WCRP ACCOMPLISHMENT REPORT 2007-2008

Climate Research in Service to Society

WCRP
World Climate Research Programme

World Climate Research Programme
Improving climate predictions and understanding human influence on climate

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WCRP Accomplishment Report 2007-2008
Climate Research in Service to Society

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Contents

WCRP
World Climate Research Programme

SPONSORS' STATEMENTS

WCRP has made a substantial contribution to the IPCC and has significantly improved our understanding of the climate system. The future challenge to climate change science is to develop a fully integrated view of the Earth system that takes into account the physical, biogeochemical and human dimensions. WCRP is in a good position to lead an Earth system modelling effort that will ultimately deliver tangible benefits to society.

Thomas Rosswall, Executive Director, ICSU

The United Nations has been playing a key role since 1984 in organizing scientific research on understanding and forecasting climate change. WCRP's coordinated research activities are making possible better prediction and assessment of the impact of sea-level change, better understanding of modes of climate variability, such as El Niño and the North Atlantic Oscillation phenomena, assessment of the risk of abrupt climate change and predicting changes in the strength and frequency of storms and tropical cyclones. WCRP is also a key element in the UNESCO and WMO-led cross-cutting element of the United Nations system's response to climate change in science, monitoring, assessment and early warning. It is also an important programme for UNESCO's contribution to climate strategy and for the IOC to deliver on its high-level objective in predicting climate change and assessment of its impact on the oceans.

Patricio Bernal, Executive Secretary, IOC, Assistant Director-General, UNESCO

Since the establishment of WCRP by WMO and ICSU in 1980, a key WMO objective has been to empower WMO Members to improve further the quantity and quality of their climate information services and products for an increasingly wide range of applications. WCRP scientists have spearheaded vital research activities in climate science, which, in turn, have enabled WMO Members to provide improved climate information and services to their societies. WCRP has also enabled us to advance our understanding of the way the Earth's climate system works and upgrade continuously the methods and models needed to predict its evolution. These models and methods are increasingly being used at Regional Climate Outlook Forums, which bring together scientists and practitioners from developed and developing countries, enabling them to share their ideas and knowledge, build capacity and develop consensus assessments of the status of our knowledge about climate variability and change and their regional impact. In addition, assessments by the WMO/UNEP Intergovernmental Panel on Climate Change (IPCC) would not be possible without significant contributions by many WCRP scientists and groups. WCRP modelling experiments were the basis for many of those assessments, and some of the relevant outputs were the climate projections being used by WMO Members in determining the likely impacts of climate variability and change, in assessing the vulnerability of natural resources as a result of these impacts and in preparing adaptation plans and mitigation strategies to manage emerging risks. WMO considers WCRP to be one of its key programmes and is pleased with the excellent collaboration that has evolved with its WCRP-sponsoring partners over the past few decades. WMO looks forward eagerly to additional WCRP contributions to the development of enhanced prediction services for climate, weather, water and the environment, as well as to the continuous strengthening of interaction among research communities.

Michel Jarraud, Secretary-General, WMO

MESSAGE FROM THE CHAIR

PHOTOMONTAGE: WMO

As the new Chair of the WCRP Joint Scientific Committee (JSC), I would like to thank the previous Chair, John Church, and Vice-Chair, Venkatachalam Ramaswamy, for their steady and unstinting leadership over the past several years. Together with the incoming Vice-Chair, David Griggs, Professor and Director of the Monash Sustainability Institute in Melbourne, Australia, and on behalf of the JSC as a whole, we look forward to working with Dr Ghassem Asrar, the newly appointed Director of WCRP. Dr Asrar's wealth of experience in climate science, observing systems and inter-governmental negotiation will serve the WCRP well as we work to meet tomorrow's climate challenges.

The new WCRP leadership team faces challenges and opportunities. Last year's Fourth Assessment from the Intergovernmental Panel on Climate Change (IPCC) clearly demonstrated the importance and need for climate information on spatial and temporal scales demanded by society. The related implications for the world's climate research agenda span the spectrum from climate change to extreme events and include the influence of aerosols on precipitation, ice-sheet dynamics and sea-level rise, modulation of modes of climate variability within a warming climate and high-resolution climate prediction and projections. As demonstrated by this year's World Modelling Summit for Climate Prediction, jointly organized by WCRP, the International Geosphere-Biosphere Programme and the World Weather Research Programme, our ability as a research community to make the transition from studies of global climate variability and change to application at the regional level has tremendous ramifications for present and future climate models, observations and needed infrastructure, such as high-performance computing.

Illustrative of the responsibility given to WCRP is the forthcoming Third World Climate Conference (WCC-3) to be held in Geneva, Switzerland, from 31 August to 4 September 2009. The two previous World Climate Conferences played a major role in establishing WCRP and the IPCC. Since 1979, WCRP has helped lead and

coordinate efforts to understand the variability and predictability of individual components of the climate system, making it possible to improve confidence in projections of the climate, one of WCRP's original objectives, and to apply research results for the benefit of society. WCC-3 will build on that success by highlighting climate prediction for decision-making with a focus on the application of climate information and predictions to problems related to agriculture, water, health and sustainable development.

A few weeks after WCC-3, OceanObs'09 will take place in Venice, Italy. Almost a decade has passed since the OceanObs'99 symposium in Saint Raphael, France, which played a key role in consolidating plans for a comprehensive ocean observing system able to deliver systematic global information about the ocean's physical environment. WCRP was a major sponsor of that conference, which helped to determine future research directions for study of the oceans' role in climate. OceanObs'09 will seek to sustain and further develop the current ocean observing system and support the spread of its full benefits across all stakeholders and for all participating countries. Once again, WCRP will be called upon to identify the research needed to back the transition from basic research to applications and operations determined by the role of the oceans in climate.

The WCRP Strategic Framework 2005–2015 for Coordinated Observation and Prediction of the Earth System has been put in place to meet just those sorts of demands on the programme. Building on the physical climate expertise in our core GEWEX, CLIVAR, SPARC and CliC projects and together with our colleagues in the Earth System Science Partnership (ESSP), the JSC looks forward to fulfilling WCRP's responsibilities in meeting these challenges and opportunities at such a critical juncture in world climate research.

Antonio J. Busalacchi
Chair of the WCRP Joint Scientific Committee,
August 2008

ADVANCES IN MODELLING AND SEAMLESS PREDICTION

DEUTSCHER WETTERDIENST

The first comprehensive climate prediction models evolved from numerical models[1] used for weather forecasting. Over the years, weather and climate prediction systems have diverged more and more. For example, priorities for weather prediction systems have focused on the development of numerical accuracy and optimal data assimilation methodologies, whereas Earth-system complexity has been the focus of climate prediction research. Both weather and climate prediction models use truncated versions of the underlying partial differential equations of physical and dynamical processes, with approximate empirically based parametrization schemes used to represent unresolved processes.

Reliable weather prediction continues to be critically important for the protection of life and property, particularly under extreme weather conditions. Recently, the demand for reliable climate prediction has increased dramatically as the issue of anthropogenic climate change has had a higher and higher profile on the global stage. Climate predictions are now used to guide policy on climate mitigation and, increasingly, regional investment decisions on, for example, infrastructure to adapt to climate change and its variations.

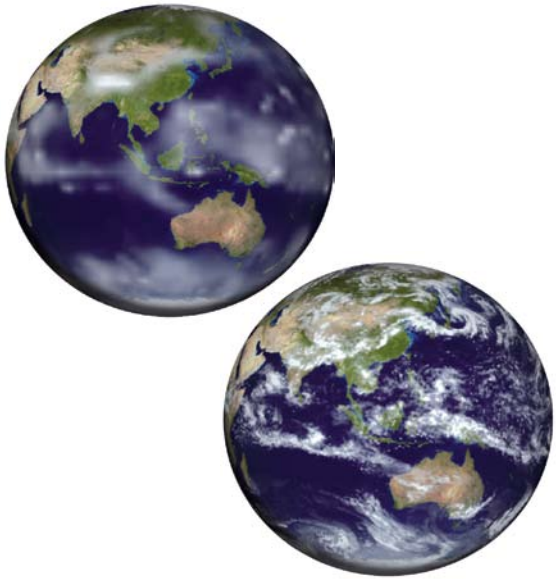
While the skill to forecast weather has improved substantially over the past few decades, uncertainties in predicting the impact of anthropogenic climate change on weather patterns continue to be substantial. To some extent, climate prediction uncertainties can be diagnosed by using multi-model ensembles of climate change predictions. However, using multi-model ensembles to diagnose uncertainty is not sufficient because there are sources of uncertainty in climate predictions associated with biases and errors common to all climate prediction models. For example, as acknowledged in the IPCC Fourth Assessment Report, we know that there are a range of climatic phenomena on timescales ranging from diurnal to multi-annual that are poorly simulated by most contemporary climate models.

The need for scientific advances and grand challenges in climate modelling was the background of the WCRP World Modelling Summit for Climate Prediction, held at the European Centre for Medium-Range Weather Forecasts in Reading, UK, on 6–9 May 2008. That Summit was co-sponsored by the World Weather Research Programme (WWRP/CAS) and the International Geosphere-Biosphere Programme (IGBP) in order to develop a strategy to revolutionize climate prediction during the twenty-first century that would provide the basis for reliable science-based adaptation and mitigation strategies designed to avoid the dire consequences of climate-related extreme events and management of their risks.

One of the key issues of that Summit was how the insights and constraints of numerical weather prediction could be brought to bear on the problem of quantifying and reducing uncertainty in climate predictions. For example, it is known that the representation of clouds in climate models is central to predicting global warming. However, the intrinsic processes associated with clouds occur on relatively fast timescales, and the quality of parametrizations of clouds can be tested in very short-range numerical weather prediction.

1 Numerical model: Computational representation of complex mathematical equations of motion in the atmosphere or ocean.

However, that raises a problem. If the models used in weather and climate prediction are fundamentally different from one another (cf. the divergence mentioned at the beginning of this article), then insights gained on the short weather timescale cannot readily be transferred to the longer climate timescale, and vice versa. For that reason, the notion of seamless prediction, a core pillar of WCRP strategic development, was one of the major issues discussed at that Summit.



TAKESHI ENOMOTO, EARTH SIMULATOR CENTER/JAMTEC

An illustration of the limitation of coarse-resolution, multi-decadal climate-projection models to resolve regional high-impact weather events routinely predicted by today's 14-day operational forecast systems. Top, global cloud distribution in a 320-km resolution climate simulation experiment. Lower globe, same as top but for a 20-km resolution simulation model, comparable in resolution to the most advanced weather forecast models of today.

For many prediction research centres, practical seamless prediction must wait for the next generation of modelling systems. Much of the discussion at the Summit concerned the practical development of next-generation seamless prediction systems. What would be the right balance between high resolution on the one hand and a more complete representation of the Earth system complexity on the other? How many independent climate models were desirable, as the global research community worked together on model development? As mentioned above, multiple models provide a means of estimating prediction uncertainty. However, quite different techniques were being developed based on stochastic representation of sub-grid processes, and a central question was whether those more systematic approaches to the representation of model uncertainty could in principle supersede the more ad hoc multi-model ensemble.

The issue of model resolution (horizontal and vertical) for climate prediction is complicated. On the one hand, we know that climate simulations are sensitive to parametrization of deep-convective[2] processes in the atmosphere. Hence, it seems natural that global climate modellers should strive to resolve deep-convective clouds explicitly. On the other hand, we appear to have no robust theoretical basis to quantify the expected decrease in uncertainty in climate predictions if deep-convective clouds were indeed resolved properly. For example, it may be that when deep convection is resolved, remaining uncertainties in cloud microphysics will still lead to substantial uncertainty in climate change predictions. In short, there seems to be

2 Convection: vertical motion of molecules driven by buoyancy forces arising from static instability leading to cloud formation.

little alternative to doing the numerical experiments and finding out. However, the global research community does not yet have the computing infrastructure to carry out those experiments.

The issue of computing infrastructure was also discussed at great length at that Summit, and there is general agreement that climate prediction is among the most computationally challenging problems in science and that progress in climate simulation and prediction is limited by the availability of computing resources. All climate centres around the world would like to have cutting-edge (so called "track one") high-performance computing technology that is becoming available to climate science. At present, that technology has reached petaflop[3] speed. However, there are currently no plans to use those computers exclusively for climate prediction, the importance of the issue notwithstanding.

One of the key outcomes of the Summit was the initiation of the Climate Prediction Project, coordinated by WCRP in collaboration with WWRP/CAS and IGBP and involving national weather and climate centres as well as the wider research community. The project's fundamental goal is to improve climate prediction, including prediction in changes in the probability of regional high-impact weather. It is strongly believed that improved predictions will be of particular help to developing countries whose national capabilities need to be increased substantially.

A key element of the Climate Prediction Project is a world climate research facility for climate prediction that will enable national centres to accelerate improvement of operational climate prediction. The central component of that world facility will be one or more dedicated multi-petaflop high-performance computing facilities to allow the numerical experimentation that currently cannot be done.

Advocacy at very high levels will be needed if such a facility is to become a reality, and that advocacy is already active. In addition, WCRP must take the lead in coordinating and facilitating the science underlying the Climate Prediction Project.

One of the most significant aspects of the World Modelling Summit for Climate Prediction was that it brought together, perhaps for the first time, a diverse set of experts from a range of disciplines. There were experts on short-range weather forecasting and on centennial prediction, on the underlying theory of weather and climate predictability, on practical issues related to

For too long, understanding and predicting weather and climate have been seen as separate problems. Getting them back together recognizes their intimate interrelationship and is essential for consideration of the impacts of regional climate change. A seamless-prediction approach provides a consistent basis for developing and testing models focussed on prediction on particular timescales.

Sir Brian Hoskins, University of Reading, UK

3 Petaflop: 10^{15} operations per second in computing.

the design of high-resolution dynamical cores that could scale across large numbers of processing elements, on representation of Earth-system complexity, on data assimilation, on deterministic parametrization of deep convection and on stochastic representation of unresolved processes.

As is well recognized in many areas of science, big leaps forward often occur when ideas cross from one area of science to another. However, the Climate Prediction Project will need a focus, and one clearly emerged from discussions at the Summit: seamless prediction on timescales ranging from a season to a few decades ahead. Why is decadal prediction such a relevant focus for WCRP seamless prediction activities? The following issues are pertinent.

- The internal dynamics of the coupled climate system and externally forced climate change truly interact at decadal timescales. Decadal prediction combines both the need for accurate initial conditions, central to weather forecasting, and the need for scenarios of greenhouse gases, central to centennial climate prediction. In that way, the experiences of numerical weather prediction and seasonal forecast communities on the one hand and centennial climate change communities on the other are extremely important in solving that problem. Initial studies have shown that there is skill in decadal prediction over and above the expected impact of increasing greenhouse-gas concentrations.

- Decadal prediction combines elements from all existing WCRP projects. Ocean-atmosphere and land-atmosphere interactions are absolutely paramount. However interactions with the cryosphere are also important on decadal timescales, as are interactions between the troposphere and stratosphere.

- The weather forecasting community has shown unambiguously the benefits of increased resolution

We are entering a very exciting era in which forecasts of increasing accuracy and fidelity can be made at the important decadal and regional scales of interest and concern to society. Such efforts will allow us to link climate change impact with human actions and drivers and to include in models feedback and interplay among physical changes, human-induced change (e.g., land use or engineered systems) and ecosystem changes. The new sets of probabilistic forecasts will need to be extensively validated, but will be of early use to many sectors of the economy and society. All of this will require the upkeep of an end-to-end "enterprise" model for the development and deployment of sophisticated Earth system codes. These codes will have to be extensible, portable and scalable in the context of modern computational architectures. We will need to focus on the development of human capital, as well as on building the needed cyberinfrastructure for this challenging task.

Dr Tim Killeen,
National Science Foundation, USA

for forecasting accuracy, but the climate community has been reluctant to embrace high resolution as a priority, not least because there are so many other demands for computing resources arising from the representation of Earth-system complexity. It is on the decadal timescale that we may see the first inklings about the potential benefits of using high resolution models for climate prediction and indeed of the benefits of striving for convectively resolved models. It is possible that the biggest impact of high resolution will be in the tropics. Therefore, the work of the Climate Prediction Project may benefit more than most, some of the world's developing countries.

- The issue of reliably representing forecast uncertainty in ensembles of climate predictions is critical. The weather and seasonal prediction community has made major strides in the analysis not only of multi-model ensembles but also using stochastic parametrization and perturbed-parameter methods. Assessing which of these methods, or indeed which combination of them, is likely to give the most reliable climate predictions is a central question for the future, and that can be assessed on decadal prediction timescales.

- A key focus for decadal and multi-decadal prediction will be modes of variability. For example, in the coming decades, can we make any useful predictions about changes in the Atlantic Meridional Overturning Circulation? Issues about the linearity versus non-linearity of such modes and the existence of regime-like structures continue to play a prominent feature in theoretical discussions of the nature of climate, and once again, decadal prediction will provide a focus for the analysis of such studies.

- The problem of model error is absolutely critical for decadal prediction. Is it important that many of the modes of variability of climate are not well simulated? Is simple bias correction sufficient to remove the effects of model drift, or is the non-linearity of climate such as to cause bias to destroy any useful predictability that may exist on the decadal timescale?

- In weather prediction, improvements in ten-day forecasts is almost entirely due to improvements in forecasts at day 1. Is it likely that the skill of decadal prediction will depend on the skill of predicting the first season?

I have no doubt that within the next decade or so, major global numerical weather prediction, climate and Earth prediction centers will be providing a set of high-resolution environmental products, including assessments, forecasts and projections over a large range of timescales, often with an associated estimate of accuracy, and produced by a set of highly integrated Earth system simulation models, so-called seamless prediction.

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Dr Michel Béland,
Environment Canada, Canada

- Decadal prediction studies will need to assess carefully whether the current observing network is adequate, thus establishing important links between observational and modelling communities.

- Prediction on timescales of one to a few decades ahead is central for guiding investment decisions on infrastructure for climate adaptation. For such investments, prediction of precipitation and storminess will be just as important as prediction of changing temperature.

In conclusion, the notion of seamless prediction, the unification of weather and climate science so that the insights and constraints of one can be brought to bear on the other, is a major issue of the Climate Prediction Project (an outcome of the recent World Modelling Summit for Climate Prediction). WCRP must play a central role in coordinating and facilitating the work of a very diverse range of experts who can be expected to contribute to this project. The seamless seasonal to decadal and multi-decadal prediction approach can also be expected to contribute significantly to the IPCC Fifth Assessment Report.

WCRP promoted the Modelling Summit statement and Climate Prediction Project at the 60th session of the WMO Executive Council in Geneva, Switzerland, in June 2008. The Executive Council considered the Summit statement in its deliberations and established an ad hoc task team to identify opportunities for coordination and integration of WMO research activities towards the goal of seamless weather, climate, water and environmental prediction and associated services that can benefit WMO Member countries and its partners.

Article by T.N. Palmer and J. Shukla

RECENT ACHIEVEMENTS

WCRP advances seasonal to decadal prediction

Predictions on seasonal timescales help farmers to choose what to plant and where and when. They help hydrologists to decide when to fill dams, health officials to determine the risks of the spread of infectious diseases and many others to make decisions that reduce risk of climate variability and change and improve the quality of life. The WCRP/CLIVAR Working Group on Seasonal to Interannual Prediction is tasked to assess and improve current seasonal prediction capability.

The first WCRP Seasonal Prediction Workshop was held in June 2007 in Barcelona, Spain, bringing together climate researchers, forecast providers and application experts to address the current status of seasonal forecasting and the application of seasonal forecasts by users. Workshop participants drafted a document outlining recommendations and best practices in the science of seasonal prediction (WCRP Seasonal Prediction Position Paper: WCRP Informal Report No.3/2008).

During the workshop, the WCRP Climate-system Historical Forecast Project (CHFP) was launched. That project is a multi-model, multi-institutional experimental framework for assessing state-of-the-science seasonal forecast systems and for evaluating the potential for untapped predictability due to interactions between components of the climate system that are currently not fully accounted for in seasonal forecasts.

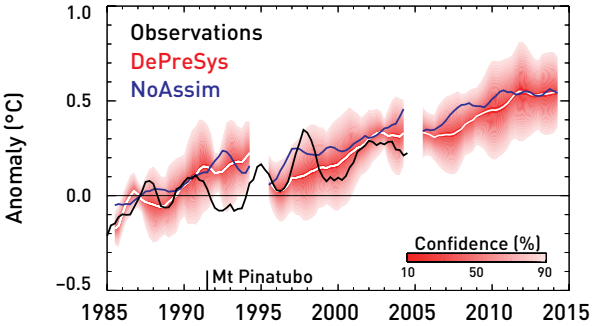
Decadal predictions are key for planning major infrastructure investments such as dams, seawalls and urban construction. In 2007, a new cross-cutting initiative was endorsed to advance the science of decadal prediction. Using state-of-the-science coupled models, a first series of experiments focused on short-term climate prediction for the next 30 years. Early results point toward the possibility of routine decadal climate predictions using a method that considers both internal natural climate variation and projected future anthropogenic forcing. Evidence for the existence of decadal predictability has arisen from research on the El Niño phenomenon and other global-scale oscillation systems, including hurricane activity and surface-temperature and rainfall variation.

Paving the way for future climate research

WCRP, in conjunction with the International Geosphere-Biosphere Project (IGBP) and the Global Climate Observing System (GCOS), organized a major workshop in October 2007 to use the findings of the IPCC Fourth Assessment Report to help guide future strategies for climate change observations, research and assessment. That workshop looked specifically at the most critical gaps in basic science and at deficiencies in information about climate change used for estimating impact, design of adaptation measures and assessment of vulnerability, particularly on a regional scale. For example, two important issues identified, which currently limit our confidence in projecting climate change, are our poor understanding of ice-sheet behaviour and its implication for sea-level rise and gaps in knowledge about the hydrological and carbon cycles. That workshop also made suggestions for research required to improve performance of regional climate change models. Workshop participants developed a risk management framework to link better science questions with

societal concerns in regions and various sectors (WCRP Series Report No. 127).

High-quality sustained observations are the basis for developing climate information products, which are urgently needed to assess climate change impact, society's vulnerability to them and to enable decision-making about adapting to future climate changes. Through two panels, the Atmospheric Observation Panel for Climate (AOPC) and the Ocean Observations Panel for Climate (OOPC), WCRP advises observation operators on data required for climate change detection, attribution and prediction. Technological solutions, proposed by WCRP in earlier scientific experiments, for example TOGA and WOCE, now form the foundation of operational observing systems. With the successful development of Argo and other observational techniques, WCRP is working towards engaging the predictive potential of the ocean to extend the predictive skill of seasonal forecasting systems and determine climate predictability at decadal timescales, which requires a breakthrough in our quantitative understanding of decadal modes of atmospheric circulation.



SMITH ET AL. (2008) SCIENCE 317

WCRP is currently exploring how to advance the science of decadal prediction. This figure shows globally averaged annual-mean surface temperature anomaly (for 1979–2001) forecast by the Met Office Decadal Prediction System (DePreSys) starting from June 2005. The confidence interval (red shading) is diagnosed from the standard deviation of the DePreSys ensemble assuming a t-distribution centred on the ensemble mean (white curve). An equivalent radiatively forced forecast (NoAssim) that has not been initialized with observations is shown for comparison (blue curve). Also shown are hindcasts starting from June 1985 and June 1995, together with observations from HadCRUT2v0A (black curve).

Climate models used to project climate change will soon include much greater biological and chemical detail than previous models. Today, standard climate models (referred to as atmosphere-ocean general circulation models, AOGCMs) include components that simulate the coupled atmosphere, ocean, land and sea ice. Some modelling centres are now incorporating carbon cycle models in a move toward an Earth system model (ESM) capability. Additional components to be included in ESMs are aerosols, chemistry, ice sheets and dynamic changes in vegetation.

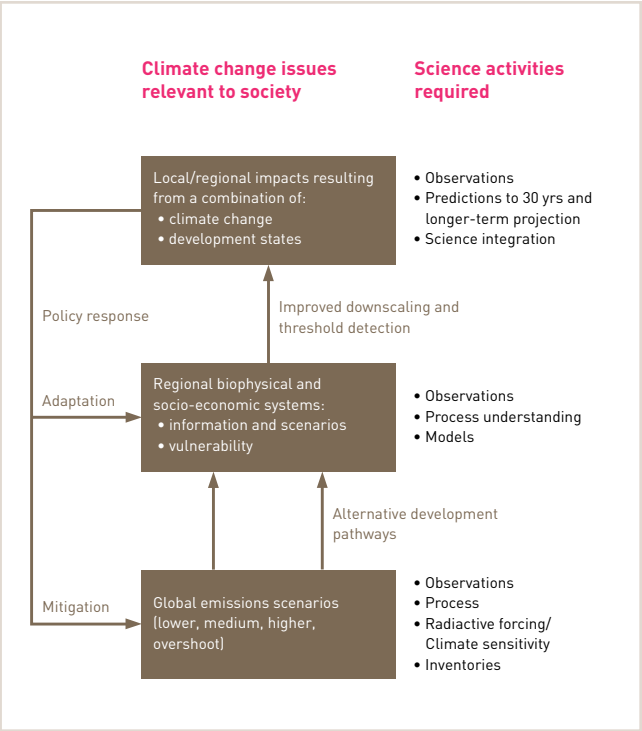
WCRP, in cooperation with IGBP, is developing a strategy for using climate system models as part of a coupled biophysical-climate and integrated model assessment approach in preparation for the next IPCC assessment. The next generation climate change stabilization experiments are outlined in the 'Aspen White Paper' (WCRP

Informal Report No. 3/2007). At the most recent session of the WCRP Working Group on Coupled Modelling held in September 2007 in Hamburg, Germany, the need for quantitative climate science was highlighted through improved simulations of climate and climate change and better prediction of anthropogenic climate change (WCRP Informal Report No. 8/2008).

Better climate information to address society's needs

WCRP scientists and WCRP activities contribute significantly to the collection and improvement of climate observations, model development and an understanding of the climate system required for the detection and attribution of past climate change and the provision of climate information, including projections of future change, as assessed by the Intergovernmental Panel on Climate Change (IPCC). Many WCRP scientists were involved as coordinating, lead and contributing authors and reviewers of chapters in the IPCC Fourth Assessment Report on the physical science basis of climate change. Almost half the contributors are WCRP-associated scientists, as are over 90 per cent of the coordinating authors and some 70 per cent of the reviewers. A milestone in the post-IPCC AR4 era was the Sydney Workshop (October 2007), where the WCRP, IGBP and GCOS communities continued to advance climate change science. To facilitate a more effective dialogue between the three IPCC working groups (WG I: physical science basis of climate change; WG II: impacts, adaptation and vulnerability to climate change; WG III: mitigation of climate change), two additional workshops were organized by WCRP. At the Aspen workshop (Aspen, Colorado, USA, August 2006), the anthropogenic-climate-change modelling communities met to discuss next-generation climate models and experiments regarding stabilization scenarios, and at the Netherlands workshop (Noordwijkerhout, The Netherlands, September 2007), experts continued their discussion on new climate change experiments and scenarios to drive them.

WCRP activities match the scientific priorities identified by the IPCC and provide the basis for responding to issues raised in the United Nations Framework Convention on Climate Change (UNFCCC). WCRP also contributed



GCOS, WCRP AND IGBP LEARNING FROM THE IPCC FOURTH ASSESSMENT REPORT. WORKSHOP AND SURVEY REPORT, JANUARY 2008

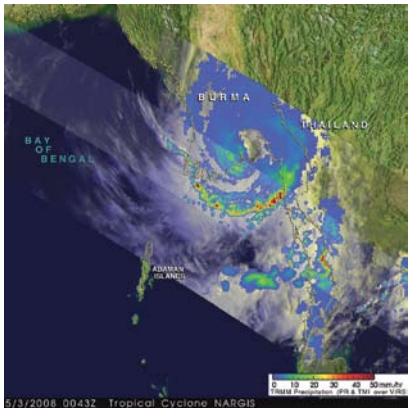
Climate change issues relevant to society (boxes), science activities required to address these issues (right) and policy responses.

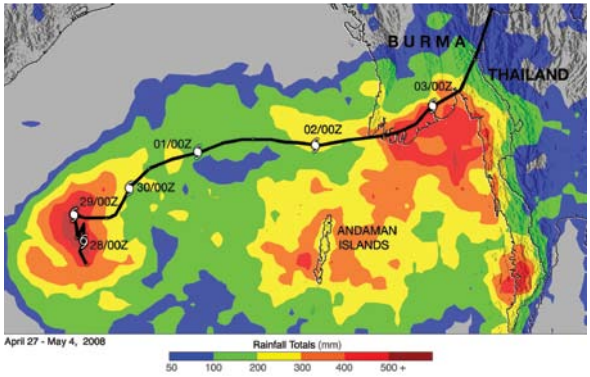
to the UNFCCC process through presentations at the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Conference of the Parties (COP) meetings in 2007 and 2008 and through participation in the Nairobi Work Programme workshops. WCRP is a leading partner in the Nairobi Work Programme in developing the science behind regional climate prediction. At the 28th session of SBSTA in Bonn, Germany, in June 2008, WCRP presented the current status of techniques for downscaling from global to regional in climate modelling. SBSTA has invited the research communities of WCRP and its ESSP partners to inform SBSTA regularly of new developments in research activities relevant to UNFCCC and the rest of the world.

Over the past year, WCRP projects have made significant progress in monsoon research, ensemble forecasting, the role of the ocean in climate and the study of droughts, among many other topics. In Asia, over three billion people rely on monsoon precipitation to obtain drinking and irrigation water. As part of the WCRP Integrated Monsoon Study (IMS), the Asian Monsoon Years 2007–2012 (AMY) research activities were launched to improve Asian monsoon prediction through better coordination of the many efforts in the region. To achieve its goal, AMY is coordinating approximately 21 regional projects throughout Asia and monsoonal Oceania and is integrating their scientific programmes into existing WCRP activities under CLIVAR and GEWEX. Ongoing WCRP regional and continental-scale activities in Monsoon Research include CLIVAR's Asian-Australian Monsoon and Indian Ocean Panels (AAMP and IOP), which have focussed on the prediction of the Indian and Australian monsoons whilst the GEWEX Asian Monsoon Experiment (GAME) and the SCSMEX (South China Sea Monsoon Experiment) focused on the eastern Asian monsoon. These and the other regional monsoon experiments including, under CLIVAR's Variability of the American Monsoon System (VAMOS) Panel, the North American Monsoon Experiment (NAME), the Monsoon Experiment in South America (MESA) and the La Plata Basin (LPB), all have distinctly regional approaches to monsoon issues as has the internationally funded African Monsoon Multidisciplinary Analysis (AMMA). In Asia, GEWEX has launched the Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative (MAHASRI). The GEWEX regional hydroclimate and land-surface projects are coordinated by the Coordinated Energy and Water Cycle Observations Project (CEOP), in order to achieve demonstrable skill in predicting ongoing and future changes in water resources and soil moisture as an integral part of the climate system up to seasonal and annual timescales.

A new WCRP effort is to support and strengthen scientific capacity worldwide in climate extremes research. WCRP aims to develop a framework for coordinating the study of extreme events, including observations and data handling, modelling, simulation, intercomparison projects, predictability of extremes and determining how and why extremes are changing.

Another WCRP research focus of immediate importance, especially to coastal communities and property, is to determine sea-level variability and change. Over the past decade, global mean sea level has been observed by tide





HAL PIERCE, NOAA/GODDARD SPACE

The WCRP projects GEWEX and CLIVAR have the lead in managing the new cross-cutting activity on climate extremes and risks. Figure: Tropical Rainfall Measuring Mission (TRMM) data used to show the path of cyclone Nargis as it moves along the southern coastal region of Burma on 3 May 2008 (top figure). Instantaneous rainfall rates from the TRMM Microwave Images (outer swath) and the Precipitation Radar (inner swath) are superimposed on the cloud imagery from the Visible Infrared Scanner. Total accumulated precipitation (bottom figure) for 27 April to 4 May 2008 from Nargis and precursor rain systems.

gauges and satellite altimeters to have risen at a rate of just above 3 mm per year, compared to a rate of less than 2 mm per year from tide gauges over the past half century. However, the extent to which that increase reflects natural variability versus anthropogenic climate change is unknown. The Sea-level Task Team was established by WCRP to focus on this research issue and to provide periodic assessment of the best available state-of-the-science knowledge for decision-makers.

WCRP is currently discussing plans for its research strategy in order to support climate forecasting. Towards that goal, WCRP envisions great opportunities for the World Weather Research Programme (WWRP) and WCRP to work together towards seamless prediction of weather, climate, water and environmental conditions, offering improved services through national meteorological and hydrological services (NMHSs) worldwide.

Addressing the challenges of data collection, assimilation and reanalysis

High-quality observations are required for (1) monitoring the climate system, (2) detecting and attributing climate change, (3) assessing the impacts of climate variability and change and (4) supporting research for improved understanding, modelling and prediction of the climate system. The WCRP research mandate emphasizes the importance of taking high-quality observations across time and space scales with attendant continuity and of generating climate data records through reprocessing. Improved observational data sets also form the basis for reanalysis to obtain homogeneous data sets from historical climate records for climate change detection and attribution studies, 'climate now-casting' and other

applications. Originally, only atmospheric reanalysis had been developed, but that method is advancing so rapidly that it is now being used for oceans and sea-ice observations.

Climate records often show biases that mask long-term variation in the climate system. Reanalysis, the reprocessing of all available historical data, both in situ and satellite observations, produces a coherent description of the changing states of the atmosphere, ocean and other components of the climate system leading to a coherent description of the Earth's climate system. Products of global reanalysis have provided the basis for advances in many areas, including climate now-casting and diagnostic studies of complex systems, such as monsoons or the El Niño-Southern Oscillation. Global reanalysis is also the foundation for regional reanalysis projects and downscaling to study local climate and climate impacts. In addition, the development of comprehensive Earth system models requires expansion of the scope of reanalysis and conducting coupled atmosphere-ocean data assimilation. As the science of reanalysis grows, there is an urgent need to align financial and infrastructural resources for data processing and to foster sustained international cooperation. Advances and challenges in this rapidly evolving field were discussed at the Third WCRP International Conference on Reanalysis held on 28 January to 1 February 2008 in Tokyo, Japan.

An example for a comprehensive quality assessment of long-term data records has just been conducted by the WCRP/GEWEX Global Precipitation Climatology Project. To estimate the current state of knowledge in measurements of global precipitation that project combined observations from space-based and in situ measurements over land and oceans for a period of 25 years. That project reviewed how precipitation records had been developed, what the underlying assumptions in sampling and processing procedures were, their spatial and temporal resolution and what the potential sources of errors and anomalies were in those records. The record length is too short for analysis of climate trends. However, that complete assessment and documentation of global precipitation records is tremendously valuable for use in assessing climate projections (WCRP Series Report No. 128).

The IPCC AR4 detailed diagnosis of the Earth's vital signs has revealed that the planet is running a 'fever' and the prognosis is that it is apt to become worse. Although mitigation of human climate change is vitally important, evidence suggests that climate will continue to change substantially because of human activities over the next several decades, so that adaptation will be essential. An imperative first step is to build a Climate Information

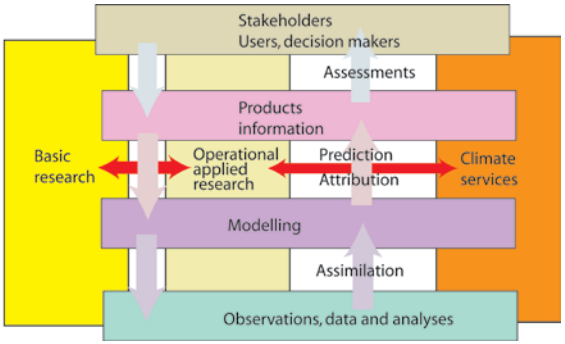


FIGURE BY KEVIN TRENBERTH, SLIGHTLY MODIFIED BY GHASSEM ASRAR

Climate Information System

System that informs decision-makers about what is happening and why, and what the immediate prospects are. What is required are observations (that satisfy the climate observing principles); a performance tracking system; the processing of data; access to data, including data management and integration; the analysis and reanalysis of observations and derivation of products, especially including historical climate data records; assessment of what has happened and why (attribution) including likely impacts on human and ecosystems; prediction of near-term climate change over several decades; and responsiveness to decision-makers and climate information users.

Building capacity and supporting adaptation planning

One of WCRP's major concerns is to make climate information products useful and easily accessible to the broad science community and to society as a whole. However, many of the tools and data sets first need skilful interpreters. WCRP is pursuing a multi-pronged approach to building capacity with its partners. Major thrusts are:

- Training young scientists and scientists in the developing countries to become full partners in climate research activities;

- Training climate practitioners to be able to better analysis and interpretation of climate information products for adaptation planning and risk reduction;

- Developing a dialogue with decision-makers, politicians and the development community to find a common language and understanding of the latest climate research findings;

- Providing opportunities for young scientists to develop an Earth system science approach to climate research in the future.

On the policy level, WCRP has been an active advisor to UNFCCC through its Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Conference of Parties (COP) meetings. At the most recent meetings, WCRP gave a briefing on advances and scientific challenges of regional climate modelling and global-to-regional downscaling techniques, which are of critical importance to achieving the Nairobi Work Programme's goals.

To build capacity for climate research and applications among scientists, national meteorological services and other users of climate products, WCRP, together with the International Centre for Theoretical Physics (ICTP), has organized several major training seminars. The Interpreting Climate Change Simulations seminar held in November 2007 in Trieste, Italy, targeted scientists and practitioners from developing and least-developed countries to demonstrate how to make use of the climate simulations available in the WCRP-CMIP3 archive. (For the African continent and regions within Africa, WCRP has already created the 'multi-model archive component' of the African Climate Atlas, which is an interactive Web page providing a user-friendly and simple tool for plotting images and making available subsets of data from the IPCC AR4 climate change model dataset, for the period needed and over regions that can be defined.) At the two-week Fourth ICTP Workshop on Theory and

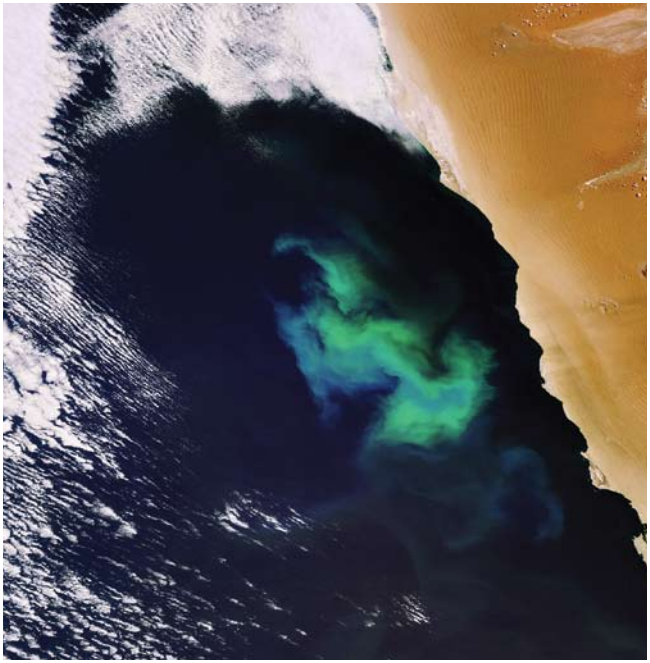
ICTP

At the WCRP-ICTP Seminar on Interpreting Climate Change Simulations, scientists and practitioners from developing countries learned how to use CMIP3 climate simulations developed for the IPCC AR4.

Use of Regional Climate Models (RCMs) held in March 2008 in Trieste, Italy, young scientists from developing countries — in total over 130 participants — learned to use regional climate models for their own climate change and seasonal prediction studies. Above all, they learned to understand the uncertainties associated with RCM-based regional climate change projections.

WCRP is increasingly interfacing directly with the users of climate prediction tools to better respond to users' needs. WCRP's preferred approach is to work with its partners, including START (System for Analysis, Research and Training), IAI (Inter-American Institute for Global Change Research), APN (Asian-Pacific Network) and the WMO/CLIPS project. A very successful example is the START, WMO/CLIPS and WCRP 'train-the-trainers' workshop held in Dar es Salaam, United Republic of Tanzania, in July 2006, to transfer knowledge and understanding of seasonal prediction methods in order for that region to be self-sufficient in teaching climate forecasters.

Recognizing that all components on Earth are linked together and that the new generation of Earth system models needs to factor in representation of these linkages, WCRP, together with the IGBP-IMBER project, held a first-of-its-kind ClimEco Training Seminar for young marine scientists in Brest, France, in April 2008, to learn about interactions between physical climate, marine biogeochemistry and ecosystems. The workshop was



EUROPEAN SPACE AGENCY

The WCRP and IGBP communities are developing a new generation of complex Earth system models that build ecosystem and carbon-cycle processes on top of coupled atmosphere-ocean general circulation models. WCRP trains the next generation of young climate researchers at this early stage of model development. ESA's Envisat satellite captured the vibrant aquamarine-coloured swirls of a plankton bloom off Namibia, Southern Africa, December 2007.

an excellent example of how to train young scientists across disciplines in Earth system research.

There are three main hurdles to adapting planning effectively: knowing with some certainty the nature of future climate conditions; creation of a specific plan tailored to the region's needs and strengths; and the natural, human and financial resources to effectively implement the plan. In addition to supporting the necessary capacity-building, especially regarding technical expertise, WCRP's role in adaptation planning is in guiding the improvement of model skill and downscaling techniques to reduce the amount of uncertainty in climate projections. In addition, WCRP's structure and partnership with national and international research organizations, including other Earth system science programmes, facilitate the sharing of experiences and development of the scientific foundation underlying adaptation best practices.

Of the nearly 1200 diagnostic subprojects registered by PCMDI (Program for Climate Model Diagnosis and Intercomparison), which use the WCRP-CMIP3 climate simulations' archive, over 100 have a focus on adaptation.

Food security is a particularly pressing adaptation concern in many arid and semi-arid regions. A recent study published by Lobell and colleagues in Science used model data from CMIP3 in conjunction with crop data to identify regions likely to experience food shortages in 2030, considering best, worst and medium case scenarios. While the authors were able to identify several crops particularly influenced by climate change, they also found that reduction in the uncertainty of model projections will further help identify which crops are most at risk and which are most resilient (Science 319: 607–610). Another study taking full advantage of the open CMIP3 database is being conducted by the World Bank, a donor concerned with how development projects may be effected by climate change, and how the projects help improve adaptive capacity. The World Bank is currently creating a computer-based adaptation tool for its own use and for use by governments and other agencies to screen development projects and determine their sensitivity to climate change.

The broad use of climate change detection tools and indices (developed by the CCl/WCRP-CLIVAR/JCOMM Expert Team ETCCDI) for adaptation planning is another example of the use of climate research products for the benefit of society. An example is the Caribbean community's recent Adaptation to Climate Change (ACCC) project aimed at improving downscaled climate scenarios for specific countries in the region, including Barbados, Jamaica and Trinidad and Tobago, as well as to create adaptation planning practices in various sectors, including water, health and agriculture. Climate indices developed by ETCCDI were an important tool used in that process. The Mainstreaming Adaptation to Climate Change (MACC) project is now being conducted in order to incorporate (or mainstream) those adaptation practices into national policies and plans. Another component of the MACC is to couple downscaled models with hazard models in order to determine the impact of extreme weather events.

GEWEX

The Global Energy and Water Cycle Experiment (GEWEX), one of four WCRP core projects, addresses observations, understanding and modelling of the hydrological cycle and energy fluxes in the atmosphere at the land surface and in the upper oceans.

Examples of GEWEX accomplishments:

- The joint GEWEX/CLIVAR African Monsoon Multidisciplinary Analysis (AMMA) project, which involves the capabilities of meteorological services in West Africa, yields unique data sets used to improve climate models.
- Developing next-generation hydrological land surface and regional climate models by improving parameterizations at high resolution and applying them to experimental predictions.
- Assembling high-quality global data sets on clouds, radiation and other parameters that are invaluable in understanding and predicting global water and energy processes and their role in the climate system.
- Advancing model development which identify key land-surface processes and conditions that contribute most significantly to the predictability of precipitation and its variability.
- Developing data assimilation systems that will resolve land surface features at resolutions as small as one kilometer.
- Contributing to the hydro-meteorological services' decision-making in virtually every social and economic sector, regionally and around the world.

www.gewex.org

CLIVAR

The WCRP core project on Climate Variability and Predictability (CLIVAR) is the focus of WCRP studies of climate variability. Its mission is to observe, simulate and predict the Earth's climate system, focusing on ocean-atmosphere interactions in order to enable a better understanding of climate variability, predictability and change.

Examples of CLIVAR accomplishments:

- Developing improved understanding and prediction of climate variability and change.
- Coordinating climate model scenario experiments for IPCC Assessments; key inputs on changes in climate extremes provided to IPCC AR4.
- Synthesising ocean data and information.
- Coordinating model intercomparison activities aimed at improving seasonal predictions and ocean model performance.
- Advocacy for real-time data and high-quality delayed mode observational data for operations and research.
- Coordinating field studies to help improve parameterization schemes for atmosphere and ocean climate models and their interactions.
- Developing a multi-compound electronic African Climate Atlas, a tool for research on African climate.
- Organizing and sponsoring training workshops on seasonal prediction in Africa, climate impact on ocean ecosystems, climate data and extremes and El Niño-Southern Oscillation.

www.clivar.org

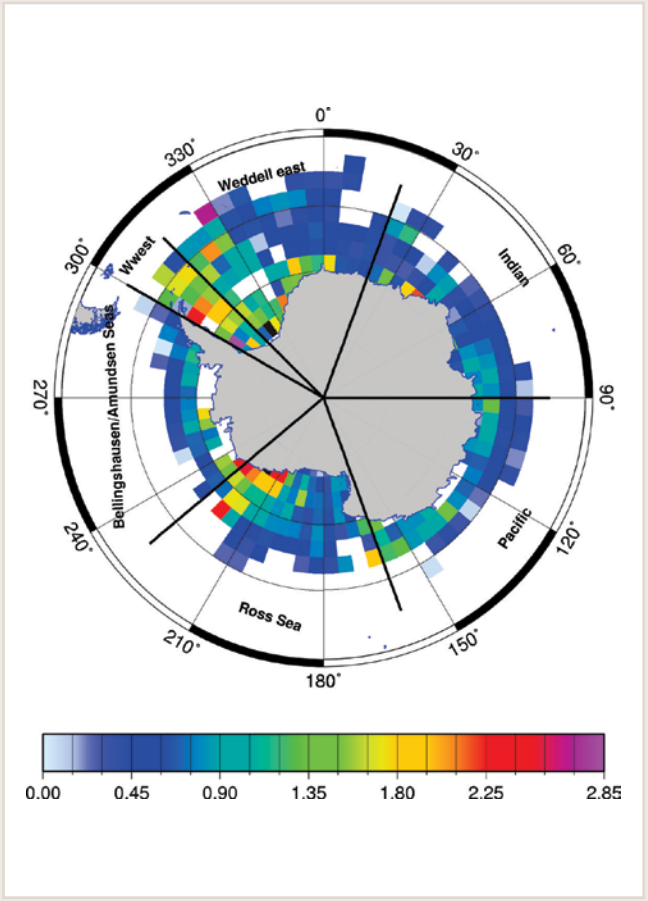
CliC

The mission of the WCRP/SCAR/IASC Climate and Cryosphere (CliC) project is to understand and represent in models the role of the cryosphere in Earth's climate system and to assess and quantify the impact that climate variability and change have on components of the cryosphere and its overall stability and the consequences of these impacts for the climate system.

Examples of CliC accomplishments:

- Developing the IGOS Theme on Cryosphere (IGOS-Cryo) in partnership with SCAR. Achieved a broad consensus on the planned development of cryospheric observations for years to come. Following IGOS-Cryo recommendations the Global Cryospheric Watch was created.
- Coordinating input from the climate research community to the scientific programme of the International Polar Year 2007–2008. The concept of polar satellite snapshot aimed at obtaining unprecedented coverage of both polar regions with observations from space.
- Drawing the attention of the world's scientific community to the role of the cryosphere in the climate system and developing a chapter on snow, ice and frozen ground for the IPCC Assessment Report 4 (2007). The report also highlights the contribution of melted water to recent sea-level change.
- Reviewing state-of-the-science on recent high-latitude changes (WCRP/SCAR CliC, WCRP Informal Report No. 18/2007).
- Through the 2nd International Conference on Arctic Research Planning, CliC engaged the Arctic climate and weather modelling communities in developing a ten-year plan to improve projections of Arctic change.

http://clic.npolar.no



WORBY ET AL. 2008, JOURNAL OF GEOPHYSICAL RESEARCH VOL. 113.

Circumpolar annual mean sea ice thickness compiled from ASPeCt ship observations for the period 1980-2005.

SPARC

The WCRP core project on Stratospheric Processes and Their Role in Climate (SPARC) addresses key questions concerning climate research on (a) climate-chemistry interactions, (b) detection, attribution and prediction of stratospheric change and (c) stratosphere-troposphere dynamical coupling.

Examples of SPARC accomplishments:

- The Chemistry-Climate Model Validation (CCMVal) project organizes model simulations and analyses that are a central element of the WMO/UNEP Scientific Assessments of Ozone Depletion.
- Participating and supporting the WMO/UNEP Assessment Steering Committee, as lead and contributing authors and reviewers.
- Publishing major scientific assessment reports such as: Trends in the Vertical Distribution of Ozone; Upper Tropospheric and Stratospheric Water Vapour; Intercomparison of Middle Atmosphere Climatologies; Stratospheric Aerosol Properties.
- SPARC reports in preparation include: Chemistry-Climate Model Validation and an updated Assessment of Upper Tropospheric and Stratospheric Water Vapour.

www.atmosp.physics.utoronto.ca/SPARC

WCRP Modelling Activities

The Working Group on Numerical Experimentation (WGNE), jointly sponsored by WCRP and the WMO Commission for Atmospheric Sciences (CAS), leads the development of atmospheric models for climate studies and numerical weather prediction. The Working Group on Coupled Modelling (WGCM) leads the development of coupled ocean-atmosphere-land models used for climate studies on longer timescales.

Examples of WCRP modelling accomplishments:

- At the World Modelling Summit for Climate Prediction, jointly organized by WCRP, the International Geosphere-Biosphere Programme (IGBP) and the World Weather Research Programme (WWRP) in Reading, UK, 6–9 May 2008, it was proposed to establish the World Climate Research Facility as part of the Climate Prediction Project.
- Coordination of Coupled Model Intercomparison Projects (CMIP): Phase 3 facilitated the collection, archive and access to all the global climate model simulations undertaken for the IPCC Fourth Assessment Report (AR4). The open-access data resulting from the current Phase 5 of coordinated climate change experiments is again organized and archived by the US Program for Climate Model Diagnosis and Intercomparison (PCMDI).

http://wcrp.wmo.int/AP_Modelling.html

WCRP Observation and Data Assimilation Activities

The WCRP Observation and Assimilation Panel (WOAP), co-sponsored by the Global Climate Observing System (GCOS), is the expert panel for all aspects of global observations, their analysis and assimilation and development of climate products.

Examples of WOAP accomplishments:

- Ensuring the highest possible quality and continuity of observations and derived products for use in climate change assessments and climate research; promoting reprocessing of observations.
- Supporting reanalysis efforts since they started for the atmosphere in 1988, WOAP now provides ongoing leadership in promoting reanalysis and expanding it to embrace ocean reanalysis and even whole Earth system reanalysis.
- Sponsoring a series of three WCRP reanalysis conferences, with the Third WCRP International Conference on Reanalysis held in January/February 2008 in Tokyo, Japan.

http://wcrp.wmo.int/AP_Observation.html

WCRP Cross-Cutting Activity on Anthropogenic Climate Change (ACC)

The WCRP Joint Scientific Committee established a dedicated Anthropogenic Climate Change (ACC) cross-cutting activity to facilitate (a) a more prominent role by the WCRP in the IPCC assessments and UNFCCC discussions and decisions; (b) a more effective identification of the scientific priorities related to ACC issues, with a corresponding strategy and capability to address them within WCRP; (c) a better definition of the interface with other ESSP partners based on these ACC priorities.

Recent ACC achievements:

- Sponsoring the GCOS/WCRP/IGBP Workshop Learning from the IPCC AR4 (Sydney, Australia, October 2007) determined 'urgent science questions', which are part of a larger strategy to address ACC policy issues and constitute issues requiring action from WCRP and IGBP, and possibly the other ESSP programmes.
- Participating in a number of activities focused on UNFCCC SBSTA and the Nairobi Work Programme, designed to disseminate scientific results to policy makers and the private sector (meetings in Bonn, Germany and at the COP in Bali, Indonesia).
- Supporting capacity-building in developing and least-developed countries (WCRP-ICTP Workshop, Trieste, Italy, November 2007).
- Supporting the development of scenarios for IPCC AR5.

http://wcrp.ipsl.jussieu.fr/SF_ACC.html

WCRP/IGBP Cross-Cutting Activity on Atmospheric Chemistry and Climate (AC&C):

The joint WCRP/IGBP initiative on Atmospheric Chemistry and Climate (AC&C) is tasked to advance our understanding of what controls the atmospheric distribution of chemically active species, their role in climate change, how their distribution might change with the climate, and the coupling of climate and air quality.

Recent AC&C activities:

- The first phase of the AC&C initiative focuses on improving process representation in chemistry-climate models and regional/global air quality models, ultimately as a contribution to future IPCC Assessments and WMO/UNEP Ozone Assessments.
- AC&C includes both new activities and improved coordination and collaboration with existing activities, e.g. CCMVal, AeroCom, the European ACCENT project Model IntercomParison (ACCENT-MIP), the Task Force on Hemispheric Transport of Air Pollution, the IGBP/AIMES Global Emission Inventory Activity (GEIA) and other activities.

www.igac.noaa.gov/ACandC.php

WCRP Cross-Cutting Activity on Seasonal Prediction

One of the overarching objectives of WCRP is to 'facilitate analysis and prediction of Earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society'. The CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP) is tasked to assess and advance current prediction capability and skill.

Examples of Seasonal Prediction accomplishments:

- The First WCRP Seasonal Prediction Workshop, Barcelona, Spain, 4–7 June 2007, had as an outcome a set of consensus statements, recommendations and best practices (WCRP Seasonal Prediction Position Paper: WCRP Informal Report No.3/2008).
- The WCRP Climate-system Historical Forecast Project (CHFP), is a multi-model, multi-institutional experimental framework for the assessment of state-of-the-science seasonal forecast systems and evaluation of the potential for untapped predictability due to interactions between the components of the climate system that are currently not fully accounted for in seasonal forecasts.

http://wcrp.wmo.int/AP_SeasonalPrediction.html

WCRP Cross-Cutting Activity on Climate Extremes and Risks

The recently launched WCRP Climate Extremes and Risks initiative is tasked to address science questions related to climate extremes and risks which are of great interest to policy decisions on climate change and managing risks and impacts of natural disasters and their economic impacts on regions and nations.

Major steps within the Climate Extremes and Risks activity:

- A focus on extremes under the GEWEX Coordinated Energy and Water Cycle Observations Project (CEOP) with the key objective of better understanding the occurrence, evolution and role of extremes within the Earth's climate system.
- Developing a global product, based on satellite observations, of heavy rainfall at 24- and 48-hour accumulation periods through a joint GEWEX/UNESCO project.
- Focus on model representation of extremes in climate predictions on seasonal, decadal and centennial timescales.
- Evaluating model products to address issues such as the role of the ocean on drought in cooperation with the US CLIVAR Drought in Coupled Models project.
- Monitoring and understanding cryospheric extremes under the WCRP Climate and Cryosphere (CliC) project.
- Studying extreme stratospheric conditions under the WCRP Stratospheric Processes and Their Role in Climate (SPARC) project.

http://wcrp.wmo.int/ExtremesRisks_index.html

WCRP Cross-Cutting Activity on Monsoon Prediction

The WCRP Monsoon Prediction initiative aims to improve accuracy of monsoon predictions and forecast on various time and space scales as these are of crucial importance to enable decision-makers, including national hydrological and meteorological services to administer effectively their programmes dealing with all aspects related to weather, climate and water.

Major steps within the Monsoon Prediction activity:

- WCRP, through the concept of an International Monsoon Study (IMS), focuses on key uncertainties in monsoon prediction and the multi-scale interactions essential for the dynamics and prediction of diurnal to intra-seasonal variability and the seasonal march of the monsoons.
- A major IMS activity has been the development of a science plan for the Asian Monsoon Years (AMY) 2007–2012, with the goal of improving Asian monsoon prediction through coordinated efforts to improve our understanding of monsoon variability.
- A realistic representation of tropical convection and its multi-scale organization in global atmospheric models continues to limit the success of Numerical Weather Prediction (NWP) forecasts, global predictions and those of monsoons. To address this issue WCRP and WWRP/THORPEX are sponsoring a year of coordinated observing, modelling and forecasting of organized tropical convection and its influences on prediction (YOTC).

www.wcrp-amy.org
www.wmo.int/yotc

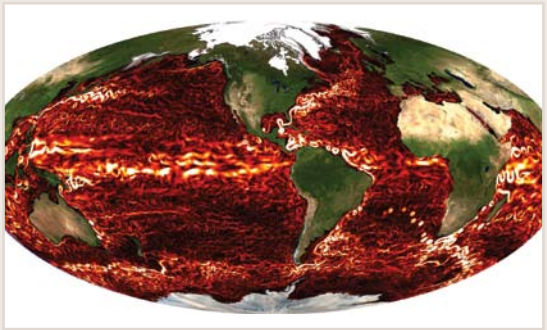
WCRP Ocean and Climate Research

In collaboration with other organizations, CLIVAR provides the focus within WCRP for understanding the role of the ocean in climate, develops observing systems, promotes reanalysis of existing ocean data and develops ocean modules of global climate models. CliC contributes to these activities on cryospheric and polar aspects and GEWEX and SOLAS in the areas of surface flux and the global hydrological cycle research. As a co-sponsor of the Ocean Observations Panel for Climate (OOPC), WCRP strives to ensure high-quality and long-lived ocean observations for climate research and prediction.

Examples of WCRP accomplishments related to Ocean Research:

- Collaborative intercomparison and assessment of global ocean synthesis products aimed at determining their quality and potential for ocean initialization in climate prediction.
- Ongoing implementation of an integrated Indian Ocean Observing System in collaboration with the Intergovernmental Oceanographic Commission (IOC) of UNESCO and Indian Ocean GOOS.
- Facilitating a Tropical Atlantic Climate Experiment (2006–2011) to improve regional climate prediction.
- Support for and coordination of programmes to monitor the Meridional Overturning Circulation (MOC) in the Atlantic.
- Input to design the Arctic and Southern Ocean Observing Systems in collaboration with several partners.
- Coordination of key international climate process studies in the Pacific.
- Developing the tropical moored buoy arrays to provide key observations for seasonal predictions.
- Design of Coordinated Ocean-ice Reference Experiments.
- Assisting IOC to provide guidelines for the future global deep ocean hydrography and carbon network.

http://wcrp.ipsl.jussieu.fr/SF_OceanClimate.html



Simulated near-surface (15m) ocean-current speed and sea-ice cover from an unconstrained eddy-permitting integration carried out by the Estimating the Circulation and Climate of the Ocean - Phase II (ECCO2) project. Units are m/s with the color scale ranging from black (0 m/s) through reds to white (→5 m/s). Simulated sea ice is shown as an opaque, white cover. Land masses and ice shelves are overlain with NASA satellite imagery. The ECCO2 project (http://ecco2.oorg/) is funded by the NASA Modeling, Analysis, and Prediction (MAP) programme.

WCRP Cross-Cutting Activity on Decadal Prediction

The new WCRP activity on decadal prediction draws on the expertise of the climate and weather modelling communities to investigate the potential for climate predictions on decadal timescale which will enable human society to better manage and adapt to the risks of climate impact. The activity aims to (a) provide model integration to allow estimation of the evolution of expected climate for the period 2005–2035 relative to the climate of recent decades; and (b) to encourage the use of higher-resolution climate models, with the hope of better resolving synoptic processes associated with extremes and assessing the benefits of higher resolution in general.

Planned activities:
WCRP has initiated an activity to advance the science of decadal prediction, based on internationally coordinated multi-model experimentation to gauge the overall level of predictability arising from having different initial conditions and different greenhouse gas forcings. A detailed proposal is being developed on numerical experimentation to assess the expected skill of decadal predictions.

WCRP Activities during the International Polar Year (IPY) 2007–2008

The main goals of WCRP during IPY are to address existing gaps in the knowledge of polar processes, develop understanding of the role of polar regions in the Earth's climate system and develop an ability to better predict global climate. The WCRP Climate and Cryosphere (CliC) project coordinates WCRP involvement in IPY.

WCRP contributions to IPY scientific achievements:

- Establishing a basis for an Arctic Ocean Observing System and sustaining Arctic observing networks.
- Establishing an Arctic hydrological cycle observing system to advance polar hydrology and enable global studies of ocean freshwater balance.
- Promoting a sustained survey of the Southern Ocean forming the foundation of the Southern Ocean Observing System.
- Coordinating for the first time a satellite snapshot of the polar regions by major space agencies, especially with Synthetic Aperture Radars.
- Initiating a bi-polar coordinated permafrost monitoring system.
- Obtaining a record-long ice-core based climate history reconstruction (Chinese contribution).
- Strengthening interoperable data exchange and information storage.
- Building capacity for generation and use of climate information products and services in polar regions in cooperation with the WMO project on Climate Information and Prediction Services (CLIPS).

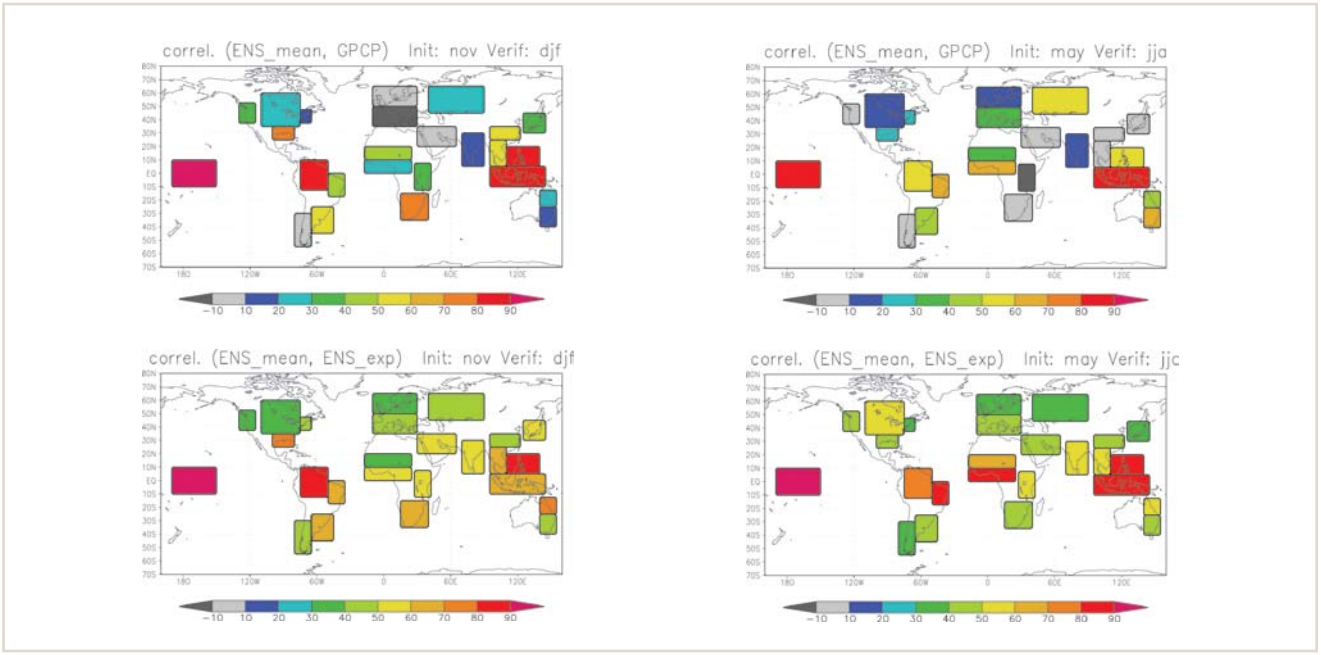
http://wcrp.ipsl.jussieu.fr/SF_OceanClimate.html

MAJOR EVENTS

A. KESHAVJEE

First WCRP Seasonal Prediction Workshop
Barcelona, Spain, 4–7 June 2007

The WCRP Task Force on Seasonal Prediction carried out a two-year study on current seasonal prediction capability and skill, considering a wide range of practical applications. That group also sought to develop and implement numerical experimentation specifically designed to enhance seasonal prediction skill and the use of seasonal forecast products for societal benefit. At the 'Barcelona Workshop', climate researchers, forecast providers and application experts evaluated the current status of seasonal forecasting and its application by users. A position paper has been issued outlining a set of specific recommendations for improving seasonal prediction skill and enhancing the use of seasonal prediction information of great value for society (see WCRP Informal Report No. 3/2008: http://wcrp.wmo.int/documents/WCRP_SeasonalPrediction_PositionPaper_Feb2008.pdf).

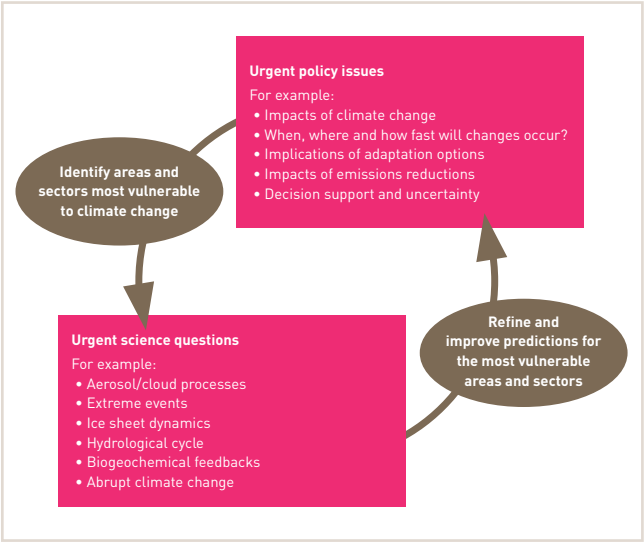


FRANCO MOLTENI, ECMWF

The anomaly correlation for area-averaged seasonal rainfall anomalies (December–February, left, June–August, right) in selected regions of the world for ECMWF System 3 seasonal forecasts. The upper panels show the correlation between forecasts and observations. In some regions this is quite high, in others it is near zero. The lower panels show the model estimate of the predictability limit, in other words the correlation that would be obtained with a prefect model. In some places, the level of potential predictability is much higher than the skill presently achieved.

Future Climate Change Research and Observations: GCOS, WCRP and IGBP Learning from the IPCC AR4 Workshop
Sydney, Australia, 4–6 October 2007

Some 66 key IPCC authors and other experts discussed the lessons learnt from the IPCC Fourth Assessment Report (AR4) at the 'Sydney Workshop' organized jointly by WCRP, the Global Climate Observing System (GCOS) and the International Geosphere-Biosphere Programme (IGBP). In addition, ways were proposed to sustain and develop future observing systems and to define climate change research challenges, based on gaps and uncertainties identified by IPCC Working Group I (The Physical Science Basis) and Working Group II (Impacts, Adaptation and Vulnerability) in their latest assessments. Research needs to be addressed jointly by WCRP and IGBP include improvement of regional climate change models by more rigorous validation of these models with observations and by advancing model intercomparison studies. In addition, better connections were postulated between global circulation models and regional models and between the climate modelling community and those involved in climate change impact assessment and response (see Series Report WCRP-127: http://wcrp.wmo.int/documents/SydneyWorkshopRep_FINAL.pdf).



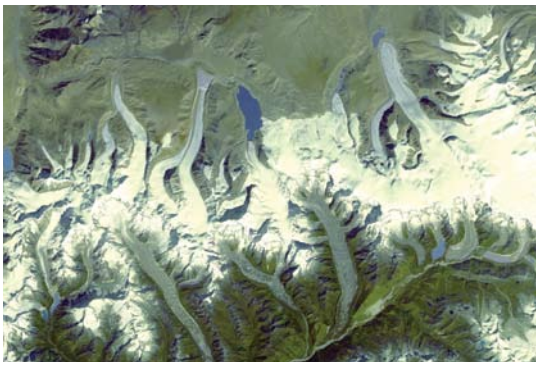
Using the vulnerability of regions and sectors to climate change as a possible framework to link urgent science questions with societal concerns.

GCOS, WCRP AND IGBP LEARNING FROM THE IPCC FOURTH ASSESSMENT REPORT. WORKSHOP AND SURVEY REPORT, JANUARY 2008

Second Asia-CliC Symposium - The State and Fate of the Asian Cryosphere
Lanzhou, China, 22–26 October 2007

About 150 cryospheric researchers, including glaciologists, hydrologists, ecologists, climate modellers and experts in data management from 15 countries

Asia-CliC supports improved observational networks and the obtainment of high-quality data. As an example, ASTER data has revealed a significant spacial variability in glacier flow in the Bhutan Himalayas.



NASA/GSFC/METI/ERSDAC/JAROS, AND U.S./JAPAN ASTER SCIENCE TEAM

met in China to foster international cooperation and communication and to examine our current understanding of the status of the Asian cryosphere. At the symposium, the insufficient use of a vast amount of existing meteorological, cryospheric, and hydrological data was highlighted. Priority areas identified requiring immediate action include the involvement of the Asia-CliC community in best-practice data management and archiving, establishment of improved observational networks, obtaining higher-quality data and the development and use of various models to overcome spatial and temporal shortcomings (see www.casnw.net/clic/Asia_clic.html).

Interpreting Climate Change Simulations: WCRP and ICTP Capacity-Building for Developing Nations Seminar
Trieste, Italy, 26–30 November 2007

Recognizing that response to climate change requires the capability to assess and properly interpret research findings and to apply those findings to national planning initiatives, WCRP and the International Centre for Theoretical Physics (ICTP) began to build capacity in the developing and least-developed countries. A training seminar focused on analysing and interpreting the international ensemble of climate simulations for the twentieth and twenty-first centuries was recently held as part of the Third WCRP Coupled Model Intercomparison Project (CMIP3), using simulations undertaken in support of the IPCC Fourth Assessment Report. Thirty participants from developing nations worked on their own projects, using the WCRP CMIP3 archive in a way relevant and helpful to their home country or organization.

Third WCRP International Conference on Reanalysis
Tokyo, Japan, 28 January–1 February 2008

Reanalysis of observations, with more complete data, improved quality control and a constant assimilation model and analysis system greatly improves the homogeneity of the record and makes it useful for examining climate variation. That technique is also the basis for regional downscaling projects and detection and attribution studies of long-term climate trends as well as for climate now-casting. Rapid development of comprehensive Earth system models requires expanding the scope of reanalysis and conducting coupled atmosphere-ocean data assimilation. As the science of reanalysis grows, there is an urgent need to align financial resources and infrastructure for data processing and to foster sustained international cooperation. Advances and challenges in this rapidly evolving field were discussed at the Third WCRP International Conference on Reanalysis (see the Conference Statement at http://wcrp.wmo.int/documents/wcrp3rac_statement.pdf).

Fourth ICTP Workshop on the Theory and Use of Regional Climate Models (RCMs): Applying RCMs to Developing Nations in Support of Climate Change Assessment and Extended-Range Prediction
Trieste, Italy, 3–14 March 2008

Regional climate models (RCMs) are being used for a wide variety of applications, from process studies to paleoclimate, climate change and, more recently, seasonal to inter-decadal and interannual prediction, which is considered of particular interest for assessing climate impacts and creating adaptation measures

in developing countries. At a recent ICTP workshop, 130 participants reviewed the status of research and investigated the possibility of new applications in regional climate modelling. The two-week workshop included hands-on training sessions with two RCMs for specific application to climate change and seasonal prediction studies.

29th Session of the WCRP Joint Scientific Committee (JSC)
Arcachon, France, 31 March–4 April 2008

The WCRP Joint Scientific Committee (JSC) gathered in France this year to discuss progress and the future direction for WCRP and its projects. The Committee decided to concentrate its discussion on an intermediate (2008–2013) and a long-term (post–2013) time horizon. The focus of the intermediate time frame is in line with the WCRP Strategic Framework 2005–2015 and will be implemented through WCRP activities and core projects (GEWEX, CLIVAR, SPARC, CliC). For the post-2013 time frame, the Committee is planning to develop a new WCRP structure supporting a more effective interfacing with the users of climate informational products. Professor Antonio J. Busalacchi from the Earth System Science Interdisciplinary Center ESSIC, University of Maryland, USA, was elected the new Chair of WCRP-JSC. Dr David Griggs from Monash University, Australia, is the new Vice-Chair (see Annual Review of the WCRP and Report of the 29th session of the WCRP JSC: http://wcrp.wmo.int/documents/JSC29FinalReport.pdf; http://wcrp.wmo.int/About_Governance_JSC29.html).

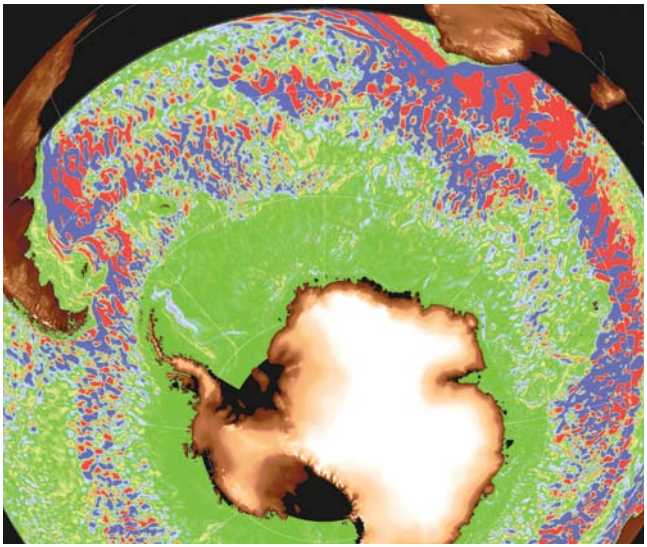
World Modelling Summit for Climate Prediction
Reading, UK, 6–9 May 2008

The world's leading climate researchers from WCRP, the International Geosphere-Biosphere Programme (IGBP) and the World Weather Research Programme discussed progress in state-of-the-science climate modelling capabilities and laid plans for the future. Modelling and prediction of regional climate change and of variations from days to decades play a significant role in the development of national action plans for coordinated adaptation and mitigation activities. However, current-generation climate models have serious limitations in simulating regional features, such as rainfall, mid-latitude storms and ecosystem dynamics. At the summit, the modelling community agreed that these limitations were mainly due to our inability to represent properly those features in climate models and to a lack of powerful computers to simulate years of the Earth's climate in days of computer time (see articles published in Nature and the Conference Statement: http://wcrp.ipsl.jussieu.fr/Workshops/ModellingSummit/DocumentList.html). See also: lead article in this Report p. 7.

Effects of Climate Change on the World's Oceans: International Symposium
Gijón, Spain, 19–23 May 2008

The oceans have received increasing scientific and policy attention in recent years. However, the impact of climate change on the ocean have received only little attention. About 400 scientists from 48 countries gathered to review the status of research and knowledge in the full spectrum of ocean topics. Three priorities were

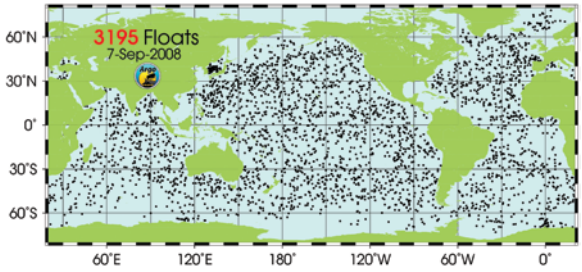
identified that require urgent attention. First, greater engagement by marine scientists is needed to address climate change issues, including climate variability and change and their impact on ecosystem structure, biodiversity, fisheries, and species' and society's adaptation to these changes. Secondly, it is essential to sustain the global-scale observing system already implemented, to compile available data into quality controlled and easily accessible databases, and to agree and implement a plan to expand the system beyond its present physical and biochemical variables. Thirdly, a critical need for sustained funding to support sustained observations was identified.



ANDREW C. COWARD, NATIONAL OCEANOGRAPHY CENTRE, UK

WCRP, through the CLIVAR and CliC projects and the co-sponsored SOLAS project, strongly focuses on ocean research, including the impact of climate change on oceans. This figure shows depth-integrated northwards eddy heat transport in the Southern Oceans.

Over 3,100 free-drifting profiling floats continuously monitor the temperature and salinity of the upper ocean (to 2,000 m). The Argo project is a major contributor to WCRP-CLIVAR and to the Global Ocean Data Assimilation Experiment (GODAE). Argo's main objective is to provide quantitative description of the changing state of the upper ocean and the patterns of ocean climate variability.



WWW.ARGO.UCSD.EDU

Met-Ocean Committee of the International Association of Oil and Gas Producers (OGP), the JCOMM and WCRP Workshop on Climate Change and the Offshore Industry

Geneva, Switzerland, 27–29 May 2008

This very successful workshop, attended by approximately 80 participants, opened a dialogue on climate change between specialists from oil companies and environmental research organizations. The following areas for future research on the adaptation of the offshore industry services to climate change were identified: understanding of the performance of climate models at various resolutions, timescales and in various regions; advanced regional downscaling methodologies; standards for data;

non-stationary extreme value analysis techniques for key metocean parameters such as wind speeds, wave heights, sea level, sea-ice coverage and explicit inclusion of uncertainty in extreme value analyses (www.wmo.ch/pages/prog/amp/mmop/documents/Jcomm-TR/J-TR-42-OGP_JCOMM_WCRP_workshop/index).

Bonn Climate Change Talks: 28th session of the UNFCCC SBSTA

Bonn, Germany, 2–13 June 2008

At the 28th session of the UNFCCC Subsidiary Body for Scientific and Technical Advice (SBSTA), the five elements of post-Kyoto negotiations on adaptation, mitigation, technology, finance and a shared vision for long-term cooperative action were advanced. The Bonn Climate Change Talks are preparation for the Climate Change Congress on Global Risks, Challenges and Decisions (Copenhagen, Denmark, 10–12 March 2009) where an international agreement on climate change action will be signed.

On 7 June, an in-session workshop on climate modelling, scenarios and downscaling was held, with Dr Ghassem R. Asrar, Director of the WCRP Joint Planning Staff, describing the status and role of downscaling techniques in climate modelling to increase resolution and better project regional climate variations and change for assessing their impact. Another meeting was held on 5 June with representatives from WCRP and the Earth System Science Partnership (ESSP) to discuss emerging research needs since the IPCC Fourth Assessment Report in the field of Earth system science and to encourage dialogue and information transfer between the parties and research communities (http://unfccc.int/adaptation/sbsta_agenda_item_adaptation/items/4377.php).

El Niño-Southern Oscillation (ENSO): Dynamics and Predictability

Puna, Big Island, Hawaii, USA, 14–24 June 2008

Sixteen graduate students in oceanography, meteorology and geology from 12 countries gathered at the jointly organized WCRP/CLIVAR–IGBP/PAGES summer school to learn about a broad range of ENSO-related topics, including ENSO theory, phenomenology, predictability and its sensitivity to past and future climate change. Students worked on their own research projects and in teams, studying the effects of ENSO on the Antarctic Peninsula, the rapid end of the 2008 La Niña event, the geographical reaches of a tropical drought some 4,200 years ago and many other issues (http://iprc.soest.hawaii.edu/~axel/ENSOsummerschool).

PUBLICATION HIGHLIGHTS

GREG MORTENSON, CENTRAL ASIA INSTITUTE

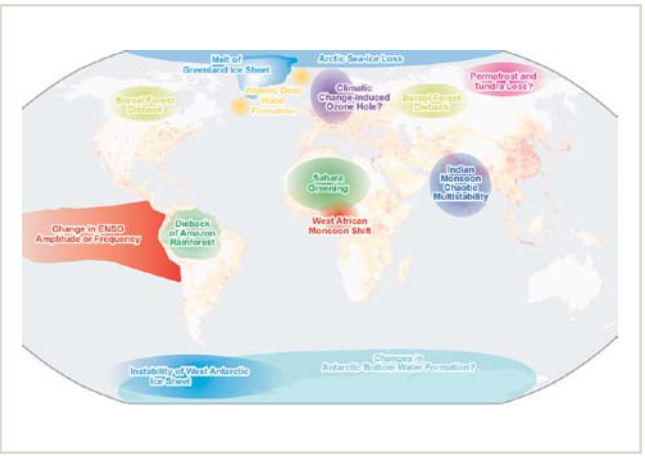
Church, J.A. (2007). A change in circulation?
Science, Vol. 317: 908–909.
The meridional overturning circulation (MOC), which includes the Gulf Stream, is an important element of the global climate system, transporting warm water from the Straits of Florida to high latitudes with serious implications for North American and European climate. "What scientists, policy makers and people living in North America and Europe are interested in is: has the northward flow of warm water changed? And: how would we know if it had, and how can we monitor it in the future?" asked Dr John Church of the Antarctic Climate and Ecosystem Cooperative Research Centre and WCRP Chair of the Joint Scientific Committee from 2006 to 2008. The stability of the MOC is being assessed in a new initiative led by the UK National Environmental Research Council, which has placed a large array of oceanographic instruments to monitor continuously the Gulf Stream at 26°N. Those observations are a component of a larger set of the WCRP/CLIVAR project activities to monitor the North Atlantic circulation system and develop a greater understanding of ocean circulation for better representation in climate models.

Zhang, X. and colleagues (2007). Detection of human influence on twentieth-century precipitation trends".
Nature DOI: 10.1038/nature06025.
An international team of scientists has detected the first direct evidence of human influence on changes in global patterns of rain and snowfall. A study published in Nature finds that precipitation has increased in northern regions during the twentieth century, a change that cannot be explained by natural forcing or internal variability. Human activity can be the only explanation for the observed and modelled changes. "We find that anthropogenic forcing has had a detectable and attributable influence on the latitudinal pattern of large-scale precipitation change", says the study led by Drs Xuebin Zhang and Francis Zwiers from Environment Canada's Climate Research Division. Both, Zhang and Zwiers are members of the Expert Team on Climate Change Detection and Indices (ETCCDI), which draws on WCRP expertise. (The Global Precipitation Assessment, Series Report WCRP-128 was recently published.)

Grassl, H. (2007). Climate change–what is correct? The most important answers.
Herder, Freiburg, Germany, 128 pp.
ISBN 978-3-451-05899-8 [in German].
The book originally entitled Klimawandel -Was stimmt? Die wichtigsten Antworten, written by Prof. Grassl, former Director of the WCRP Joint Planning Staff (1994–1999), is meant for non-specialists and laymen. Each sub-chapter starts with a public slogan, for example "The Sun causes climate change!" or "Global warming will make our planet greener!". In-depth background information then examines whether the statement is close to current scientific understanding. The book also discusses climate change impact on weather extremes and global attempts to unify climate policy on international levels and ends with a chapter entitled "The Second Solar Era" on how to effectively reduce the factors causing anthropogenic climate change.

Meehl, G.A. and colleagues (2007). The WCRP CMIP3 multimodel dataset. A new era in climate change research.
Bulletin of the American Meteorological Society (BAMS), Vol. 88 (9) September 2007, pp. 1383–1394.
A coordinated set of global coupled climate model experiments for twentieth and twenty-first century

climate, as well as several climate change commitments and other experiments, was run by 17 modelling groups from 12 countries with 24 models for assessment in the IPCC Fourth Assessment Report (AR4). This WCRP-initiated effort and the subsequent analysis phase, known as the third phase of the Coupled Model Intercomparison Project (CMIP3), are openly available to the international climate science community. "The WCRP CMIP3 multimodel dataset represents the largest and most comprehensive international global coupled climate model experiment and multimodel analysis effort ever attempted and will continue to be maintained for at least the next several years" says Dr Gerald Meehl from the US National Center for Atmospheric Research (NCAR) and Co-chair of the WCRP/CLIVAR Working Group on Coupled Modelling.



Map of potential policy-relevant tipping elements in the climate system.

Lenton, T.M. and colleagues (2008).
Tipping elements in the Earth's climate system.
PNAS, Vol. 105(6) February 2008, pp. 1786–1793.
The term 'tipping point' commonly refers to a critical threshold at which a tiny perturbation can qualitatively alter the state or development of a system. In their recent publication, Dr Timothy Lenton from the Tyndall Centre for Climate Change Research and his team of researchers introduce the term 'tipping element' to describe large-scale components of the Earth system that may pass a tipping point. They critically evaluate potential policy-relevant tipping elements in the climate system under anthropogenic forcing and assess where their tipping points lie. An expert team helps ranking their sensitivity to global warming and determining the uncertainty about the underlying physical mechanisms. Finally, the team explains how, in principle, early warning systems could be established to detect the proximity of some tipping points.

Trenberth, K.E. (2008). Progress and prospects for reanalysis for weather and climate.
EOS, Vol. 89: 234–235.
Atmospheric reanalysis of past observations has greatly improved our ability to determine climate variability. "The science of reanalysis has made great advances. The greatest challenges, however, are still ahead of us" says Dr Kevin Trenberth from the US National Center for Atmospheric Research (NCAR) and Chair of the WCRP Assimilation and Observation Panel. Further improvement in the science of reanalysis will help to depict climate changes on a multi-decadal scale as well as the state of the current climate ('climate nowcasts'). Efforts are under way to encompass key trace constituents and the ocean, land, and sea ice domains, to boost research in modelling the Earth system as a whole. Another challenge is to determine uncertainty in reanalysis products. The list of progress and prospects

for reanalysis for improving research and applications in weather and climate research is long. As discussed at the Third WCRP International Conference on Reanalysis, held in Tokyo, Japan, 28 January–1 February 2008, progress is, however, hampered by limited infrastructure for data processing.

Palmer and Williams (2008). Stochastic Physics and Climate Modelling.
Royal Society Publishing, 220 pp.,
ISBN 978-0-85-403695-0.
Finite computing resources limit the spatial resolution of state-of-the-science global climate simulations to hundreds of kilometres. In neither the atmosphere nor the ocean are small-scale processes such as convection, clouds and ocean eddies properly represented. Climate simulations are known to depend, sometimes quite strongly, on the resulting bulk-formula representation of unresolved processes. Stochastic physics schemes within weather and climate models have the potential to represent the dynamical effects of unresolved scales in ways which conventional bulk-formula representations are incapable of doing. The latest research findings of applying stochastic physics to climate modelling are gathered in a special issue of Philosophical Transactions of the Royal Society. (This publication is available to WCRP scientists at a discounted price. Contact Debbie Vaughan at debbie.vaughan@royalsociety.org).

WCRP Web downloads

E-zine

- The WCRP e-zine (electronic newsletter), published quarterly, is available at http://wcrp.wmo.int/Newsletter_index.html. To subscribe, send an e-mail with your electronic contact details to wcrp@wmo.int.

Reports and assessments

- Global Precipitation Assessment: A Project of the GEWEX Radiation Panel. May 2008, Series Report WCRP-128, WMO/TD-No. 1430.
- Future Climate Change Research and Observations: GCOS, WCRP and IGBP learning from the IPCC Fourth Assessment Report. January 2008, Series Report WCRP-127, WMO/TD-No. 1418.
- Integrated Global Observing Strategy. IGOS Cryosphere Theme Report: For the Monitoring of our Environment from Space and from Earth. August 2007, WMO/TD-No. 1405.
- WCRP Position Paper on Seasonal Prediction. Report from the First WCRP Seasonal Prediction Workshop, Barcelona, Spain, 4–7 June 2007. WCRP Informal Report 3/2008.
- A strategy for climate change stabilization experiments with AOGCMs and ESMs, Aspen, Colorado, 30 July–5 August 2006. White paper from the Aspen Meeting on Earth System Modelling. WCRP Informal Report 3/2007.
- The BACC Author Team: Assessment of Climate Change for the Baltic Sea Basin. 2008, 474 pp., Publisher Springer, ISBN: 978-3-540-72785-9.
- WCRP Annual Report 2006–2007: Providing the Science for Climate Change Solutions. WMO/TD-No. 1404.

Other research products

- African Climate Atlas, Part V on the WCRP CMIP3 Multi-Model Data Module (2007), published by the Variability of the African Climate System (VACS) programme of the WCRP CLIVAR project; www.ouce.ox.ac.uk/%7Eclivar/ClimateAtlas/ipcc.

- World Ocean Circulation Experiment (WOCE) (2007): Pacific Ocean Hydrographic Atlas. Compiled by L.D. Talley www.pord.ucsd.edu/whp_atlas/pacific_index.
- Assessment of Global Precipitation Products (2008). Gruber, A. and Levizzani, V. (eds.). WCRP Series Report No. 128; http://wcrp.wmo.int/documents/AssessmentGlobalPrecipitationReport.

More WCRP Newsletters

- GEWEX News for download at www.gewex.org/gewex_nwsltr.html.
- CLIVAR Exchanges for download at www.clivar.org/publications/exchanges/exchanges.php.
- SPARC Newsletter for download at www.atmosp.physics.utoronto.ca/SPARC/Newsletters.
- CliC Ice and Climate News for download at http://clic.npolar.no/disc/disc_newsletters.php.
- WGSF Flux News for download at www.sail.msk.ru/newsletter.php.
- SOLAS Bulleting for download at www.uea.ac.uk/env/solas/latest.

ESSP-Global Carbon Project

Publications:

- Carbon reductions and offsets (2008) ESSP Report No. 5/GCP Report No. 6.
- Canadell et al. (2007) Contributions to accelerating atmospheric CO2 growth from economic activity, carbon intensity and efficiency of natural sinks. PNAS Vol. 104: 18866–18870.
- Raupach et al. (2007) Global and regional drivers of accelerating CO2 emissions. PNAS Vol. 104: 10288–10293.

ESSP-Global Water System Project

Publications:

- Alcamo et al. (2008) A grand challenge for freshwater research: understanding the global water system. Environmental Research Letters 3: 010202 (6 pp.).

Other products:

- GWSP Digital Water Atlas (2007) http://atlas.gwsp.org.

START-System for Analysis, Research and Training

Publications:

- Leary et al. (2007) Climate change and adaptation. Earthscan, London, UK and Sterling, VA, USA.
- Leary et al. (2007) Climate change and vulnerability. Earthscan, London, UK and Sterling, VA, USA.
- Otter et al. (2007) Global change processes and impacts in Africa: A synthesis. East African Educational Publishers, Ltd.
- Fu et al. (2008) Changes in the human-monsoon system of East Asia in the context of global change. Monsoon Asia Integrated Regional Study on Global Change Vol. 1, ISBN: 978-981-283241-2.

PEOPLE

PHOTODISC

Awards and Recognitions

Dr Qin Dahe, former Director of the China Meteorological Administration, won the prestigious 2008 International Meteorological Organization (IMO) Prize for his achievements in cryosphere and climate research and for promoting international cooperation in meteorology. Dr Qin is a member of the WCRP/CliC Scientific Steering Group and Initiator and Chair of the Chinese National Committee on Climate and Cryosphere (CNC-CliC) Scientific Steering Group.

The 2007 IMO Prize was awarded to **Dr Jagadish Shukla**, Professor and Chair of the Department of Climate Dynamics in the College of Science, George Mason University, Virginia, USA, who is a member of the WCRP Joint Scientific Committee and has been Chair of the WCRP Modelling Panel since 2001.

Sir Brian Hoskins, Deputy Chair of the WCRP Joint Scientific Committee (2001–2004) and Professor at Reading University, UK, was knighted by Her Majesty Queen Elizabeth II at the time of her birthday honours in June 2007.

Dr Paola Salio, University of Buenos Aires, Argentina, won the 2007 WMO Research Award for Young Scientists for her paper entitled "Mesoscale convective systems over south-eastern South America and their relationship with the South American low-level jet" published in Monthly Weather Review (Vol. 135) in 2007. The South American Low Level Jet Experiment (SALLJEX) was conducted by WCRP/CLIVAR-VAMOS (the Variability of the American Monsoon System study) and improved our understanding of the role of the atmospheric jet along the lee of the Andes Mountains.

Professor Guoxiong Wu, member of the WCRP Joint Scientific Committee and academician at the Institute of Atmospheric Physics, Chinese Academy of Sciences, China, was elected president (2007–2011) of the International Association of Meteorology and Atmospheric Sciences (IAMAS) during the 24th meeting of the International Union of Geodesy and Geophysics (IUGG) held in Perugia, Italy, in July 2007. Prof. Wu is the first Asian to hold this post since the establishment of that organization more than 70 years ago. He specializes in weather dynamics, climate dynamics and atmospheric general circulation and is a member of the Steering Committee of the WCRP-endorsed Asian Monsoon Years (AMY).

Dr Pierre Morel, Director of the WCRP from 1982 to 1994, was awarded the 2008 European Geophysical Union (EGU) Alfred Wegener Medal. The Medal honours Morel's outstanding contributions to geophysical fluid dynamics and his leadership in the development of climate research and the application of space observation to meteorology and Earth system science.

Each year no more than 0.1 per cent of the AGU membership may be elected as fellows. Among this year's 2008 selectees are three WCRP scientists: **Professors V. Ramaswamy** (NOAA Geophysical Fluid Dynamics

Laboratory, Princeton, USA), **J. Shukla** (George Mason University, Calverton, USA) and **U. Lohmann** (ETH, Zurich, Switzerland).

Dr John Church, Antarctic Corporate Research Centre and CSIRO Marine Research, Australia, and former Chair of the WCRP Joint Scientific Committee, was awarded the Australian Museum Eureka Prize for his outstanding scientific research on rising sea levels and climate change.

Dr Dev Raj Sikka, former Director of the Indian Institute of Tropical Meteorology in Pune, India, received the National Award for Lifetime Achievement in Atmospheric Science and Technology from the Ministry of Earth Sciences, Government of India. Dr Sikka worked in the Tropical Ocean and Global Atmosphere (TOGA) Project Office in Boulder, USA, in 1984–1986, and became later a member of the TOGA Scientific Steering Group. TOGA was the first coupled atmosphere-ocean initiative led by WCRP, which laid the physical basis for understanding and predicting world-wide anomalies in the global atmospheric circulation and its links to El Niño, which has paved the way for operational seasonal forecasting. Dr Sikka is now the Chairman of the Indian Climate Research Programme and a member of the International Scientific Steering Committee of the Asian Monsoon Years (2008–2012) programme, a coordinated observation and modelling effort under WCRP leadership.

Dr Francis Zwiers, Director of the Climate Research Division, Science and Technology Branch, Environment Canada, and co-chair of the CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI), won the 2007 Patterson Medal Award for distinguished service to meteorology in Canada. The Patterson Distinguished Service Medal, presented since 1954, is considered the most pre-eminent award recognizing outstanding work in meteorology.

Welcome and Farewell

Dr Ghassem R. Asrar, the new Director of the WCRP Joint Planning Staff, was NASA's Earth Science Associate Administrator and subsequently served as Deputy Administrator for Natural Resources and Sustainable Agricultural Systems at the U.S. Department of Agriculture. He took up his duties with WCRP in mid March 2008. Dr Asrar also serves as the co-director of the WMO Research Department.

Professor Ann Henderson-Sellers, Director of the WCRP Joint Planning Staff from 2006–2007, returned to Australia where she holds an Australian Research Council Professorial Fellowship in the Department of Physical Geography of Macquarie University, Australia.

Dr Venkataramaiah Satyan retired in April 2008 after six years of service with WCRP as Director of Climate Modelling. Prior to that, he was the Deputy Director and Head of the Climate and Global Modelling Division, Indian Institute of Tropical Meteorology, Pune, India. Dr Satyan oversaw WCRP modelling activities including the Working Group on Numerical Experimentation (WGNE),

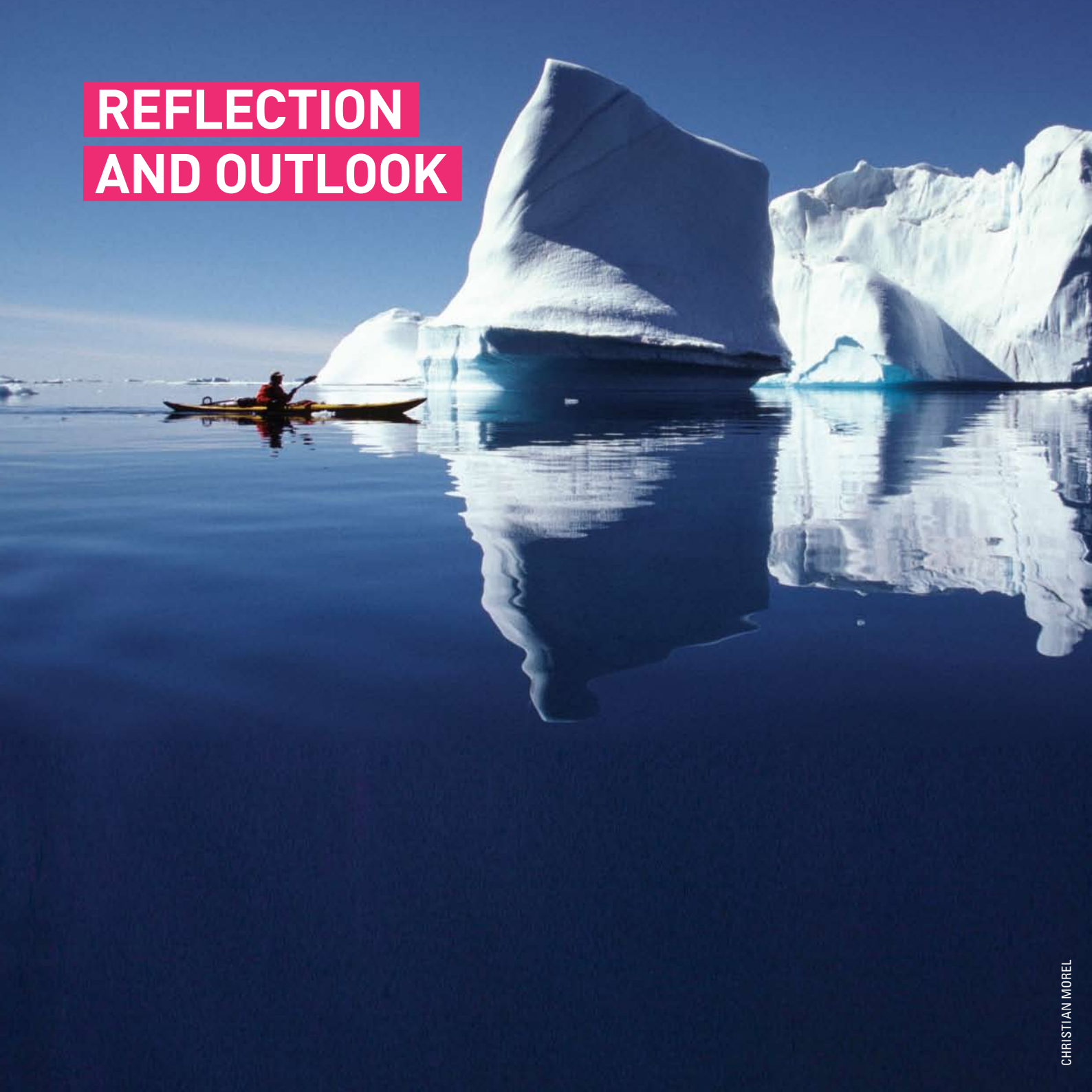
the Working Group on Coupled Modelling (WGCM) and the WCRP Modelling Panel (WMP).

Welcome to **Professor David Griggs** who is the Vice-Chair of the WCRP Joint Scientific Committee, succeeding Professor Ramaswamy. Professor Griggs is the Director of the Monash Sustainability Institute, Monash University, Australia. Thank you, Professor V. Ramaswamy, for your excellent support and leadership as previous Vice-Chair of the WCRP JSC.

Professor Antonio Busalacchi, Director of the Earth System Science Interdisciplinary Center ESSIC, University of Maryland, USA, was elected as Chair of the WCRP Joint Scientific Committee (JSC). Welcome! Professor Busalacchi succeeds Dr John Church. We thank Dr Church for his steady and unstinting leadership as chair of the WCRP JSC.

Dr Peter van Oevelen became the new Director of the International GEWEX Project Office (IGPO), succeeding Dr Rick Lawford in January 2008. Dr Oevelen had been the European GEWEX Coordinator for the previous three years supported by the European Space Agency (ESA) in The Netherlands. At ESA, Dr van Oevelen was involved in scientific activities related to satellite missions, such as the Soil Moisture and Ocean Salinity Mission. Welcome!

REFLECTION AND OUTLOOK



CHRISTIAN MOREL

The World Climate Research Programme (WCRP) had another successful year in supporting the coordination and integration of climate research, modelling and prediction activities of its over 190 Member countries. These coordination and integration activities were carried out through sponsoring over 20 conferences, workshops, meetings and symposia focused on all aspects of Earth's climate system (i.e. atmosphere, oceans, cryosphere and land-surface), with a major emphasis on (1) seasonal to interannual climate prediction/projection; (2) regional forecasts and their application in climate change adaptation, mitigation and risk and vulnerability assessments; (3) coupled climate system models that represent interactions among the physical, chemical and biological aspects of the climate system; (4) regional capacity-building and use of model results for resource management and decision making; and (5) new climate scenarios for future climate change and variability assessments supporting policy makers' decisions, such as future IPCC and ozone assessments.

WCRP also made great strides in transferring scientific information and knowledge about the Earth's climate system for policy decisions through the IPCC, the UNFCCC Conference of Parties and its Subsidiary Body on Scientific and Technological Advice (SBSTA). More than one half of the scientific and technical contributions used in the IPCC assessments were provided by WCRP-affiliated scientists. WCRP made a concerted effort to provide worldwide access to its model predictions/projections and research results for use by scientists from developing and least-developed countries to assess the consequences of potential climate variability and change on major economic sectors (e.g. food, water, energy, health), for their country or geographic region.

That was also a productive year in developing and publishing a variety of peer-reviewed scientific and technical papers on research findings, climate model predictions/projections, scientific and technical assessment reports on climate data records, ocean atlases resulting from legacy projects such as the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean and Global Atmosphere (TOGA) project, and regular newsletters published by WCRP projects and the secretariat. These were all in support of WCRP's commitment to communication and outreach to its present and future constituencies and in the spirit of the 'science-servicing-society' mission of its sponsoring agencies.

WCRP continued to build on its existing partnerships with other international research programmes, such as the International Geosphere-Biosphere Programme (IGBP) in biogeochemical aspects and the International Human Dimensions Programme (IHDP) on social and human dimensions of climate change research, and with START and regional organizations such as the Asian-Pacific Network (APN) and the Inter-American Institute (IAI) on capacity-building, education and outreach. The Earth System Science Partnership (ESSP) continues to make great progress in programme planning and implementation through its major projects on water, carbon, health and food security. WCRP together with IGBP, IHDP and DIVERSITAS are the foundation for that partnership, and they actively support ESSP planning and implementation activities. ESSP is expected to help its parent research organizations with the delivery and dissemination of scientific knowledge generated beyond the traditional scientific, technical and policy-making communities.

WCRP initiated a major planning effort at its 2008 annual Joint Scientific Committee (JSC) meeting. The Committee decided to concentrate its discussion on two time horizons: intermediate (2008–2013) and long term (post-2013). The focus of the intermediate time frame is in line with the WCRP Strategic Framework 2005–2015 and is implemented through WCRP cross-cutting activities and core projects (GEWEX, CLIVAR, SPARC, CliC). For the post-2013 time frame, the Committee is developing a new WCRP structure supporting a more effective interface with the users of climate information and knowledge generated by WCRP and its partners. One major challenge that WCRP foresees is the effective and timely delivery of climate information and knowledge to decision makers, a task that will undoubtedly benefit from existing networks such as the WMO National Meteorological and Hydrological Centres, emerging networks through ESSP, WMO-sponsored Regional Climate Outlook Forums (RCOFs) and Regional Climate Centres (RCCs) and other future mechanisms.

WCRP's accomplishments and progress were all made possible by the generous and sustained contributions of its sponsors: WMO, ICSU and IOC, and their network of more than 190 Member countries. The entire WCRP community is grateful for this sponsorship and support and is excited about the many opportunities that have made possible major contributions to understanding the causes and consequences of climate change and variability, assessing their impact on major sectors of the world economy, and enabling the use of resulting knowledge for managing the risks associated with these changes for our generation, our children and those who will follow them in this century and beyond.

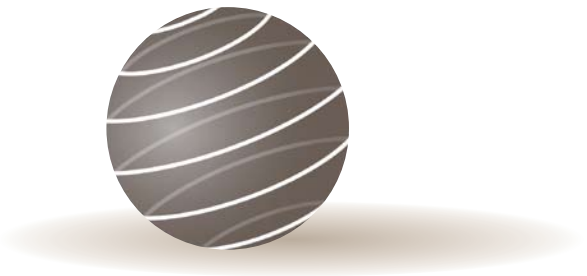
Ghassem R. Asrar
Director of the WCRP Joint Planning Staff, August 2008

RESOURCES

Finances

WCRP benefits greatly from the financial support of its sponsors, the World Meteorological Organization, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO, based on the generous contributions of the Member countries of these organizations. In addition to the direct financial contributions by the Member countries, WCRP also benefits from the invaluable scientific and technical knowledge of the participating scientists from across the world. This aspect of the national and international support for WCRP is very difficult to quantify and it is clear that without this support WCRP would not be able to function.

The funds that WCRP receives are used for supporting staff salaries and organizing, conducting and reporting the outcome of the regional and international scientific and technical workshops, conferences and symposia. Such events are focused on topics and issues that require participation and support of scientific and technical experts from around the world.



WCRP Income and Expenditure for 2007 (Swiss Francs)

2007	Carry forward from 2006	278,908
Income	WMO	1,879,078
	ICSU	381,743
	IOC	152,500
	Interest income	21,800
	ESSP 2006 Open Science Conference	25,260
Total income		2,460,381
Total funds available		2,739,289
Expenditure	Salaries and associated costs	1,649,700
	Operating expenses (including staff travel, publications, contractual support and office expenses)	207,486
	ESSP 2006 Open Science Conference	159,387
	Programme/project support	670,811
Total expenditure		2,687,384
	Carried forward to 2008	51,905

WCRP's core projects CLIVAR, GEWEX, CliC and SPARC also receive generous financial support from their host countries and major partners. Contributions are in the form of cash and secondment of scientific, technical and support staff and office space. Funds are allocated directly to projects (see table). However, there is close coordination and integration of the management of scientific and technical activities of the international project offices and WCRP secretariat to maximize benefits from all investments.

WCRP's ability to provide the support expected by the climate community depends on these contributions,

and any shortfall in one of these sources will create an imbalance and reduce efficiency and total programme impact. We take this opportunity to thank our sponsors and their member countries for their generous and sustained support for WCRP since its creation over 25 years ago. The WCRP community accepts the challenge of meeting future expectations of its international constituency, in the spirit of its successful legacy contributions of the past projects such as GARP (Global Atmospheric Research Programme), TOGA (Tropical Ocean Global Atmosphere programme), WOCE (the World Ocean Circulation Experiment) and ACSYS (the Arctic Climate System Study).

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The International Group of Funding Agencies for global change research (IGFA) helps promote dialogue with national funding agencies.

The Institut Pierre Simon Laplace (IPSL), through CNRS and CNES fully supports the WCRP Strategic Support Unit in Paris and a JPS staff member.

The GEWEX international project office is supported by the US National Aeronautics and Space Administration (NASA), and some staff travel is supported by the US National Oceanic and Atmospheric Administration (NOAA). China Meteorological Administration (CMA) supports the Chinese GEWEX coordinator, and the International CEOP Coordinator receives support from the University of Tokyo, Japan.

The CLIVAR international project office is supported by the Natural Environment Research Council, UK, and NASA, NOAA and the US National Science Foundation through US CLIVAR. The National Oceanography Centre, Southampton, UK, IIM- Consejo Superior de Investigación Científica, Vigo, Spain, the University of Buenos Aires, Argentina, and the University of Princeton, New Jersey, USA, provide additional support as hosts.

The SPARC international project office is supported by contributions from the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS), the Canadian Space Agency, Environment Canada and the University of Toronto.

The CliC international project office is supported by the Norwegian Polar Institute. CliC has been co-sponsored by the Scientific Committee on Antarctic Research (SCAR) since 2004 and by the International Arctic Science Committee (IASC) since 2008.

WCRP expresses its gratitude to all of those organizations.

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ACRONYMS

ACC	Anthropogenic Climate Change Project (WCRP)
AC&C	Atmospheric Chemistry and Climate Project (WCRP/IGBP)
AGU	American Geophysical Union
AMMA	African Monsoon Multidisciplinary Analysis
AMY	Asian Monsoon Years
AOGCM	Atmosphere-Ocean General Circulation Model
AOPC	Atmospheric Observation Panel for Climate
APN	Asian-Pacific Network
AR4	IPCC Fourth Assessment Report
CACGP	Commission for Atmospheric Chemistry and Global Pollution
CAS	Commission for Atmospheric Sciences
CCl	Commission for Climatology
CCMVal	Chemistry-Climate Model Validation Project
CEOP	Coordinated Energy and Water Cycle Observation Project (WCRP/GEWEX)
CliC	Climate and Cryosphere Project (WCRP/SCAR/IASC)
CLIPS	Climate Information and Prediction Services
CLIVAR	Climate Variability and Predictability Project (WCRP)
CMIP	Coupled Model Intercomparison Project
COP	Conference of the Parties
ENSO	El Niño Southern Oscillation
ESM	Earth System Model
ESSP	Earth System Science Partnership
ETCCDI	Expert Team on Climate Change Detection and Indices
GCOS	Global Climate Observing System
GEWEX	Global Energy and Water Cycle Experiment (WCRP)
GOOS	Global Ocean Observing System (IOC-UNESCO/WMO/UNEP/ICSU)
IAI	Inter-American Institute
IASC	International Arctic Science Committee
ICSU	International Council for Science
ICTP	International Centre for Theoretical Physics
IGAC	International Global Atmospheric Chemistry Project (IGBP)
IGBP	International Geosphere-Biosphere Programme
IMS	Integrated Monsoon Study (WCRP)
IOC	Ingergovernmental Oceanographic Commission (UNESCO)
IGOS	Integrated Global Observing System
IGOS-Cryo	Cryospheric Theme of IGOS
IPCC	Intergovernmental Panel on Climate Change
IPO	International Project Office
IPY	International Polar Year 2007–2008
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
JSC	Joint Scientific Committee
JPS	Joint Planning Staff
JCRF	Joint Climate Research Fund
MOC	Meridional Overturning Circulation
NWP	Numerical Weather Prediction
OOPC	Ocean Observations Panel for Climate (WCRP/GCOS/GOOS/JCOMM)
PCMDI	Program for Climate Model Diagnosis and Intercomparison
RCM	Regional Climate Model
SBSTA	Subsidiary Body for Scientific and Technological Advice [of UNFCCC]
SCAR	Scientific Committee on Antarctic Research
SCOR	Scientific Committee on Oceanic Research
SOLAS	Surface Ocean – Lower Atmosphere Study (WCRP/IGBP/SCOR/CACGP)
SPARC	Stratospheric Processes and Their Role in Climate (WCRP)
START	SysTem for Analysis, Research and Training (ESSP)
TOGA	Tropical Ocean and Global Atmosphere Project (WCRP)
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
VACS	Variability of the African Climate System (WCRP/CLIVAR study)
VAMOS	Variability of the American Monsoon System (WCRP/CLIVAR study)
WG	Working Group
WGCM	Working Group on Coupled Modelling (WCRP)
WGNE	Working Group on Numerical Experimentation (WMO-CAS/WCRP)
WGSF	Working Group on Surface Fluxes (WCRP)
WGSIP	Working Group on Seasonal to Inter-annual Prediction (WCRP/CLIVAR)
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment (WCRP)
WOAP	WCRP Observation and Assimilation Panel (WCRP)
WWRP	World Weather Research Programme
YOTC	Year of Tropical Convection

Getting involved in the WCRP

The great success of WCRP is directly related to the proactive involvement of leading climate scientists and effective partnering with organizations from around the world. The following are the primary means of partnering with this programme.

Sponsors: Sponsors support WCRP financially or sponsor scientists, our core projects and integrative research activities. Many WCRP workshops and meetings are possible only because of external funding. Even small contributions can make a big difference. For example, relatively small amounts can make it possible for scientists from developing countries to participate in regional and international efforts that would normally be beyond a country's means. Part of WCRP's remit is to build capacity in international climate research through education and training activities, facilitate a lively multidisciplinary network of world-class climate scientists, stimulate in-depth research to fill knowledge gaps and strike new paths in climate research.

Partners: Partners contribute to WCRP initiatives by identifying joint scientific priorities, contributing scientific expertise and securing financial resources to conduct join projects. Joining one of our partnerships provides an excellent opportunity for individuals and organizations to demonstrate a strong commitment to climate and climate change research by multiplying organizational strengths among partners. WCRP welcomes the opportunity to form partnerships with private industries, non-governmental and intergovernmental organizations, foundations and associations.

National Academies, Agencies and Climate Committees: WCRP greatly benefits from the active involvement of national agencies (such as national meteorological and hydrological services and national space agencies) and national academies. The establishment of national climate and global change committees as a mean of building a truly international network in support of integrated climate research is very helpful. Those organizations and groups play an important role in linking national and international programmes, as well as interacting with policy makers and other interested parties in their home countries. The greatest benefit to all parties involved is the strengthening of complementarity and avoidance of redundant efforts.

Scientists: WCRP invites and encourages individual scientists to make the WCRP secretariat aware of their ongoing research and to suggest ways to integrate local and international initiatives. The WCRP Joint Scientific Committee and the core projects and cross-cutting activities, welcome proposals for new collaborative activities (research projects, workshops and syntheses) that support implementation of the WCRP Strategic Framework. Those proposals should be high-priority issues where significant progress can be expected in a short time and should result in a synthesis or integration of research activities across WCRP.

Interested Participants: Keep up-to-date with WCRP activities by subscribing to the programme's quarterly newsletter (e-zine) and submit news on recent research findings, publications, upcoming or successfully completed meetings for listing on the WCRP Web site.

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