. with the Terrestrial Carbon Observations (TCO) network of GTOS; and the CO_2 Panel). A highlight was the publication of the Science Framework and Implementation with over 2000 copies distributed within a month of its publication. The pdf copy can be downloaded from: http://www.globalcarbonproject.org/science_plan_and_implementation.htm.

One of the main challenges of the GCP was the development of a formal framework for coupling the natural and human dimensions of the carbon cycle and its links to the climate system. Unfortunately, the launching of the workshop series for this activity has been postponed several times due to the delay in getting the IPO in Tsukuba up and running. The launching of the series was now scheduled for the end of 2004. A second major challenge for the GCP was to establish strong links with all the major national and regional C cycle research projects. This would take a few years before the GCP could claim success but efforts were going on to strengthen the links and make them more specific with the USA and China (there were already good links with Europe, Australia, Japan, Southeast Asia, and Central America). Other major regions not currently represented in the GCP were Russia and South America, and a big gap remains in Africa. Countries like Mexico and Spain have shown interest in organizing their national carbon research and contributing to the GCP. There was also the current plan to develop a network for carbon cycle research in the Americas as a contribution to the GCP and the IGBP/Global Land Project. The IPO in Canberra had a budget cut with an associated cut on staff. The budget was currently covering Dr Canadell and a part-time administrative assistant. The delay of the IPO in Tsukuba had put further pressure on Canberra. A second International Project Office would be opened at NIES in Tsukuba, Japan in April 2004. Professor P. Canan, University of Denver, Colorado, has been appointed to be the Executive Director of the Tsukuba office. Professor Canan is a sociologist and spent a good deal of her career on issues related to the Montreal Protocol. There are also two Affiliated Offices for the GCP: at CarboEurope European Office (A. Freibauer, in charge), Max-Planck-Institute for Biogeochemistry, Jena, Germany and at the Intergovernmental Oceanographic Commission (SCOR-IOC Advisory Panel on Ocean CO_2, Dr M. Hood, in charge), UNESCO, Paris, France. Discussions were under way to establish two other Affiliated Offices, one in the US shared with the North American Carbon Plan in Washington, D.C, and another with the China Carbon Flux Project in Beijing, China.

The JSC acknowledged with approval the progress made in implementation of the GCP. Main implementation challenges were: the meaningful integration of the 'human dimension' into the project's activities; the need to expand involvement in the project, especially into Africa; the difficulty of ensuring and coordinating the necessary interactions between GCP and the wide range of relevant core projects within the Programmes of the ESSP; and the concern that the reporting structure for the GCP is complicated and lies, to a degree, outside of the structure for the recognized core activities of the ESSP Programmes.

The JSC recognized that such challenges applied to all the ESSP joint projects and requested that such issues be addressed at the next session of the ESSP Chairs and Directors, May 2004.

11.2.2 Global Environmental Change and Food Systems (GECAFS)

Dr J. Ingram, Executive Officer, GECAFS, briefed the JSC on the status of the Global Environmental Change and Food Systems (GECAFS) joint project and the progress in the past year. Several workshops were conducted in 2003. Notable among them were: GECAFS Vulnerability Workshop, hosted by the US National Academy of Sciences, Caribbean Food Systems "Proposal Planning" Workshop, Barbados, Indo-Gangetic Plains "Research Planning" Workshop, Kathmandu, Nepal, Southern Africa "Issue Identification" Workshop, hosted by Development Bank of Southern Africa, Johannesburg, and

"Comprehensive Scenarios" Initial Workshop, Reading, UK. Achievements in the past year included: re-organization of GECAFS research framework and clearer definition of several key components; a major proposal ($2M/3 years/ 8 institutions) prepared for GECAFS Indo-Gangetic Plain research drafted; and GECAFS IPO funding from NERC established for 5 years from September 2003. However challenges remain such as securing funds for regional projects, securing funds for two Science Officer posts in the IPO, and preparing the Science Plan and Implementation Strategy. Lack of Science Officers and lack of regional research funds continue to be the major constraining factors.

The JSC noted the progress made in the further articulation, development and implementation of GECAFS.

11.2.3 Global Water System Project (GWSP)

Dr J. Alcamo, Chair, the GWSP Framing Committee, briefed the JSC on the status of the Global Water System Project (GWSP). On behalf of the Framing Committee, he submitted a Review Draft of the "Science Framework and Implementation Activities" report of the GWSP. This draft was a "Review Draft" because the Committee felt that the four-month period available to prepare the report (October 2003 through January 2004) was not long enough to produce a final version of the report. In particular, the implementation activities of the project should be further elaborated. On the other hand, it was felt that progress has been made in clarifying the goals and scope of the project, in justifying the need for the project, in balancing the perspectives of the different programmes of the ESSP, and in incorporating the views of both social and natural scientists. The report would now benefit from two short cycles of review and revision – the first would be a two-month "internal review" within the four ESSP global change programmes (including the input of the GWSP-IPO), with a two-month period to revise the document. The second cycle would involve a three-month review by experts outside the circles of the ESSP followed by another two-month period for revising the document. The target would be to distribute a final document by the end of 2004.

The JSC welcomed the review draft (February 2004) of the GWSP Science Framework and Implementation Activities. The JSC re-stated the need to recognize and build on existing core-project expertise, especially in GEWEX, whilst ensuring no overlap. In this context, some concern was expressed that the draft GWSP focused more on 'feedbacks' within the system, rather than 'consequences'. ESSP joint projects should be demonstrating the need and value of core-project science, and its consequences for the environment and human activities and well-being. Such a focus should make clearer the distinction and synergistic relationships between the joint projects and the ESSP Programmes' core activities. The JSC requested Director, WCRP, to solicit further WCRP comments on the draft framework document and to provide a consolidated WCRP response by mid-May 2004.

11.2.4 Global Environmental Change and Human Health project

Dr Anne-Hélène Prieur-Richard, DIVERSITAS Secretariat, briefed the JSC on the developments in the Global Environmental Change and Human Health (GEC & HH) project. Activities in 2003 consisted of a Scoping Meeting on Health and Global Environmental Change held in Paris, 27 February to 1 March 2003, organised by DIVERSITAS and preparation of a Scoping Report to the ESSP Chairs and Directors Meeting in June in Paris. Dr U. Confalonieri (National School of Public Health, Brazil) and Dr A. McMichael (National Centre for Epidemiology & Population Health, Australian National University, Australia) have been nominated as co-chairs of this new initiative. The challenge of this ESSP joint project remains to establish bridges between ecological, epidemiological, medical, social and natural scientific communities and to represent them in the science plan and in the design of concrete activities. The involved community was very enthusiastic about the opportunity of this new ESSP project and motivated to develop it. Contacts with WHO have been very constructive and an MoU would be considered between the four programmes of ESSP and WHO. There was no scientific steering committee yet, but a Planning Team has been appointed by the ESSP Chairs and Directors, with the task to finalise a science plan. The activities of the project were being co-ordinated by the DIVERSITAS Secretariat; possibilities for an IPO would be explored in 2004.

The JSC noted the progress made in scoping this project and that the climate component focused very much on long-term climate trends and change and recommended that consideration should also be given to the influences of shorter-period climate variability (e.g. ENSO-related variability) on human health.

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

Dr Hassan Virji, Deputy Director, International START Secretariat, reported on the progress of START during the past year. START has over 50 ongoing collaborative regional research projects on the themes:(i) Land Use Change and its Impacts on Terrestrial Ecosystems, (ii) Regional Climate Variability and

Change, (iii) Regional Changes in Atmosphere, (iv) Coastal Zones, (v) Global Change and Water Resources, and (vi) Assessments of Impacts of and Adaptations to Climate Change. A description of these projects is given in the Annual Reports from START regional centres/secretariats and http://www.start.org. A significant activity carried out during 2003 was the International Young Scientists' Global Change Conference held at Trieste during November 2003. This conference attracted over 1000 applications and extended abstracts. Of these, 85 were selected through rigorous peer review for presentations and poster sessions. The complete set of extended abstracts is available at http://www.start.org. During 2003, over 1000 scholars from developing countries were involved in various START activities, including regional science planning and research workshops, collaborative research networks, short term fellowships, visiting scientists and lecturer awards, African dissertation/PhD fellowships programme, small grants programme, and young scientists awards. A major activity of START during 2003 was implementation of 24 regional projects involving 45 countries on assessments of impacts of and adaptations to climate change (AIACC) that has engaged 235 scientists from developing countries, including 60 graduate and undergraduate students. This Global Environmental Facility (GEF)-funded project was being implemented in collaboration with the Third World Academy of Sciences and was expected to provide significant inputs to the next IPCC assessment. In addition, START has conducted or has made plans for several joint activities with the core and joint projects of ESSP. The joint activities with WCRP included: (i) Co-sponsorship of Regional Climate Modelling Workshop (Lund), March 2004, (ii) START would co-sponsor and host a Climate Change Detection Workshop (Cape Town), and (iii) was considering co-sponsorship of the First International CLIVAR Science Conference.

The JSC welcomed the comprehensive and impressive oral report on recent START activities. It re-iterated support for the range of START activities conducted on behalf of its sponsoring Programmes (WCRP, IGBP and IHDP) and that WCRP core projects should establish appropriate links with START, especially with a view to increasing the involvement of developing-country scientists in WCRP activities and transferring research knowledge to developing countries. The JSC also endorsed the summary of the findings and recommendations of the Strategic Review of START in Relation to Regional Research/Capacity Building in the Global Change Programmes, conducted 2002-03.

11.4 Summary of other issues in joint session with SC-IGBP

The JSC welcomed the first joint session of the JSC-WCRP and SC-IGBP and acknowledged that some useful exchanges had taken place but that the size of the forum and the day's agenda had not been conducive to stimulate enough meaningful discussion, and no joint decisions had been taken. In particular:

(1) The JSC concluded that insufficient time had been allocated to review the joint projects and other ESSP activities and issues (e.g. governance of ESSP activities) and requested that more time be allocated for these at JSC-XXVI, March 2005. Also WCRP should explore opportunities for additional, more direct links with IHDP and DIVERSITAS.

(2) The JSC valued the opportunity to exchange information and views with SC-IGBP on current and future plans and proposals for Programme-specific and joint, bilateral and wider ESSP, activities covering observations, analysis, assimilation, re-analysis, modelling, predictability and prediction. In particular, it endorsed strongly a draft 'ESSP Modelling Strategy: Requirements to Understand and Predict the Earth System', articulated and submitted by the Chair and Vice-Chair, JSC, which proposed seven strategic and collaborative elements for making effective and necessary progress towards fuller 'Earth System modelling' and identified specific independent and collaborative roles for each ESSP Programme, and the ESSP itself. A refined version of the WCRP-proposed ESSP Modelling Strategy is at Appendix D.

(3) The JSC acknowledged that the complementary roles of COPES (see also 4.1) and of IGBP's proposed new core project on Analysis, Integration and Modelling of the Earth System (AIMES) would be central and critical to the successful implementation of such a strategy. The JSC requested Chair, JSC, and Director, WCRP, to develop the strategy further in full collaboration with ESSP partners and with particular recognition of both COPES and AIMES.

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

12.1 Global Climate Observing System (GCOS)

Professor P. Mason, Chair of the GCOS Steering Committee (SC) briefed the JSC on current important issues in GCOS, including some highlights of AOPC activities.

12.1.1 Second Adequacy Report and Interactions with the UNFCCC

GCOS, on behalf of the global observing systems for climate, led the completion of the Second Adequacy Report and submitted it, through the Subsidiary Body on Scientific and Technological Advice (SBSTA), to the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) at its ninth session in Milan, Italy (December 2003). COP-9 welcomed the Report and adopted a broad-ranging decision which, *inter alia*: requested Parties to respond to its findings; requested the GCOS Secretariat to lead the development of a phased 5- to 10-year implementation plan for the integrated global observing systems for climate; invited the GCOS sponsoring agencies to develop a framework for preparation of guidance material and standards for terrestrial observations; invited appropriate national and international agencies to develop and make available a range of integrated climate products; encouraged Parties to provide reports on their systematic climate observation activities; requested the Subsidiary Body for Implementation (SBI) to adopt the updated GCOS Climate Monitoring Principles that had been approved by WMO Cg-XIV; and urged Parties to contribute as feasible to a new GCOS Cooperation Mechanism. GCOS will continue its interactions with the UNFCCC in carrying out many of these requests from COP.

In response to the COP-9 decision, GCOS, in cooperation with relevant agencies, organizations and scientists, has begun the development of a draft implementation plan for the global climate observing systems. This effort was being led by the SC Chairman with the strong support of the chairmen of the science panels. Working meetings were held in September 2003 and January 2004 and work would continue through the upcoming GCOS SC meeting. It was intended to have a draft plan available for open review by mid-April, and a final document for COP-10 in December 2004.

The GCOS Regional Workshop Programme was continuing, with six of the ten planned workshops having been completed (the seventh, for the countries of Central Asia, would take place in Almaty, Kazakhstan from 25-27 May 2004). The remaining three workshops are planned for countries of South and Southwest Asia; Eastern and Central Europe; and the Mediterranean Basin. The main objective of the workshops was 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 was being supported by the UNFCCC through the GEF.

In response to requests from the GCOS-SC, and with the encouragement of the UNFCCC/COP to investigate a donor fund for climate observing systems, a high-level meeting of potential donors was hosted by the USA/NOAA in October 2003. The meeting agreed the concept of a GCOS Cooperative Mechanism (GCM), aimed at addressing priority improvements in atmospheric, oceanic and terrestrial observing systems for climate, especially in developing countries. The GCM is intended to complement and work in cooperation with other funding and implementation mechanisms, especially the WMO Voluntary Cooperation Programme.

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

The AOPC held its ninth session at the National Climatic Data Center (NCDC) in Asheville, USA from 23-27 June 2003. The main items of discussion focused around: (i) the status and latest developments regarding the GCOS atmospheric networks, especially the GCOS Surface Network (GSN) and GCOS Upper-Air Network (GUAN); (ii) consideration of new or enhanced networks for measurement of additional parameters of importance to AOPC (surface radiation, CO_2, ozone, aerosols); (iii) further development and review of statements of guidance for WMO/ Commission for Basic Systems (CBS) in three climate applications areas; and (iv) review of the latest status of the Second Adequacy Report.

The performance of the GSN and GUAN networks remains well below ideal, with about 65% of expected reports being received at the GCOS Monitoring Centres for GSN and 75% for GUAN. GCOS was working closely with WMO/WWW and the Technical Cooperation Programme of WMO to take specific actions to revitalize a number of GUAN stations, under the guidance of AOPC for station selection and with funding support provided recently by the USA/NOAA through its Climate Change Research Initiative. A contractor has been engaged by GCOS to carry out these activities, which are expected to continue for some time and include underperforming GSN as well as GUAN stations.

Presentations were made at AOPC-IX by scientists from NOAA/ Climate Monitoring and Diagnostics Laboratory (CMDL) representing global CO_2 monitoring activities and the GEWEX/WCRP Baseline Surface Radiation Network (BSRN), with a view to adding or developing GCOS baseline networks for these parameters. In the case of BSRN, it was agreed to establish a small ad-hoc group to pursue the issue of designating the BSRN as the GCOS baseline network for surface radiation. That group completed its work in December with the development of an agreement defining the terms under which BSRN would be accepted as the GCOS global baseline surface radiation network. The agreement has been endorsed by the GEWEX Radiation Panel and

SSG, and was being presented to this session of the JSC for its consideration and approval. It will also be presented for approval to the GCOS SC at its twelfth session, 15-18 March 2004.

The JSC thanked Professor P.J. Mason, Chair, GCOS SC, for the willingness and help of GCOS to adopt BSRN as the GCOS global baseline surface radiation network. (See also 6.1.3).

The JSC welcomed strongly the invitation to provide input at the drafting stage to the developing GCOS Implementation Plan; this would be needed before the SBSTA meeting in June 2004. It expressed continuing concern that the GCOS GUAN did not contain any sites in India and considered this a major problem for the Indian monsoon region and requested GCOS to address this as a matter of some priority, including registering this problem with WMO. The JSC acknowledged the intention within GCOS to have a coordination group on reanalysis and stressed the need for WCRP and GCOS to coordinate their common interests in this area through WGOA and AOPC so as to pool resources and avoid duplication. The JSC congratulated GCOS on its continuing programme of valuable regional workshops and encouraged it to ensure that such capacity-building investments are built on by having clear, practical and publicised follow-up plans for the regions involved.

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

Dr Ed Harrison, Chairman of the OOPC, informed the JSC on OOPC activities. The priority activities during the last year included: completion of the ocean domain contribution to the GCOS Second Report on the Adequacy of the Global Climate Observing System; advocacy for implementation of the agreed 'Next Steps' toward the initial global ocean climate observing system (satellite and in situ) for improvement of ocean data system, ocean analysis, synthesis and forecast efforts; development of strategies for evaluation and evolution of the initial system; liaison with JCOMM implementation subgroups, with other groups interested in global ocean observations and with the GOOS Coastal Ocean Observations Panel. New activities since the OOPC-8 Panel Session, Sept 2003, included: Implementation Plan for Second Adequacy Report, participation in GEO architecture and implementation planning, further development of ocean indices and evaluation metrics, collaboration with new WCRP air-sea flux group, continuation of work toward high latitude sustained observations recommendations, and increased advocacy for recommended ocean satellite missions.

The JSC noted with approval the progress in, and future plans for, OOPC activities.

12.2 The Integrated Global Observing Strategy (IGOS)

Dr R. Lawford briefed the JSC on the developments in the IGOS Partnership (IGOS-P) and the Integrated Global Water Cycle Observations (IGWCO) theme. IGOS-P undertakes its work through the development of themes and teams to oversee their implementation. It has initiated the development of four themes that have been approved: oceans (2000), carbon (2003), geohazards (2003) and water (2003). It is currently developing themes related to coastal issues and atmospheric chemistry. In addition, a proposal for a cryospheric theme is under development. To date, WCRP has its most active involvement in the water cycle theme, providing a chair for the theme's advisory committee (Dr D. Carson) and a co-chair for the theme report writing team (Dr R. Lawford).

WCRP, at the request of the IGOS-P, has taken the lead in the development of a Water Cycle theme proposal (adopted in 2001) and in the preparation of an Integrated Global Water Cycle Observations (IGWCO) theme report (accepted in November 2003). The IGWCO report was in the final stages of production. Through GEWEX, WCRP would also contribute to the implementation of that plan. The theme brings together a range of interests and groups to review water cycle observations and provides an opportunity to bring priority needs for new satellite developments to the attention of space agencies through the Committee on Earth Observation Satellites (CEOS) and its Strategic Implementation Team (SIT). The theme also places a priority on helping to define the needs of users for satellite data and products related to water resources and water in the atmosphere.

The implementation plan for the IGWCO theme will be developed over the next six months. The key projects agreed at the implementation workshop, held in Tokyo, in February 2004 for the theme include: development of integrated CEOP data products, development of a clear definition of data requirements for the ESSP Global Water System Project (GWSP), development of an integrated precipitation product, and exploring the possibility of an "indicators" project in the area of water resources. The next IGOS-P meeting is scheduled for Summer 2004. IGOS-P will be reviewing draft implementation plans for the approved themes. IGWCO will be asked to present a draft implementation plan to CEOS-SIT, also in Summer 2004.

The JSC thanked Dr R. Lawford for his continuing leadership of the development of the IGOS Integrated Global Water Cycle Observations (IGWCO) theme report, which would be published in time for the ministerial-level Earth Observation Summit, Tokyo, April 2004. The JSC endorsed the proposal that WCRP should continue to play a leading role, with WMO and CEOS, in the small Executive Committee that will be responsible to IGOS for the theme's implementation. The JSC noted that IGOS-P would review draft implementation plans for IGWCO at its next meeting, in May 2004.

12.3 WCRP space mission requirements

Dr G. Sommeria informed the JSC on WCRP space mission requirements. The WCRP initiative was encouraged by CEOS Chair and pursued with the support of an informal working group composed of representatives of the main space agencies and the various WCRP core projects, and other interested scientists, which met 20-22 October 2003 in Geneva.

The WCRP Satellite Working Group recommended that the WCRP "space strategy" should be established along the main following lines:

- To ensure that operational agencies maintain the continuity of existing operational space systems and upgrade operational sensors as appropriate to achieve better performance and meet WCRP requirements for long-term, consistent and well-calibrated data sets.
- To encourage space agencies to develop new research / precursor sensors providing better quality space measurements (in terms of accuracy, resolution, coverage…) for those measurements already existing but requiring major improvements to meet WCRP specifications and/or to explore new techniques / technologies for measurements not yet derived from space but in great demand by WCRP scientists.
- To support the progressive transfer of appropriate research / precursor sensors to operational platforms when they have been adequately validated. WCRP encourages space agencies to consider means or mechanisms to ensure long-term continuation, without gaps and preferably with some overlapping of these measurements whenever needed.
- To ensure that adequate / major efforts and resources are devoted to the integration of satellite data into global, quality climate products required by WCRP projects.

A close interaction between WCRP and space agencies at all levels (strategic, programme management and day to day work) is recognised as a key factor of progress in the domain of climate research. WCRP has developed longstanding relationships with major space agencies active in Earth Observation, and this has been formalised by its association with CEOS and its participation in the IGOS partnership. The recently approved WMO Space Programme is a new channel to take into account WCRP priorities. WCRP is one of the WMO-supported programmes, and takes part in the annual sessions of the WMO Consultative Meetings (CM) on High-level Policy on Satellite Matters. The IGOS partnership is a key mechanism for developing the cooperation between WCRP and agencies involved in Earth Observation, both on the space and the "user" side, and the active involvement of WCRP in several IGOS themes is an efficient way to express its requirements in the various climate-related domains. However, the absence of a specific climate "theme" does not allow for a coordinated expression of the climate research community in this framework.

The WCRP Satellite Working Group noted with satisfaction that significant progress has been achieved since the first report of the WCRP study was released in early January 2003, including:

- New important space missions for climate research launched in 2003 (NASA SORCE and ICESat, Canadian SCISAT-1) and several planned in 2004/2005 (Cryosat, Aura, Calipso, Parasol)
- Final approval given for the development and launch of new important missions in the second half of this decade (SMOS, Aquarius, HYDROS …) in line with previous WCRP recommendations
- Numerous missions of high importance for climate research currently under definition for decisions in 2004/2005 (GPM, GOSAT, ESA Earth Explorers including WALES, EarthCare, ACE+, SPECTRA).

The WCRP Satellite Working Group recommendations, in the short-term, include the following priorities:

- Continuation of TRMM operations for as long as possible
- Final decision to proceed with the GPM mission including the EGPM component
- Identification of option(s) for the timely implementation of Megha-Tropiques
- Final decision on GOSAT implementation
- Provision of continuity for high resolution optical imagery mission of the Landsat / SPOT class

- Detailed definition and work plan for a strategy for the development of quality climate products with the involvement of CEOS Working Group on Information Services and Systems (WGISS).
- Involvement of CEOS Cal/Val Working Group for an enhanced Cal/Val programme focusing on sensor cross-calibration
- Release by space agencies of coordinated Calls for Ideas / Mission concept for climate research and coordinated selection
- Development of innovative instrumentation for atmospheric chemistry and precipitation measurements from GEO.

The WCRP Satellite Working Group reiterated the general recommendations expressed last year and strongly recommended that clear mechanisms be identified by space agencies to ensure data continuity for experimental missions whenever appropriate for climate research. This is also valid for operational missions of importance for climate research. The Group also felt very concerned with the alarming situation concerning frequency allocation and urged space agencies to take the appropriate initiatives with their appropriate authorities to protect frequency bands of high importance for climate measurements. The CEOS Plenary in November 2003 expressed its appreciation of the work performed by the WCRP Satellite Working Group and recommended that a closer interaction be established with the corresponding GCOS activities. A proposal was made to further discuss the above recommendations at a future CEOS SIT meeting.

A presentation of the above activities at CM-4, January 2004 focused on the systematic re-processing and coordinated re-analyses of relevant climate data sets in association with GCOS. The session suggested that this would be a major challenge especially with regard to data in the tropics and supported the project, which should be done in close co-operation with the CEOS Working Groups especially Cal/Val and WGISS, and avoid duplications with on-going efforts within CGMS (the Co-ordination Group for Meteorological Satellites). It also recommended that the WMO Space Programme should serve as a focal point for these activities.

The JSC thanked the WCRP Satellite Working Group for its update of the WCRP space mission requirements, January 2004, and gave general approval of the main conclusions and recommendations. It reaffirmed the vital need for WCRP to maintain its close, direct and productive working links with individual space agencies and through fora such as those provided by CEOS, IGOS-P, CGMS and WMO. The JSC endorsed the specific recommendations that the proposed WGOA should help facilitate interactions between WCRP and space agencies (see also 6.1.3) and that there is a need to develop homogeneous climate products (1979-present) by systematic reprocessing of global satellite observations. The JSC acknowledged that the latter might be an appropriate specific contribution to COPES.

12.4 Group on Earth Observations (GEO)

Dr G. Sommeria briefed the JSC on the WCRP's possible role in the GEO process. WCRP is one of the "international agencies" represented in the inter-governmental *ad hoc* Group on Earth Observations (GEO) established by the first Earth Observation Summit which took place in Washington D.C., 31 July 2003. (General information on the GEO process is available on the website: http://earthobservations.org). WCRP is contributing specifically to two of the GEO subgroups, dealing respectively with data utilisation and users requirements. WCRP should take advantage of this opportunity to have its role and action reinforced at a wide international level. The 10-year plan for Earth Observations (so-called Global Earth Observation System of Systems: GEOSS), which is being prepared by GEO for the end of 2004, will be built mainly on existing international initiatives, among them the IGOS-Partnership and WCRP itself. GEO encompasses several domains, and climate is only one of them. It is important that, in this domain, the present and future role of WCRP be clearly defined with respect to the other actors. A strategic plan for WCRP including the COPES concept, which broadly encompasses the next ten years, will be timely as a contribution to the GEO discussions and can be taken into account in the 10-year GEO implementation plan. This assumes that its main lines are defined sufficiently early in 2004. Conversely, WCRP should take advantage of the GEO process to get the necessary political support and, subsequently, the financial support for specific projects WCRP wishes to initiate and/or encourage. Participation of WCRP in GEO was discussed at the WCRP Officers, Chairs and Directors Meeting, held in Geneva on 21-23 January 2004, and the following participants agreed to act as focal points in the GEO consultation process: Drs. J. Church, B. Goodison, R. Lawford, A. O'Neill, and K. Trenberth.

The plan of action for the year was as follows:

1. A first version of the GEO framework document was issued on 5 February 2004 and it will serve as the basis for discussions at GEO-3 in Capetown, 25-27 February 2004, as a preparation for intergovernmental approval expected at the second Earth Observation Summit in Tokyo on 25 April 2004.
2. In addition to the framework document, a statement at ministerial level will be prepared for the Tokyo summit.
3. Along with the framework document, a more extensive GEO report was being prepared as a compilation of the various subgroup contributions. It will be presented and discussed in Capetown, with probably at least another iteration before Tokyo.
4. A good part of the year will be dedicated to the preparation of the GEOSS 10-year implementation plan, in preparation for the third Earth Observation Summit to be held in Brussels in February 2005. WCRP's input to this document should be significant, and prepared in coordination with GCOS and WMO.

The JSC appreciated the comprehensive and up-to-date briefing on the GEO process and its status by Dr G. Sommeria. The JSC agreed that a visible and positive WCRP representation in GEO and specific sub-groups was necessary and potentially a great opportunity for climate research. The JSC confirmed the need and value of working in close partnership with GCOS in order to ensure that the needs and uses for climate data are well and fully represented in the GEO process. The JSC supported the recent formation of a WCRP "quick-response group", with representation from CliC, CLIVAR, GEWEX and SPARC, in order to ensure that WCRP could provide the rapid input that was frequently needed in response to requests from GEO and its sub-groups.

13. RELATIONSHIPS WITH IPCC AND UNFCCC

13.1 Intergovernmental Panel on Climate Change (IPCC)

Dr S. Solomon, Co-chair, IPCC WGI briefed the JSC on the status of the planning for IPCC's Fourth Assessment Report (AR4).

The JSC welcomed with appreciation this comprehensive and timely briefing by Dr Solomon and noted that new peer-reviewed research results would need to be effectively in press by the end of 2005 to qualify for consideration for AR4. Some concern was expressed that climate-model scenario experiments now being done for AR4 could not possibly be analysed fully to meet the AR4 deadline. The JSC urged all WCRP core activities to consider if there were any important IPCC research issues that could be addressed quickly in order to provide new results for AR4. It requested Director, WCRP, to use WCRP mailing lists to inform others of this situation.

13.2 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 twenty-fourth session (Reading, UK, March 2003) the JSC welcomed the SBSTA decision to regularly consider issues related to research on climate at its future sessions. Whilst acknowledging that it is important to be able to detect climate change and attribute it to individual sources, it was 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 therefore proposed that WCRP should 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'. The Director, WCRP, subsequently conveyed the JSC's decisions on the 'Brazilian proposal' to the UNFCCC/SBSTA Secretariat. In keeping with the proposals at JSC-XXIV, Dr H. Cattle, Director of the International CLIVAR Project Office, represented WCRP at the Third Expert Meeting on Scientific and Methodological Aspects of the Proposal by Brazil, which was supported by the governments of Brazil, Germany and the UK, and held 8-9 September 2003, Berlin. The stated aim of the work to be done under this activity is to model and assess the contributions of sources of emissions to climate change, to improve the robustness of the preliminary results and to explore the uncertainty and sensitivity of the results to different assumptions. The meeting consisted of three parts. First, experts presented new results and findings. Second, experts discussed a possible future process. Third, experts reviewed the progress on specific subjects in working groups. Dr Cattle gave an oral report on the meeting at JSC-XXV, March 2004,

and made further proposals for WCRP's involvement with the 'Brazilian proposal' for consideration and decision by the JSC.

One of the outcomes of the 'third expert meeting' had been to establish an ad-hoc group for the Modelling and Assessment of Contributions to Climate Change (MATCH), whose aim is to improve the robustness of the preliminary results concerning contributions to climate change based on a proposal by Brazil for the calculation of contributions of emissions to climate change and to explore the uncertainty and sensitivity of the results to different assumptions as requested by the Parties to the UNFCCC at SBSTA17. One of the proposals (to SBSTA) from JSC-XXIV was that WCRP should offer to conduct a critical review of any comprehensive scientific report, submitted by SBSTA, on the clear objectives of the Brazilian proposal, the methodologies used to date in addressing the scientific issues involved, and the results achieved to date. No such formal report or request has yet been forthcoming from SBSTA. However, Dr Cattle argued that it would be potentially much more helpful if WCRP were willing to provide a review of the current scientific plans for the continuation of this project, rather than simply provide a critical appraisal of work done. Such an offer would be much more constructive and more positively responsive to SBSTA's appeal.

It is clear that SBSTA and the scientific communities engaged with the Brazilian proposal would like this activity to be directed, managed and assessed under the auspices of a recognised international research programme, such as WCRP. However, the problem being addressed requires input not only from the WCRP community, but also those of IGBP and IHDP. Although WCRP is one such player at that level, it is not necessarily the most appropriate programme to adopt this activity.

The JSC decided that the current organization and focus of this work do not appear to require support from WCRP. MATCH seemed to be already suitably organized and implemented at an international level. Choices and decisions underlying the "Brazilian proposal" related to political concerns. Concern was expressed regarding the need for a clear description of the uncertainties and limitations of current planned steps under MATCH; e.g. the need to fully consider aerosols, chemical feedbacks, and non-linearities to achieve outputs suitable for peer review, publication and ultimately assessment, where appropriate, under IPCC, SBSTA itself, or other bodies.

14. ADMINISTRATIVE MATTERS

14.1 Internal matters of the JSC

WCRP Officers

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. Professor P.Lemke (Chairman) was unanimously re-elected for a further two-year period (1 April 2004-31 March 2006). Professor B.J. Hoskins, Vice-chairman, would step down from the JSC on 31 December 2004, having completed ten years as a Member of the JSC. Dr J. Church (Officer) was unanimously elected to succeed Professor Hoskins as Vice-chairman, JSC, for the period 1 April 2004-31 March 2006. Professor Yihui Ding, Officer, would also step down at the end of the year having served eight years as a Member of the JSC. Professors S. Gulev and V. Ramaswamy were unanimously elected as the Officers for the two vacant positions for the two-year period 1 April 2004-31 March 2006.The appointments of Professor Lemke, Dr Church and Professor Gulev beyond 31 December 2004 are dependent on extension of their terms of membership of the JSC (to be determined by the sponsoring agencies during 2004).

WCRP Officers, Chairs and Directors (OCD) Meeting

The JSC welcomed and acknowledged the value of the first WCRP OCD Meeting, held 21-23 January 2004, WMO, Geneva and requested that the second such meeting should be held, in Geneva, in September 2004.

WCRP 25th Anniversary

The JSC endorsed the following proposals by Chair, JSC:

- resurrection of a WCRP Newsletter; twice per year; first issue June 2004
- a WCRP 25th Anniversary brochure of about 8-10 pages, to highlight WCRP achievements and inform about COPES; September 2004
- a WCRP 25th Anniversary book, to be published in time to be included as part of the conference package for the proposed second ESSP Open Science Conference in 2006

- a special WCRP edition of the WMO *Bulletin*; April 2005.

The JSC requested Chair, JSC and Director, WCRP to make the necessary arrangements to achieve the above publications and the proposed conference.

14.2 Organization and membership of WCRP scientific and working groups

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.

The JSC dealt with expiry dates of 31 December 2003 and 31 December 2004. JSC-XXVI, March 2005, will deal with terms of appointment expiring on 31 December 2005. Changes with effect from 1 January 2006 should be examined in the first instance at the WCRP Officers, Chairs and Directors meeting in September 2004. The JSC also recommended that all SSGs and main WGs should have either two Co-Chairs or a Chair and (at least) one Vice-Chair and requested the Director, WCRP to carry out the necessary follow-up actions.

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. The term of the Chairman, Dr K. Puri, which expired on 31 December 2003 was extended by two years as a member. The terms of Drs Chen Dehui, V. Kattsov, S. Lord, A. Lorenc, M. Miller and D. Williamson, which expired on 31 December 2003, were extended by two years. In addition, Dr Miller was appointed the new Chairman. Dr P. Bougeault whose term expired on 31 December 2003 was now leaving the group. Dr M. Déqué (Météo-France) was appointed as a new member for a period of four years. Thus the composition of the group was:

Membership	Expiry of appointment
M. Miller (Chair)	31 December 2005
K. Puri	" 2005
M. Déqué	" 2007
J. Côté	" 2005
Chen Dehui	" 2005
V. Kattsov	" 2005
S. Lord	" 2005
A. Lorenc	" 2005
D. Majewski	" 2005
K. Saito	" 2005
D. Williamson	" 2005

JSC/CLIVAR Working Group on Coupled Modelling (WGCM)

The terms of the members Drs J. Mitchell, G. Meehl and B. McAvaney which expired on 31 December 2003 were extended by two years. Dr Mitchell was re-appointed as Chairman for a further two years. Dr G. Meehl was appointed as Vice-Chairman. The terms of the members Drs T.Delworth and A. Noda which expired on 31 December 2003 were extended by one year. Drs H. Le Treut, A. Weaver and D. Webb stepped down after their terms expired on 31 December 2003. Dr G. Flato accepted membership for an initial term of four years. Two further nominations to the WGCM were pending. The group was thus now constituted as follows:

Membership	Expiry of appointment
J. Mitchell (Chair)	31 December 2005
G. Meehl (Vice- Chair)	" 2005
C. Boening	" 2004
P. Braconnot	" 2005
T. Delworth	" 2004
G.Flato	" 2007
G. Hegerl	" 2004
A. Hirst	" 2005

M. Latif	"	2004
B. McAvaney	"	2005
A. Noda	"	2004

CLIVAR Scientific Steering Group

Drs A. Busalacchi and R. Weller whose terms were due to expire on 31 December 2004 had their terms of appointment extended by two years. Drs J. Willebrand, I. Simmonds, M. Suarez and K. Takeuchi stepped down from membership when their terms expired on 31 December 2003. Drs J. Marotzke, F. Molteni, M. Reinecker, T. Tokioka and B. Wang have accepted invitations to be members of the SSG for an initial term of four years. It was agreed that recommendations on the memberships of Drs K. Trenberth and T. Stocker whose terms were due to expire on 31 December 2004 would be submitted for approval inter-sessionally by the JSC after the CLIVAR SSG session in June 2004. The membership of the CLIVAR Scientific Steering Group was thus:

Membership	Expiry of appointment	
A. Busalacchi (Co-chair)	31 December	2006
T. Palmer (Co-chair)	"	2007
H. Cullen	"	2006
P. L. da Silva Dias	"	2005
J. Marotzke	"	2007
F. Molteni	"	2007
M. Reinecker	"	2007
T. Stocker	"	2004
T. Tokioka	"	2007
K. Trenberth	"	2004
B. Wang	"	2007
R. Weller	"	2006
R. Zhang	"	2006

CliC Scientific Steering Group

For the members whose terms of appointment expired on 31 December 2003, the memberships of Drs B. Goodison and I. Allison were extended by three years and those of Drs R. Barry and T. Fichefet by two years. For those whose terms were due to expire on 31 December 2004, Drs M. Drinkwater, V. Kotlyakov, and Qin Da He had their terms of appointment extended by two years and Drs T. Ohata and H. Zwally had their terms of appointment extended by one year. Dr M. Burgess had stepped down. Dr C. Mauritzen (Norwegian Meteorological Institute) had accepted membership for an initial term of four years. The composition of the group was thus:

Membership	Expiry of appointment	
B. Goodison (Chair)	31 December	2006
I. Allison (Vice-chair)	"	2006
R. Barry (Vice-chair)	"	2005
M. Drinkwater	"	2006
T. Fichefet	"	2005
D. Kane	"	2006
V. Kotlyakov	"	2006
C. Mauritzen	"	2007
T. Ohata	"	2005
Qin Da He	"	2006
J. Turner	"	2006
H. Zwally	"	2005

GEWEX Scientific Steering Group

The terms of the Chairman and that of Dr T. Ackerman, D. Randall and Dr K. Takeuchi, which were expiring on 31 December 2004, were extended by three years. Dr L. Gottschalk had resigned and was replaced by the appointment of Dr K.D. Sharma (National Institute of Hydrology, India) for an initial term of

four years. The terms of Drs Y. Kerr, U. Schumann and Z. Kopaliani expiring on 31 December 2004 were extended by two years and those of Drs K. Nakamura, M.F. Silva Dias and G. Wu by one year. The membership of the group was thus:

Membership	Expiry of appointment
S. Sorooshian (Chair)	31 December 2007
T. Ackerman	" 2007
R. Atlas	" 2004
A. Beljaars	" 2005
Y. Kerr	" 2006
Z. Kopaliani	" 2006
K. Nakamura	" 2005
D. Randall	" 2007
U. Schumann	" 2006
K.D.Sharma	" 2007
M.F. Silva Dias	" 2005
K. Takeuchi	" 2007
G. Wu	" 2005

SPARC Scientific Steering Group

The Co-chairs Professor A. O'Neill and Dr A.R. Ravishankara whose terms were due to expire on 31 December 2004 had their terms of appointment extended by two years. The terms of P. Canziani, C. Granier, T. Peter, U. Schmidt, S. Yoden and V. Yushkov which were due to expire on 31 December 2004 were extended by one year. The membership of the group was thus as follows:

Membership	Expiry of appointment
A. O'Neill (Co-chair)	31 December 2006
A.R. Ravishankara (Co-chair)	" 2006
J.P. Burrows	" 2006
P. Canziani	" 2005
C. Granier	" 2005
K. Hamilton	" 2004
D. Hartmann	" 2006
T. Peter	" 2005
U. Schmidt	" 2005
T. Shepherd	" 2005
S. Yoden	" 2005
V. Yushkov	" 2005

Working Group on Surface Fluxes (WGSF)

The JSC endorsed the proposals put forward by the Chairman of the new Working Group for the nomination of the members for a term of 4 years. The membership of the group was thus as follows:

Membership	Expiry of appointment
C. Fairall (Chair)	31 December 2007
E. Andreas	" 2007
B. Barnier	" 2007
A. Beljaars	" 2007
A. Bentamy	" 2007
F. Bradley	" 2007
W.Drennan	" 2007
E. Kent	" 2007
W.McGillis	" 2007
R. Philipona	" 2007
S. Smith	" 2007
B. Weller	" 2007

WCRP/GCOS/GOOS Ocean Observations Panel for Climate

Drs W. Zenk and M. Kawabe whose terms expired had left the group. Dr Y. Michida, Ocean Research Institute, University of Tokyo, Japan was appointed. The composition of the Ocean Observations Panel for Climate, jointly sponsored by the JSC and the Joint Scientific and Technical Committees for GCOS and GOOS was thus 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
- Y. Michida, 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

WCRP/GCOS Atmospheric Observation Panel for Climate

Dr G. Stephens whose term expired had left the group and in his place Dr M. Goldberg, NOAA/NESDIS, Office of Research and Applications, USA had been appointed. The membership of the Panel is thus:

- M. Manton, Bureau of Meteorology Research Centre, Melbourne, Australia (Chair)
- P. Arkin, University of Maryland, USA
- M. Goldberg, NOAA/NESDIS, Office of Research and Applications, Camp Springs, MD, USA
- E. Harrison, NOAA Pacific Marine Environmental Laboratory, Seattle, WA, USA
- R. Heino, Climate Research, Finnish Meteorological Institute, Helsinki, Ex-officio member,
- Commission for Climatology (CCL)
- 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
- B. Rudolf, Detscher Wetterdienst, Offenbach, Germany
- J. Schmetz, EUMETSAT, Darmstadt, Germany
- M. Suzuki, National Space Development Agency, Tokyo, Japan

14.3 Publications

The following reports were produced under WCRP auspices in various series since the twenty-fourth session of the JSC:

WCRP Report Series

None

Informal WCRP reports and documents

5/2003	Report of the tenth session of the SPARC Scientific Steering Group (Kyoto, Japan, 18-21 November 2002)
6/2003	Report of the seventh session of the CLIVAR Working Group on Seasonal to Interannual Prediction (Cape Town, South Africa, 19-22 November 2002)
7/2003	Report of the third session of the WCRP ACSYS/CliC Scientific Steering Group (Beijing, China, 21-25 October 2002)

8/2003	Report of the WCRP Satellite Working Group on "Update of Space Mission Requirements for WCRP"(Geneva, 6-7 November 2002)
9/2003	Workshop on Sea Ice Extent and the Global Climate System (Météo-France, Toulouse, France, 15-17 April 2002) Mini-conference on the Long Term Variability of the Barents Sea Region (Météo-France, Toulouse, France, 18-19 April 2002)
10/2003 (available on CD only)	WCRP Workshop on Determination of Solid Precipitation in Cold Climate Regions (Fairbanks, Alaska, 9-14 June 2002)
11/2003	Report of the GEWEX-GPCP Workshop on Precipitation Analysis (Reading, UK, 11-13 March 2003)
12/2003	Report of the fifteenth session of the GEWEX Scientific Steering Group (Bangkok, Thailand, 20-24 January 2003)
13/2003	Sixth Session of the CLIVAR VAMOS Panel (Miami, Florida,23-26 April 2003)-ICPO No. 70
14/2003	WGCM/CLIVAR Working Group on Ocean Model Development Report of the fourth session (Villefranche sur mer, France, 13-15 April 2003)-ICPO No. 71
15/2003	Report of the fifth CLIVAR Asian-Australian Monsoon Panel Meeting (Atlanta, USA, 23-27 February 2003)-ICPO No. 72
16/2003	Fifth CLIVAR Atlantic Sector Implementation Panel Meeting (Villefranche sur mer, France,13-14 April 2003)-ICPO No. 73
17/2003	Third Session of the CLIVAR VACS Panel (Cape Town, South Africa, 14-17 January 2003)- ICPO No. 74
18/2003	Report of the second Meeting of the CLIVAR Pacific Panel (Yokohama, Japan, 14-16 July 2003)-ICPO No. 75
1/2004	Report of the eleventh session of the SPARC Scientific Steering Group (Frankfurt am Main, Germany, 22-25 September 2003)

Special WCRP Reports

- 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) (WMO/TD-No. 1200)

CAS/JSC Working Group on Numerical Experimentation publications

- Research Activities in Atmospheric and Oceanic Modelling (edited by J. Côté) (Report No.33, WMO/TD-No. 1161,also available on the web: http://www.cmc.ec.gc.ca/rpn/wgne/)

- Report of the eighteenth session of the CAS/JSC Working Group on Numerical Experimentation (Toulouse, France, 18-22 October 2002, Report No.18, WMO/TD-No.1173)

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**

14.4 WCRP resources

The budget for the WMO/ICSU/IOC Joint Climate Research Fund (JCRF) for the WCRP for the first biennium (2004-05) of the WMO Fourteenth Financial Period 2004-07 was presented to JSC.

The budget for the WMO Fourteenth Financial Period, 2004-07, was approved at the WMO Fourteenth Congress held in May 2003. The fifty-fifth session of the WMO Executive Council, May 2003, then approved the budget for the JCRF for the biennium 2004-05. It noted that ICSU was expected to contribute SFR 786,000 (equivalent to USD 600,000, using the UN official exchange rate of May 2003 (SFR 1.31/USD)) and IOC was expected to contribute SFR 655,000 (equivalent USD 500,000) to the fund for 2004-05. It authorized a total WMO contribution of SFR 3,935,400 for 2004-05. A detailed list of specific activities for the first biennium, 2004-05, of the Fourteenth Financial Period, was also approved. Several decisions have compounded to result in a highly significantly reduced figure (in SFR) budgeted for JCRF-supported WCRP activities for the WMO Fourteenth Financial Period (2004-07) compared with the corresponding budget for the Thirteenth Financial Period (2000-03). These include: the decision of the WMO Congress (May 2003) to adopt effectively a zero nominal growth budget; new WMO directives about staffing and staff costs; and the imposed (May 2003) UN official exchange rate (SFR 1.31/USD). The net effect is a

notional loss of about 1.9M SFR in the JCRF budget for WCRP activities in 2004-07, relative to the period 2000-03.

The number of positions in the Joint Planning Staff (JPS), Geneva, is 7.6 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 support to its core projects through its four International Project Offices is also generally under-funded and otherwise under-resourced, and therefore under constant and increasing strain.

In noting the above situation with concern, the JSC also recognised that the COPES initiative, combined with the special activities and events proposed for WCRP's 25th anniversary (2005), would require resources not budgeted for. JSC therefore requested that the Director, WCRP, should appeal through the official WMO processes and procedures for additional funds to be made available though the JCRF for the WCRP budget for 2004-05.

In view of the scarcity of, and pressure on, resources and the significant decrease in available funds in the JCRF for period 2004-07, JSC members are asked, as part of their primary duty as advocates of the WCRP in their home countries, to pursue actively and vigorously all means of finding additional support and funding for the WCRP, the operation of the Joint Planning Staff for the WCRP and the four International Project Offices. Furthermore, JSC members are invited to investigate possibilities for obtaining national and institutional resources to cover the costs of attendance of individual national participants in WCRP meetings, working group sessions, and workshops. JSC members are also asked to encourage increased national contributions to the ICSU fund for the WCRP (approaches need to be made to the relevant national scientific council or body in members' countries).

In noting the above situation with concern, the JSC recognised that the COPES initiative, combined with the special activities and events proposed for WCRP's 25th anniversary (2005), would require resources not budgeted for. JSC therefore requested that the Director, WCRP, should appeal through the official WMO processes and procedures for additional funds to be made available through the JCRF for the WCRP budget for 2004-05.

15. DATE AND PLACE OF THE TWENTY-SIXTH SESSION OF THE JSC

The JSC gratefully accepted the kind invitation of Professor P. Cornejo R. de Grunauer, JSC Member, to host the twenty-sixth session of the Committee in Guayaquil, Ecuador, from 14 to 18 March 2005.

16. CLOSURE OF SESSION

Closing the session, the Chairman expressed his thanks to all participants for their contributions to the session, the high quality of scientific discussions, and the actions that had been taken for further development of the WCRP. Looking ahead, he called for further discussions on the new WCRP strategic framework Coordinated Observation and Prediction of the Earth System (COPES). The Chairman also acknowledged the excellent scientific presentations that had been given to the Committee by Dr V. Kattsov, MGO, St Petersburg, on "Arctic Climate in the 21st Century: modelling and scenarios", and by Dr O. Zolina, IORAS, Moscow and MIUB, Bonn, on "European precipitation: long-term changes in the extremes, their reliability and impacts".

The Chairman expressed deep gratitude to colleagues who were now retiring from their positions and who had been long involved in WCRP activities and in supporting the JSC. In particular, he emphasised again the remarkable contributions of Marie-Lise Chanin, Kamal Puri and Jurgen Willebrand.

Finally, the Chairman expressed his special thanks to Dr S. Gulev, his colleagues and staff for the excellent arrangements that had been made for the JSC session, all the facilities provided, and generous hospitality. He asked that the appreciation of the JSC be conveyed to all involved.

The twenty-fifth session of the WMO/ICSU/IOC Joint Scientific Committee for the WCRP was closed at 1230 hours on 6 March 2004.

APPENDIX A

LIST OF PARTICIPANTS

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APPENDIX C

REPORT OF THE WCRP COORDINATED OBSERVATION AND PREDICTION OF THE EARTH SYSTEM (COPES) TASK FORCE ON SEASONAL PREDICTION (TFSP)

(Submitted by B. Kirtman, Chair, TFSP)

1. BACKGROUND

The World Climate Research Programme (WCRP) was established with the following aims:

- *To determine to what extent climate can be predicted*
- *To determine the extent of man's influence on climate*

These two aims have been, and remain, the main guiding principles for WCRP activities. The essence of WCRP science, guided by these two aims, is understanding, observation, quantification, prediction and projection of the climate system. The WCRP has launched several successful observational and modelling programmes designed to address these objectives. The Tropical Ocean Global Atmosphere (TOGA) project was an excellent example of one of these programmes.

Currently, the WCRP is organized into four major sub-programmes: CLIVAR, GEWEX, CliC and SPARC. In addition, WCRP established two over-arching modelling activities overseen by the Working Group on Numerical Experimentation (WGNE) and the Working Group on Coupled Modelling (WGCM). The CLIVAR programme addresses the physical aspects of understanding how the Earth's climate system works, documenting its variability, detecting and attributing human influences, determining the extent to which climate is predictable and developing predictive capabilities. CLIVAR primarily focuses on the role of the oceans in climate. One of the main goals of GEWEX is to understand the full energy and water cycle of evaporation, cloud formation, and precipitation and the role of land surface processes, as the highest priority for predicting climate variations and climate change. The SPARC programme deals with the role of stratospheric dynamical, chemical and radiative processes in the influence of the climate of the troposphere-stratosphere system. The key scientific issues have been identified as: the influence of the stratosphere on climate, the physics and chemistry associated with stratospheric ozone decreases and stratospheric variability. The main theme of CliC is the role of the cryosphere in climate. By establishing these four processes based research components, the WCRP has articulated a framework and a pathway for the world's climate research, which have been embraced by the world community, and each of the components has made tremendous progress in observing, modelling understanding the mechanisms for the processes associated with the individual components of the climate system.

A fundamental guiding principle for WCRP activities will be the vision that the problem of prediction from weeks through decades to the projection of climate changes is seamless. The continuum must be predicted. It must be recognized that the regional manifestations of global change will be felt by society mainly through changes in the character of existing modes of climate variability. For example, just as the presence or absence of a strong ENSO event can significantly change the nature of intraseasonal variations, a warmer climate can change the nature of ENSO events. For predictions beyond one or two weeks, it is essential to include the interactions between the atmosphere, ocean, land and cryosphere. While the essence of WCRP science is observations, diagnosis and modelling of the physical climate system leading to a better understanding of the mechanisms that determine the mean climate and its variability, the ultimate expectation is that the WCRP will provide the coordination and tools necessary for the prediction of the total physical climate system including an assessment of what is, and what is not, predictable.

1.1 Coordinated Observation and Prediction of the Earth System (COPES)

In the context of the above vision for the WCRP, and recognizing the renewed emphasis on the seamless prediction of the total physical climate system from weeks through decades to the projection of climate change, and the observational and modelling activities that are needed to achieve this, the WCRP is developing a new strategic framework for 2005-2015 called Coordinated Observation and Prediction of the Earth System (COPES).

The COPES strategy will include three central themes:

(i) To describe the structure and variability of the global coupled ocean-land-atmosphere cryosphere climate system, and to model and understand the mechanisms and coupled processes responsible for observed climate variability and change.

(ii) To assess the predictability of the physical climate system, and to determine the extent to which regional climate is predictable by making retrospective forecasts of weekly, seasonal, interannual and decadal variations for the 30 year period (1979-2009) and real time forecasts for the 10-year period (2010-2020).

(iii) To understand the mechanisms that determine the anthropogenic regional climate change and variability, and to estimate the uncertainty in prediction of regional climate change.

COPES represents a synthesis of the ongoing observational and modelling activities of the various WCRP components. COPES will have the dual goals of providing society with a tangible result on what is, and what is not, predictable at weekly, seasonal, interannual and decadal time scales. It will also provide the research community with a central theme for building climate observation systems, developing climate system models and climate data assimilation techniques, and making estimates of the uncertainty in the prediction of regional climate variations in a changing climate.

1.2 Task Force on Seasonal Prediction

Recognizing the importance of seasonal prediction as a specific objective under COPES, the JSC recommend that a limited-term Task Force on Seasonal Prediction (TFSP) be established. This task force would draw on expertise in all WCRP core projects (i.e. CLIVAR, GEWEX, CliC and SPARC), WGNE and WGCM, and will report to the JSC in March 2004. The overarching goal of the TFSP was to determine the extent to which seasonal prediction is possible and useful in all regions of the globe with currently available models and data.

In order to provide direct and immediate support and input to the TFSP, the International CLIVAR Project Office (ICPO) and the CLIVAR Scientific Steering Group (SSG) asked the Working Group on Seasonal-to-Interannual Prediction (WGSIP) to take the lead in organizing a seasonal prediction workshop drawing on expertise across all the relevant WCRP activities. The goals and expected outcomes of the workshop included:

(i) Assessing the nature and level of seasonal prediction activities across the whole of WCRP. What is the current state-of-the-art in seasonal predictions? What prediction data sets are currently available?

(ii) Developing a strategy and working plan for determining the extent to which seasonal prediction is possible and useful in all regions of the globe with currently available models and data.

(iii) Identifying the current limitations and prospects for improving seasonal predictions. What are the present data sets that support seasonal prediction? What new/improved data sets are required to advance seasonal prediction skill? What sort of advances might we expect?

(iv) Assessing the current and planned process studies and field experiments that will have a demonstrable impact on WCRP seasonal prediction activities.

(v) Describing the programmatic structures or mechanisms that are needed to facilitate the development and improvement of WCRP seasonal prediction activities.

The overarching objectives of COPES include designing a comprehensive set of WCRP-wide coordinated prediction and predictability experiments with ocean-land-atmosphere models that will ultimately lead to seamless weekly-seasonal-interannual-decadal forecasts. The workshop and the creation of the TFSP are the first steps towards allowing WCRP to meet these objectives. This report, based on the outcomes of the workshop, describes a set of seasonal prediction experiments that are designed to form a foundation for COPES (see Section 2).

1.2.1 TFSP Terms of Reference

(i) Determine the extent to which seasonal prediction of the global climate system is possible and useful in all regions of the globe with currently available models and data. This activity necessarily includes assessing predictability at the appropriate temporal and spatial scales, and how climate change might affect seasonal predictability and actual prediction. This charge draws heavily on expertise within the CLIVAR WGSIP in meeting its own Terms of

Reference (ToR), but also extends beyond the scope of WGSIP to include the wider expertise in all WCRP core projects (i.e. CLIVAR, GEWEX, CliC and SPARC), and in WGNE and WGCM, by considering *all* elements of the climate system and the possible impacts of climate change.

(ii) Identify the current limitations of climate system models and observational data sets used to determine seasonal predictability and to produce useful seasonal forecasts. Such an assessment should also identify the current observational and modelling barriers to producing seamless weekly to decadal predictions. Again, the TFSP will rely heavily on the knowledge base and expertise already developed within WGSIP, but complemented strongly by synthesizing the relevant ongoing observational and modelling activities across WCRP.

(iii) Develop a coordinated plan for pan-WCRP climate-system, retrospective, seasonal-forecasting experiments. These should be designed to include as many modelling groups (and models) as possible, and should be highly explicit in their experimental strategy. These experiments will include coupled ocean-land-atmosphere-cryosphere models and the uncoupled component models.

(iv) The TFSP will submit a preliminary report regarding items (i)-(iii) above to the JSC session in March 2004, and a final report to the following JSC session in March 2005.

While it is clear that the TFSP will depend significantly on input and guidance from the CLIVAR WGSIP, it is also evident from the above ToR that it also requires considerable collaboration and coordination across the WCRP. While the TFSP is intended to be a short-term task force (i.e. until March 2005), the development and implementation of the still-emerging Coordinated Observation and Prediction of the Earth System (COPES) will require continual assessment of the skill of seasonal forecasts. This requires an ongoing process for developing strategies for improving the evaluations of the predictions and observing systems which will extend beyond the life span of the TFSP, but falls naturally within the purview of WGSIP. The seamless weekly-to-decadal prediction activities envisaged under COPES will involve all elements of the climate system, and, therefore, must also reach beyond WGSIP to involve all relevant parts of the WCRP.

2. SEASONAL PREDICTION EXPERIMENTS

One of the overarching goals of COPES is determine the predictability of the complete climate system on time scales of weeks to decades. Here we focus on seasonal time scales. By complete climate system, we mean contributions from the atmosphere, oceans, land surface, cryosphere and atmospheric composition in producing regional and seasonal climate anomalies. Advances in climate research during the past decade have led to the understanding that modelling and predicting a given seasonal climate anomaly over any region are incomplete without a proper treatment of the effects of SST, sea ice, snow, soil wetness, vegetation, stratospheric processes, and chemical composition (carbon dioxide, ozone, etc.,). The observed current climate changes are a combination of anthropogenic influences and the natural variability. In addition to possible anthropogenic influence on climate due to changing the atmospheric composition, it is quite likely that land use in the tropics will undergo extensive changes which will lead to significant changes in the biophysical properties of the land surface, which in turn will impact atmospheric variability on seasonal time scales. It is therefore essential that research by the two communities (i.e., climate change and seasonal prediction) be merged into a focused effort to understand the predictability of the complete climate system.

This problem of prediction and predictability of seasonal climate variability is necessarily multi-model and multi-institutional. We argue that the multi-model approach is necessary because there is compelling evidence that, with imperfect models, perturbing the physics of the models is superior to perturbing initial conditions of one model in terms of resolving the probability density function or quantifying the uncertainty. A multi-model approach is essentially a simple and consistent way of perturbing the physics. Moreover, by testing our hypotheses with multiple models it is possible to determine which results are model independent, and hence likely to be robust. This problem is also necessarily multi-institutional simply because the level of effort and computational resources required is too large for any one institution.

The primary role of COPES (and the JSC) should be to ensure that these experiments are coordinated across all relevant WCRP activities. The various component projects of the WCRP will continue to provide the key elements for this experiment through their efforts to develop strategies and experiments for improving the forecasts and component models, and by carrying out observing system evaluations, process studies and field campaigns.

2.1 The Total Climate System Prediction Experiment

The TFSP proposes a comprehensive seasonal prediction experiment that is designed to test the following hypothesis:

> *There is currently untapped coupled predictability due to interactions and memory associated with all the elements of the climate system (Atmosphere-Ocean-Land-Ice).*

The core experiment is an 'Interactive Atmosphere-Ocean-Land-Ice Prediction Experiment' emphasizing the use of comprehensive coupled general circulation models that include realistic interactions among the component models. The experiment is to perform six-month lead ensemble (10-member) predictions of the total climate system. If possible, longer leads and larger ensembles will be encouraged. The initialization strategy is to use the best available observations of all the components of the climate system.

While the emphasis is on comprehensive coupled general circulation models, uncoupled component, intermediate, simplified and statistical models are encouraged to participate where appropriate. The fundamental experimental design is to mimic real prediction in the sense that no "future" information can be used after the forecast is initialized. For example, the DEMETER or DSP experiments would be excluded because they use observed SST as the simulation evolves, whereas the SMIP/HFP experiment could be included as a subset since no future information is used as the forecast evolves[1].

The component models should be interactive, but this is left open to allow for a wider participation, e.g. for groups without sea-ice or vegetation model. The only firm requirement is that no "future" information is used once the prediction is initialized. This requirement means that model tuning and development using observations should be done with data taken from an independent time period (i.e. in a cross-validated way). This is also the case with any statistical model development for the possible prediction of the boundary conditions. The intent here is to mimic real forecast situations and to exclude any artificial skill.

The component models are:

- Ocean – Open but interactive (e.g., slab mixed layer or GCM)
- Atmosphere – Open but interactive, most likely a GCM
- Land – Open but interactive, e.g. SSiB, Mosaic, BATS, CLM, Bucket …
- Ice – Open but interactive (e.g., thermodynamic or dynamic)

The results of these experiments provide a framework for future experiments; specifically these prediction results will:

(i) Provide a baseline assessment of our seasonal prediction capabilities using the best available models of the climate system and data for initialization.
(ii) Provide a framework for assessing current and planned observing systems, and a test bed for integrating process studies and field campaigns into model improvements.
(iii) Provide an experimental framework for focused research on how various components of the climate system interact and affect one another.
(iv) Provide a test bed for evaluating IPCC class models in seasonal prediction mode.

The TFSP recognizes that certain elements of the proposed experiment are already part of various WCRP activities. The intent here is to leverage these ongoing activities and to coordinate and synthesize these activities into a focused seasonal prediction experiment that incorporates all elements of the climate system. These experiments are the first necessary steps in developing seamless weekly-to-decadal prediction of the complete climate system.

The parameters of the experiment are as follows:

[1] The SMIP/HFP experiment is viewed as a subset of the experiments proposed here since they do not necessarily include feedbacks from land surface or sea ice processes or the initialization of these components of the climate system.

(i) Coupled models and resolution are left to the individual participants, but it is desirable that the models have a realistic simulation of the atmosphere, ocean, land and ice and the interactions among these components. Simplified component models (e.g., slab mixed layer or statistically predicted ice) are acceptable as long as the no future information is used in developing the simplified model.

(ii) Atmospheric initial states are to be taken from NCEP (or ECMWF) reanalysis each month of each year from 1979-present. Forecasts should be initialized on 00Z and 12Z on the last five days of each preceding month forming a 10-member ensemble. Other strategies for generating the ensemble members are acceptable as long as the basic principle of no future information as the forecast evolves is not violated. Each ensemble member should be run for at least six months. Additional ensemble members and longer leads are encouraged.

(iii) Oceanic initial states: (if appropriate) to be taken from most appropriate ocean data assimilation system.

(iv) Sea Ice initial states: (if appropriate) to be taken from best available observational data.

(v) Land initial states: (if appropriate) to be taken from most appropriate land data assimilation system or consistent offline analyses driven by observed meteorology (i.e., GSWP).

(vi) Atmospheric output:
   a. Every 24 hours at 00 GMT-
      i. Pressure levels (instantaneous): Geopotential Height, Temperature, Velocity and specific humidity for 850, 500, 200, (if available 100, 50, 10; these higher pressure levels are used for interactions with SPARC) hPa.
      ii. Surface (instantaneous): 2m Tmax – daily, 2m Tmin – daily, Total soil moisture, Snow depth, Sea surface temperature and/or some temperature over land, Mean sea level pressure
      iii. Surface (accumulated): Total precipitation, Downward surface solar radiation, Downward surface longwave radiation, Surface net solar radiation, Surface net longwave radiation, Top net solar radiation, Top net longwave radiation, Surface momentum flux, Evaporation.
   b. Every 6 hours at 00, 06, 12, 18 GMT-
      i. Surface (instantaneous): Total cloud cover, 10m wind, 2m Temperature, 2m Dew Point, 2 m specific humidity.

(vii) Oceanic output (where appropriate)
   a. Every 24 hours at 00 GMT-
      i. Accumulate temperature, salinity and currents in the upper 250 meters, surface fluxes of heat, momentum and fresh water, sea level height, mixed layer depth
   b. Every 6 hours at 00, 06, 12 18 GMT-
      i. Surface fluxes of heat, momentum, and freshwater. Sea level height and mixed layer depth

(viii) Sea Ice output (where appropriate)
   a. Every 24 hours at GMT –
      i. Surface fluxes of heat and momentum. Snow cover, Sea ice concentration, thickness and temperature.

(ix) Soil wetness and vegetation predicted.

(x) Snow cover and depth predicted.

(xi) Chemical Composition (carbon dioxide, ozone …) prescribed and varying. This explicitly includes the transient changes in the chemical composition from 1979-present.

2.2 Examples of Potential Diagnostic Sub-Projects

In order to maximize collaboration and minimize duplication of effort, the proposed experiment will include a diagnostic sub-project approval process. The following is an abbreviated list of potential sub-projects. It is anticipated that a large number of additional sub-projects will be implemented as the experimental results become available.

- Limit of Predictability Estimates: One potential estimate for the limit of predictability is to determine when a particular forecast probability density function (pdf) is indistinguishable from climatological pdf of the forecasts.
- ENSO mechanism diagnostic: Recharge oscillator versus delayed oscillator, role of stochastic forcing, westerly wind events.

- Impact of the AO on seasonal predictability
- Regional predictability
  - Local land surface predictability
  - Extreme events
  - Monsoon predictability
  - Diurnal cycle in ocean
  - Diurnal cycle in the atmosphere
- Coupled Feedbacks
  - Intra-seasonal oscillations

2.3 Unresolved Issues

- A timeline for the Total Climate System Prediction Experiment (TCSPE) should be developed. Although it was agreed to discuss this issue in more depth at the next session of the JSC, a date around 2008 or 2009 (30 years of FGGE) was suggested for completion of the first phase. It was recognized that earlier dates would be hard to match because of the IPCC AR4.
- SMIP/HFP experiment should be continued. It was considerable value-added to the TCSPE.
- Dialogue with ENSEMBLES was encouraged, since this project has very similar goals and scope. Nevertheless, not all diagnostics and analysis will match with TCSPE.
- The final proposal should also include a connection to applications of the predictions (including links to IHDP).
- Data: The data requirements from the DEMETER project could serve as a starting point. Details need to be fleshed out. The TFSP should start to develop a data management plan for TCSPE, which should be handed over to WCRP once their DM structure is in place.
- Observational data requirements for verification: These requirements need to be formulated as well as the requirements for data in order to initialize the experiments.

ESSP MODELLING STRATEGY:
Requirements to Understand and Predict the Earth System

Proposed by P. Lemke and B.J. Hoskins

(18 May 2004)

The current status of modelling the Earth system is characterized by sophisticated high-resolution general circulation models (GCMs) for the physical climate system, with these complex models being expanded to encompass chemical and biological aspects of the Earth system. In particular, detailed models for the atmospheric chemistry and the carbon cycle, including dynamic vegetation modules and interactive marine ecosystems, are now being developed for GCMs. Earth system Models of Intermediate Complexity (EMICs) offer a complementary approach for long-term simulations, and more holistic, exploratory models are being developed for the investigation of the interaction of human societies with the other components of the Earth system. Improvement of the present modelling capability thus requires a co-ordinated hierarchical approach with a suite of different models. In particular, there is a need for:

1. Experimentation with current GCMs to:

    a. provide the material for IPCC and other international assessments through sensitivity studies, climate hindcasts and projections of future change;
    b. assimilate and predict the coupled system on intraseasonal to interannual (and eventually longer) time-scales.

2. Continued experimentation (including 'retrospective predictions' at various time-scales) and process studies with current GCMs and comparison with observations to improve and validate the models used in 1.

3. Development of the ability to perform more detailed global modelling of the carbon cycle, hydrology, dynamic vegetation, tropospheric and stratospheric chemistry, ocean biology, lateral transport of elements and a range of other biogeochemical processes (requiring observations, process studies and modelling of the individual systems).

4. Work on extending GCMs to include each of these additional components of the Earth system in turn, as a basis for the studies in 1.

5. Development of and work with more holistic models (including EMICs) to:

    a. study the interactive aspects of the natural system;
    b. simulate longer time-scales, e.g. Ice Age Cycles;
    c. compare and validate with GCMs where possible.

6. Development of models of the interaction between the human and natural systems based on the more holistic models.

7. Use of simpler models to help in the design of the diagnosis of the more complex coupled models.

The effective development and implementation of such a modelling programme would require a range of separate but coordinated and collaborative activities. Including all of these in a single overarching ESSP activity would not be appropriate, at least at this stage. Instead, the coordination of the various modelling activities above could be achieved at least initially through presentation, discussion and agreement at the now-annual sessions of the ESSP Chairs and Directors. However, more dedicated mechanisms, procedures and fora will also be needed to make effective progress on the necessary cooperative efforts, and such issues should also be considered in the first instance and as a matter of high priority by the ESSP Chairs and Directors.

Based on experience and track-record to date, it would be most fitting for WCRP to continue to take the lead for activities 1 and 2 above, through its projects and Working Group on Coupled Modelling (WGCM), drawing on the expertise of IGBP projects as appropriate. In turn, IGBP should continue its lead, in partnership with WCRP, in activity 3, which builds on the work of the IGBP projects and draws, as appropriate on the expertise of WCRP projects. Item 4 is being implemented through the existing partnership between WCRP's WGCM and IGBP's Global Analysis, Integration and Modelling (GAIM) activity (to be replaced in IGBP by Analysis, Integration and Modelling of the Earth System (AIMES)), with WCRP taking the lead. This productive partnership provides a common platform for a broad range of communities to collaborate as complex models of the physical climate evolve towards more complex and integrated Earth System models. IGBP should take the lead for activity 5, which must provide inputs to activities 2 and 3, linking closely with WGCM, WCRP Climate Variability and Predictability (CLIVAR) project and IGBP's Past Global Changes (PAGES) project. Activity 6 should be implemented in the first instance through a full and equal partnership between IGBP and IHDP, with WCRP being kept informed but with a view to playing an increasingly more active and direct role in the development, use and evaluation of such model components. Activity 7 is relevant for each of the ESSP programmes.