



# Review of the World Climate Research Programme (WCRP)

Report from an ICSU-WMO-IOC-IGFA Review Panel

## **ICSU**

Founded in 1931, the International Council for Science is a non-governmental organization representing a global membership that includes both national scientific bodies (116 National Members representing 136 countries) and International Scientific Unions (30 Members). The ICSU 'family' also includes more than 20 Interdisciplinary Bodies - international scientific networks established to address specific areas of investigation. Through these networks, ICSU coordinates interdisciplinary research to address major issues of relevance to both science and society. In addition, the Council actively advocates for freedom in the conduct of science, promotes equitable access to scientific data and information, and facilitates science education and capacity building. [[www.icsu.org](http://www.icsu.org)]

## **WMO**

The World Meteorological Organization (WMO) is a specialized agency of the United Nations. It is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces, and the resulting distribution of water resources. WMO has a membership of 188 Member States and Territories (since 24 January 2007). It originated from the International Meteorological Organization (IMO), which was founded in 1873. Established in 1950, WMO became the specialized agency of the United Nations in 1951 for meteorology (weather and climate), operational hydrology, and related geophysical sciences. [[www.wmo.int](http://www.wmo.int)]

## **IOC**

The Intergovernmental Oceanographic Commission (IOC) of UNESCO was created in 1960. On behalf of its 136 Member States (as of 25 April 2007), IOC promotes international cooperation and coordinate programmes in research, sustainable development, protection of the marine environment, capacity-building for improved management, and decision-making. It facilitates interagency coordination in the UN system through the UN-Oceans mechanism and collaborates on global reporting and assessment of the state of the marine environment. Through the Global Ocean Observing System, IOC helps improve operational oceanography, weather and climate forecasts, and monitoring. [[ioc-unesco.org](http://ioc-unesco.org)]

## **IGFA**

The International Group of Funding Agencies for Global Change Research (IGFA) is a cooperative organization of funding agencies that support scientific research on global change. IGFA fosters international coordination of research efforts through dialogue at a senior level. It provides a forum for funding agencies to identify issues of mutual interest and to develop strategies that address these issues both nationally and internationally. IGFA cooperates with ICSU and associated agencies, and promotes interaction with the International Global Change Research Programs. [[www.igfagcr.org](http://www.igfagcr.org)]

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Review Panel*

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# Executive Summary



This report is the result of a review of the World Climate Research Programme (WCRP) carried out by a Review Panel appointed by its sponsors—the International Council for Science (ICSU), World Meteorological Organization (WMO), and the Intergovernmental Oceanographic Commission (IOC) of UNESCO—and the International Group of Funding Agencies for Global Change Research (IGFA). The review was undertaken simultaneously with a review of the International Geosphere-Biosphere Programme (IGBP). The report consists of three parts: an introductory chapter, a chapter on findings and other relevant information, and a chapter on recommendations. The Annexes present background information including a list of Review Panel members and the Terms of Reference for the Review.

In short, the WCRP Review Panel recognizes the many important achievements of this international scientific research programme, and we conclude that WCRP can play a significant role in helping society meet the challenges of global climate change. But at the present time, WCRP lacks the focus, planning, and funding to meet these challenges. WCRP must focus its Projects and connect with partners and users in strategic ways, and it will need new resources to do so. The Review Panel's recommendations are aimed at building the necessary focus and connections into WCRP and its partnerships. In particular, WCRP should:

1. immediately focus its 2005 WCRP Strategic Framework<sup>1</sup> to better capture the WCRP role in providing the science that underpins research on climate predictability, adaptation, and mitigation, thus strengthening the links with key end-user groups.
2. rapidly implement its focused Strategic Framework, paying special attention to societal needs while maintaining its science-driven approach.
3. introduce clear priorities into WCRP as a whole, collaborating with other Global Environmental Change programmes to take into account urgent science required for IPCC and other societal demands.
4. lead the initiative on Earth system modelling, in collaboration with IGBP and other Programmes, utilizing the full richness of relevant disciplines, and explicitly addressing scientific problems that lie at the interfaces with these disciplines.
5. consolidate and strengthen its focus as a user and promoter of observations as well as its support of the components of the Global Climate Observing System.
6. set specific strategy and goals for building its scientific capacity in diversity of age and gender and for participation of developing country scientists in planning and research.
7. build its resource capacity by enhancing support for coordination and advocacy for research and infrastructure needs. This will necessitate expanding its funding sources outside traditional targets and working through IGFA.
8. expand its strategic outreach activities to target greater visibility and better uptake and utilization of WCRP outputs by the climate research community, the policy world and private sector, and more broadly to the general public.

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<sup>1</sup> Subtitled: Coordinated Observation and Prediction of the Earth System (COPEs).

In addition,

9. WCRP's sponsors should meet regularly to review their mutual responsibilities for the Programme in light of society's increasing need for climate understanding, mitigation, and adaptation.
10. WCRP, in partnership with other global environmental change programmes, should develop a framework for future joint research operation, with the initial focus on the elements identified in this Review. A sponsor-convened 12-month study is proposed to initiate and plan the process.



# 1. Context and Terms of Reference

## 1.1 Introduction

This report is the result of a review of the World Climate Research Programme (WCRP).<sup>2</sup> The review was carried out by a Review Panel appointed by the programme's sponsors—the International Council for Science (ICSU), the World Meteorological Organization (WMO), and the Intergovernmental Oceanographic Commission (IOC) of UNESCO—and the International Group of Funding Agencies for Global Change Research (IGFA). The Review Panel consists of scientists familiar with the Programme and representatives of the sponsors and IGFA (Annex 2). Each organization agreed on the Terms of Reference (Annex 3) and contributed suggestions for the Panel membership. The Review Panel submits its report to all sponsors, but the report is the Panel's and sponsors are not bound by the recommendations.

The review is timely: WCRP has been operating as a programme for almost 30 years (Box 1) and was last reviewed over a decade ago. In addition, the Global Environmental Change (GEC) research arena has become increasingly complex and the issues it addresses have become increasingly prominent (ICSU, 2003), with growing demand for regional-scale climate predictions to assist with adaptation and mitigation strategies, for example. Consequently, ICSU's Strategic Plan 2006-2011 (ICSU, 2006) called for reviews of all the GEC programmes that it sponsors. This review of WCRP was undertaken simultaneously with a review of the International Geosphere-Biosphere Programme (IGBP) (ICSU-IGFA, 2009). Recognizing the increasing appreciation for the biological linkages into research questions tackled by WCRP, the two Review Panels shared information and had one common member and one joint meeting. The parallel conduct of these reviews underscores the fact that WCRP and IGBP already collaborate and there is dialogue within the Programmes themselves about closer working relationships.

The report consists of three parts: an introductory chapter, a chapter on findings and other relevant evidence, and a chapter on recommendations. The order of the material in the second and third chapters follows a general flow from function to form. The Annexes present background information including a list of Review Panel members and the Terms of Reference for the review.

In short, the Review Panel recognizes the many important achievements of this international scientific research programme and commends the WCRP for its success. We agree with the many observers who conclude that WCRP can play an increasingly significant role in helping society meet the challenges of climate impacts and global climate variability and change. In particular, WCRP can play a key role in helping to formulate an operational framework of climate prediction with strong links to end-users. To do all this, WCRP will need to focus its activities and connect with partners and end-users in strategic ways, and the resources for the Secretariat functions will need to be brought to a sustainable footing. Our recommendations are aimed at building the necessary strength into WCRP and its partnerships.

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<sup>2</sup> A list of acronyms is presented in Annex 1.

## Box 1 Background on the World Climate Research Programme

### History

WCRP was established by ICSU and WMO in 1980 as an outcome of the first World Climate Conference in 1979. IOC joined as a sponsor in 1993. As the first of the modern-day global environmental change (GEC) research programmes, WCRP built on the successes of the Global Atmosphere Research Programme, which was launched by ICSU and WMO in 1967. The two major objectives of WCRP are to determine the extent to which climate can be predicted, and to determine the extent of human influence on climate.

### Structure

WCRP works through Cross-cutting Activities, Working Groups and other joint activities, and Projects. The Cross-cutting Activities currently focus on such areas as seasonal prediction, monsoons, and anthropogenic climate change. The Working Groups and other joint activities currently are

- Working Group on Numerical Experimentation (WGNE) (jointly with the WMO Commission on Atmospheric Sciences)
- Working Group on Coupled Modelling (WGCM)
- Ocean Observations Panel for Climate (OOPC) (jointly with Global Climate Observing System [GCOS] and Global Ocean Observing System [GOOS])
- Atmospheric Observations Panel for Climate (AOPC) (jointly with GCOS)
- Surface Ocean-Lower Atmosphere Study (SOLAS) (jointly with IGBP, the Scientific Committee on Ocean Research [SCOR], and the Commission on Atmospheric Chemistry and Global Pollution).

The Programme's four major Projects are

1. Climate and Cryosphere (CliC) Project
2. Climate Variability and Predictability (CLIVAR) Project
3. Global Energy and Water Cycle Experiment (GEWEX)
4. Stratospheric Processes and their Role in Climate (SPARC) Project.

### Governance and Implementation

A Joint Scientific Committee (JSC) of 18 members appointed by the sponsors formulates the overall scientific goals and concepts of the Programme. In addition, the JSC organizes the required international coordination and research efforts that underpin the Programme. The JSC's Terms of Reference and the overall focus and conduct of the Programme are summarized in a 1993 Memorandum of Understanding among the three sponsors. Each of the four WCRP major projects (CliC, CLIVAR, GEWEX, and SPARC) and the WCRP-IGBP joint program SOLAS has an International Project Office (IPO) with its own scientific steering committee, and each is now in transition to form a new WCRP structure before 2015.

In addition to the JSC, WCRP uses two supporting bodies to coordinate its work. These are (1) the WCRP Modelling Panel, which promotes, coordinates, and integrates modelling activities across WCRP, and (2) the WCRP Observation and Assimilation Panel, which is co-sponsored by GCOS, and addresses cross-cutting issues related to global observations, their analysis and assimilation, and the resulting products from a research perspective.

The work of the JSC is supported by a Joint Planning Staff (JPS). The JPS currently consists of eight staff and is hosted by WMO in Geneva. All staff are WMO employees except one at a satellite office at the Institute Pierre-Simon Laplace in Paris. The Director of the WCRP JPS changed in 2007 from Ann Henderson-Sellers to Ghassem Asrar. The annual budget of the JPS was approximately \$3 Million from 2004 to 2007. This includes core national contributions that are channelled through the three sponsors, as well as miscellaneous items such as grant funding and money for secondments.

In 2005, the Programme completed a Strategic Framework document called the Coordinated Observation and Prediction of the Earth System (COPES). This document aims to provide "a unifying context and agenda for the wide range of climate science coordinated by and performed through WCRP projects and activities, and for demonstrating their relevance to society" (WMO, 2005).



## 1.2 Background

WCRP has encouraged and supported a global scientific enterprise with an enormous quantity of high-quality research. The Programme has helped the world understand the trends and cycles of natural climate change and human-induced greenhouse warming. The success and recognition of the Intergovernmental Panel on Climate Change (IPCC) is built largely on the research results of WCRP and IGBP (IPCC, 2007; Solomon and Manning, 2008). The climate change threat and the role of WCRP was internationally recognized when IPCC was awarded the Nobel Peace Prize for 2007. The scientists, national institutions, and international organizations involved are to be congratulated for their success.

There is now better understanding of climate change and human impacts, and the world is challenged to understand and deal with the consequences of global climate change (see Box 1 of ICSU-IGFA, 2009, for example). Society needs the research that will underpin mitigation strategies and climate adaptation at the regional scale. The demand for and uptake of climate science is changing rapidly and WCRP must learn to flexibly respond, either by evolving into a more relevant form by broadening its scientific base, or by focusing on current strengths and being ready to collaborate with others on new programmes. The world has changed, and, to be successful, WCRP must adapt accordingly.

This is an important time in history for WCRP. Its science has shown how just one species on Earth—humans—can affect the global environment. At the same time, global climate change driven by a growing global population and its use of energy threatens society as we know it. How should WCRP continue research in this new context? The need for clarification of WCRP roles and focus is high.

The magnitude of the problem of global climate variation and change is enormous, and all sectors of society are involved. After almost 30 years of high achievement, the breadth of WCRP programmes has outgrown the willingness of society to support all the necessary research, infrastructure, and coordination. Yet the need for WCRP's work is more important than ever, and it is critical that policy makers and the public understand this importance. We see many societal issues of immediate relevance to WCRP such as changing land use, effects of new sources of energy, the potential for a seasonally ice-free Arctic, and emerging carbon markets. In addition, the other GEC programmes (IGBP, International Human Dimensions Programme on Global Environmental Change [IHDP], DIVERSITAS—a Programme on global biodiversity science) have increasingly common interests; emerging activities such as the Earth System Science Partnership (ESSP) are making the landscape increasingly complex; and competition for funds is tight. Interdisciplinarity has evolved and broadened. Now ESSP is the broadest example, and its role relative to its GEC programme parents (of which WCRP is one) is still not well differentiated, defined, or broadly understood.

All programmes need to change and adapt, and WCRP is no exception. In 2008, WCRP has a new director and new JSC chair, making this an opportune time to optimize the direction and effectiveness of the Programme. There does seem to be potential to extend the role of WCRP and in doing so engage more closely with those impacted by the science and provide direct motivation for investment in WCRP's functions.

## 1.3 Framework and Terms of Reference

The overriding objective of the Review is to evaluate the extent to which WCRP adds value to its area of research and to the national programmes that contribute to it. A primary question that the Review attempts to answer is “What do scientists, sponsors and the end-users get out of participating in and supporting the international programme that they would not have gained if the international programme did not exist?” To address this question, the Review Panel takes a prospective view with the aim of maximizing the future added value of WCRP while learning from a retrospective analysis of the current programme and its recent evolution.

The Panel's full Terms of Reference (Annex 3) emphasize a review of the Programme as a whole and not including an in-depth analysis of the component parts. These parts are, of course, the foundation of the Programme and they rely on the voluntary participation of thousands of scientists. The Panel was fully cognizant of and sensitive to this structure as it conducted the review and in making its recommendations.

The Review focused on interactions within WCRP and also its external connections. The major questions considered by the Review Panel emphasize not just science relevance, but also policy and development relevance. In addition, the Panel has asked: What is the role of natural versus social science? Does the Programme engage the younger generation of scientists? What is the relationship of WCRP to ESSP? Is the increasing collaboration between IGBP and WCRP an impetus for even tighter working relationships? What do end-users serviced by Members of the sponsoring international organizations expect from WCRP? What should be the role of WCRP in relation to other climate-related programmes, in particular the World Climate Programme? Or perhaps the Programme is no longer needed and needs a sunset clause?

Additional detailed questions were provided to the Review Panel for guidance (Annex 3). The Panel used these questions to focus its discussion and interviews with key personnel in the Programme and with other scientists. We were not able to answer all of the questions, but the recommendations reflect the issues that have been raised in the answers to the questions.

## 1.4 Review Process

After a preparatory meeting of the Chairs and sponsors in December 2007, the full Review Panel had three meetings in 2008 (in January, April, and September). The final meeting included one overlapping day with the IGBP Review Panel in order to compare notes and make sure that there were no gaps or inconsistencies in the reviews. During the first meeting, the Panel agreed on the conduct of the review, the information necessary to perform the review, and the division of work. In addition, the Review Panel designed an interview/questionnaire process for collection of views of the sponsors, stakeholders, programme leadership, projects, and individual participating scientists (Annex 4). At its second meeting, following a meeting of the JSC at which the Chair and other members of the Review Panel participated, the Panel reviewed the material collected and assigned tasks for the first draft of the review. Immediately following this second meeting, the Chair visited WMO in Geneva for discussions with programme leadership and WMO leadership as hosts of the programme Secretariat and collaborators within the WMO structure.

Presentations of summary issues were made to the Executive Councils of WMO and IOC for comment in June 2008 and to the ICSU General Assembly in October 2008. The first draft was circulated to the Review Panel in August 2008 for comment and preparation for the September meeting, where agreement was reached on the contents of the report. The Review Panel's draft report was then submitted to the Programme for a fact check and subsequently to all sponsors and IGFA for comment. Upon consideration of these comments, a final version of the report was delivered to sponsors and IGFA in early 2009.

The Review Panel is grateful to all who contributed input to the process and for the guidance and assistance of Paul Cutler in all aspects of the report.



## 2. What the Review Panel Learned and Considerations for the Future WCRP

This chapter summarizes the information that the Review Panel gathered in its meetings, interviews, and from reading and analyzing the extensive documentation that was provided or available to the Panel. From all of these sources, it is fair to say that the strongest value of WCRP is undoubtedly its unique international networking function, which is to catalyze and facilitate international collaboration and setting of joint objectives.

### 2.1 Meeting the Challenges

A summary of the challenges faced by WCRP, derived from five key documents and responses to the Review Panel's questionnaires, helps lay the groundwork for the Panel's deliberations on the future added value of WCRP. The first four documents summarized in this section focus on scientific challenges whereas the fifth document and questionnaire responses mainly highlight practical challenges.

#### 2.1.1 Challenges Faced by the Programme

##### ***WCRP Strategic Framework***

The challenges and opportunities have been laid out in the World Climate Research Programme Strategic Framework 2005-2015: Coordinated Observation and Prediction of the Earth System (WMO, 2005). The aim of the Strategic Framework 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 report identifies these scientific challenges and opportunities for WCRP:

- The seamless prediction problem (merging weather and climate prediction effectively)
- Predictability of the climate/Earth system
- Prediction of climate taking into account the whole Earth system
- Analysis of climate system behavior
- Application of WCRP science to socio-economic problems and demonstration of the usefulness of WCRP-enabled analysis and predictions.

##### ***Documents on Seamless Forecasting***

The virtues of a seamless prediction process have been raised in WCRP's Strategic Framework document and discussed further by several groups (e.g., Brunet et al., 2007; Palmer et al., 2008). There is not a uniform interpretation of what seamless means, but for WCRP, in concept at least, it

could mean that the science of prediction will no longer be broken into compartments based on time scale (weather, extended range, intraseasonal, seasonal, interannual, decadal), but will be approached as one, with systems designed to address predictions across all scales. This also has implications for the space dimension. The Brunet et al. paper concludes that

“there is a need for closer ties between weather and climate research centres that can provide state-of-the-art weather and climate forecast information and [end]-user groups that understand the scientific issues underpinning the practical application of forecasts in decision support systems. In general, capacity is needed in terms of developing social and interdisciplinary scientists around the globe who have expertise in: i) understanding how information at the weather/climate interface, including uncertainty, connects with decision-making, ii) developing decision-relevant information from weather and climate predictions, iii) bridging among weather and climate researchers, weather and climate information providers, and policy- and decision-makers.”

### ***Proposal for a Weather, Climate, and Earth-System Prediction Project***

The socio-economic and environmental benefits of a revolution in weather, climate, and Earth system analysis and prediction were outlined by Shapiro and co-authors, in “The Full Picture”—a Group on Earth Observations (GEO) publication for the IV GEO Ministerial Summit in 2007 (Shapiro et al., 2007). The article concludes that there is an urgent need for establishing a weather, climate, and Earth-system prediction project. The project would increase the capacity of disaster-risk reduction managers and environmental policy makers to make sound decisions, in order to minimize and adapt to the societal, economic, and environmental vulnerabilities arising from high-impact weather and climate. The proposed project would be a mega-science programme, comparable in size to the Apollo Moon Project, the Genome Project, or the International Space Station, with socio-economic and environmental benefits-to-cost ratio that is much higher. Shapiro et al. recognize that such a project will require unprecedented international collaboration and good will, but note that the global scope of the problem makes this inescapable, as no single nation possesses the scientific capacity and infrastructure to meet the challenges.

### ***IPCC Fourth Assessment Report***

The IPCC Fourth Assessment Report (AR4) exposed important needs for future WCRP as well as IGBP research. In the report from the workshop on “Future Climate Change Research and Observations: GCOS, WCRP and IGBP learning from the IPCC Fourth Assessment Report” (WMO, 2008) held in Sydney, Australia in October 2007, the assembled scientists identified the gaps in observations and basic science raised by the IPCC process. The report also identified deficiencies in the way information about climate change is used for estimation of impacts, design of adaptation measures, and assessment of vulnerability, particularly on the regional scale. The issues that limit confidence in projections of climate change were identified, and there was strong agreement that vulnerability of regions and societies to climate change should be considered when framing future climate change research strategies and needs for additional observations.

### ***Network Survey Report on WCRP***

In 2006, the WCRP Director at the time, Anne Henderson-Sellers, contracted with Eera Consultancy to prepare a “Network Survey Report” (Eera, 2006) to “point out issues that need close attention in developing WCRP further in regard to efficiency and effectiveness and especially in becoming more relevant to society” (Eera, 2006). The ideas presented in the report draw on in-depth interviews with 85 stakeholders.<sup>3 4</sup> The stakeholders identified several practical challenges to solve:

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<sup>3</sup> These include members of the WCRP JSC and core projects, individual scientists from a broad range of fields, sponsors, funding agents, other relevant programmes such as UNFCCC, climate research organizations, National Meteorological and Hydrological Services (NMHS), and end-users such as financial institutions and energy companies.

<sup>4</sup> It should be recognized that the survey was selective and, while broad-ranging, did not capture opinions of some institutions and agencies in the WMO family. That said, not all members of ICSU or IOC were able to respond to this Review Panel’s survey. Nonetheless, the combined set of opinions from these various sources was a valuable resource to the Panel.

- WCRP has little experience in creating research products for end-users and it was questioned whether that should be their role at all,
- WCRP has little experience in applying for or raising funding beyond the normal science agency support, nor the required resources to enter that field today,
- WCRP today is science-oriented; to become a more end-user- or operational funding-agent-oriented player requires adding different capabilities to WCRP and improving its linkages with other groups, including WMO's World Climate Programme,
- WCRP core staff is too small to make this change happen, or its allocation of time and resources should be reconsidered, and
- WCRP and its Secretariat must be able to induce enthusiasm that both drives and motivates scientists.

All these points have been considered by the Review Panel in its deliberations.

The Network Survey summarized WCRP's challenges as the Programme having been inward looking and not noticing sufficiently the world is changing; its organizational and process structure not meeting the demands of today; and funding in its present format is not sufficient. The Review Panel takes up these general issues later in the report and its judgments on these points will be apparent.

### **Survey Responses**

In addition to the perspectives summarized by Eera (2006), the Review Panel's own questions to stakeholders added a number of additional challenges:<sup>5</sup> The impact of WCRP has been strongest at the international scale (such as the World Ocean Circulation Experience [WOCE]) and the regional scale (such as the African Monsoon Multidisciplinary Analyses—AMMA) with less impact at national scales (also the case for IGBP).<sup>6</sup> Involvement of developing countries was considered too low by the majority, and development actors were the top target category for better engagement. Opinions were split on the effectiveness of capacity building, whereas the effectiveness of outreach was considered by the majority not to be effective.

The parallel review of IGBP (ICSU-IGFA, 2009) examined stakeholder perspectives on the future of IGBP and other GEC programmes in the increasingly complex landscape of GEC activities. A majority of IGBP survey respondents<sup>7</sup> was in favour of a single GEC research programme in the future. Opinions on timescales for this evolution ranged from five to 10 years. The IGBP Review Panel recommends a consultative process to discuss how GEC-wide priorities can be set—as a first step toward a unified approach to organizing GEC research. Such a process would necessarily involve WCRP participation and perspectives. A clear challenge to WCRP will be determining the future evolution of the Programme in this broader context.

## **2.1.2 Response of WCRP to these Challenges**

An important overall question to the Review Panel was how well is WCRP responding to the large scientific and organizational challenges raised in this section? It is clear to all that WCRP has earned renown for excellence over its lifetime of almost 30 years. This excellence provides a strong foundation for the future. At the same time, there must be a strategy for improving both the prioritization of WCRP science and related activities and for the conversion of WCRP science into future societal benefit. The WCRP Strategic Framework document provides a framework but lacks

<sup>5</sup> Because of the existence of the Network Survey, the Panel used its own survey as a supplement rather than as its central information gathering tool as in the case of the IGBP review. With 23 responses (see Annex 4), we emphasize only the general trends.

<sup>6</sup> Note that many of WCRP's hallmark activities have been regional research activities and field experiments, such as AMMA, but with broader impacts.

<sup>7</sup> The IGBP Review Panel conducted an extensive survey of 74 IGBP National Committees (50% of whom responded and of which 39% are in fact already broadly focused on national GEC interests) as well as the nine IGBP Core Projects (seven substantive responses), the IGBP Scientific Committee and leadership, funders (three substantive responses) and the stakeholder community (23 substantive responses).

future priorities and an implementation plan. The absence of a detailed implementation plan will make the required societal and policy relevance more difficult to achieve in the future. Yet it is the societal and policy relevance that will sustain the Programme in the long run and make the necessary resources easier to acquire.

A key part of this Review is to identify what can be done to build this relevance in order to make the Programme more attractive to potential funders while retaining the focus of WCRP on the fundamental science that has been the basis of its contribution so far. The recommendations in Chapter 3, supported by background material in the remainder of this Chapter, are aimed at making that happen.

## 2.2 Connecting With End-Users

WCRP's connections to end-users, while strong in some areas (e.g., as input to the development and implementation of conventions such as the Montreal Protocol on Ozone Depleting Substances), are not yet managed strategically or clearly understood, particularly in the context of operational and other applied users. Indeed, the Review Panel's interactions with participants at the 2008 JSC meeting exposed a general feeling that the connection of WCRP science with end-users (Box 2) could use substantial strengthening.

### Box 2 Terminology on Interactions

The term "user" needs clear definition because of the distinction between direct users of WCRP outputs and end-users who primarily benefit indirectly. Before explaining our distinction of users and end-users, it is useful to list examples of the outputs users actually use from WCRP.

**WCRP outputs (for example)** include not only new science that explains processes or describes the state of the climate system, but also new products such as reanalysis products or model scenarios, international consensus on the status and needs of particular areas of climate science (e.g., modelling requirements; seamless prediction), international collaborations that combine resources to address shared problems or satisfy shared needs, and guidance for and invigoration of national climate research programmes.

**Users** (i.e., direct users) of WCRP include (i) *research scientists* whose work builds on WCRP science, advances climate science in general, and underpins scientific assessments such as those of the IPCC or ozone assessments; (ii) *research organizations* that implement national research agendas and/or support service delivery organizations, and (iii) the *climate service delivery* components of National Hydrological and Meteorological Services and their national partners.

**End-users** (i.e., indirect users) include policymakers, organizations, and private citizens who make decisions based on climate information from the direct users (this would include decisions on adaptation and mitigation strategies).

WCRP aims to coordinate international research on climate through its Strategic Framework. In that framework, those Core Projects addressing specific themes and certain uses are intended to contribute to a set of cross-cutting initiatives that address a different and complementary set of needs and questions. The current links from programme activities to users and end-users are manifold, ranging from simple individual investigator interactions with their sponsors to links made to end-user communities by the Core Projects and other groups of WCRP. Some of these connections occur through regional initiatives such as regional monsoon studies, which the Programme has been organizing since the 1990s, and which help WCRP demonstrate relevance to governments in countries with some of the largest populations and greatest vulnerabilities.

End-users of WCRP research such as (i) assessment bodies served by research scientists and (ii) clients served by National Meteorological and Hydrological Services (NMHS) and ocean service agencies can particularly benefit from WCRP science and climate predictions. In the remainder of this section,

we highlight these two categories in which the connection to end-users is already occurring but which could become the focus of WCRP's efforts to maximize its impact on end-users. The reason for advocating for better connection to end-users through these channels is to maximize societal relevance, improve WCRP visibility, improve the WCRP resource base, and improve uptake of the important outcomes of WCRP's basic research.

### 2.2.1 Research Scientists

The WCRP link to end-users through research scientists involved in the IPCC assessment, and its further link into the UN Framework Convention on Climate Change (UNFCCC), is a shining example of successful connection of science all the way to political decisions. Another assessment-related example is the role of WCRP scientists from the SPARC Project in ozone assessments. Beyond assessments, research scientists in many contexts make use of WCRP science to the benefit of end-users. We give the specific example of IOC science in relation to marine ecosystem variability.

Climate prediction and analysis in the IPCC context has to do with decadal to century time scales and strong interaction with IGBP and ESSP. The achievement of end-user linkage in this case has been somewhat natural because WCRP is a science generation engine and IPCC is a science assessment process that uses knowledge recorded in peer-reviewed publications to carry out its assessments. In addition, many WCRP scientists are involved in the assessment process, so the natural connection becomes even stronger. Furthermore, WCRP's Working Group on Coupled Modelling has organized the modelling simulations for future climate that are required for the IPCC AR4 and is now organizing new future climate simulations under the timetable set by IPCC for its Fifth Assessment Report (AR5).<sup>8</sup> Over the four assessment cycles of IPCC to date, a dynamic dialogue has developed that helps guide WCRP in shaping and setting its agenda. The most recent example of this is the set of needs expressed at the Sydney meeting (WMO, 2008). These needs, if not yet addressed, must be built into WCRP research priorities.

As another example of structures that can be utilized by scientists to bring WCRP science to end-users, it is noted that WCRP provides data and science for several programmes under the IOC Ocean Science Section such as those examining marine ecosystem variability. Such variability cannot be understood without considering climate variability and change, and for instance ecosystem regime shifts, changes in routes of oceanic migratory species (such as tuna fish) and studies on global ecosystem dynamics (e.g., Global Ocean Ecosystem Dynamics Project—GLOBEC) demand data on regional climatic conditions, climate change, and climate predictions in order to refine their own models for ecosystem variability, fish recruitment, species displacement, and changes in biodiversity.

### 2.2.2 Research Agencies and Operational Users

As society moves into climate change mitigation and adaptation, a service delivery mechanism for long-term climate predictions or projections, particularly at the regional scale, is mostly insufficient or missing although there are some ongoing activities conducted by national centers or the regional climate centers of WMO. WCRP conducts the underlying research that underpins the work to fill this gap (e.g., Box 3), and WMO programmes that are driven by NMHSs and their partners transform this into the operational domain through service delivery mechanisms of the World Climate Programme (WCP). This is done jointly with IOC through the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM).

The connection to the end-user base is in place and under constant development. WCP and associated elements of WMO could provide a key mechanism for delivery of climate information for WCRP, though, as noted by Eera (2006), the relationship between WCRP and WCP has been weak. In addition, other mechanisms and organizations have emerged to help fill this gap (e.g., International

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<sup>8</sup> In this case, the end-user (IPCC, the parties to the UNFCCC, and other) drives the agenda of groups like WGCM and the Coupled Model Intercomparison Project, including setting timelines. In turn, it is the ability of WCRP to coordinate the science and agree standards and benchmarks that makes the assessments of IPCC possible. In other words, WCRP enables.

Research Institute for Climate and Society (IRI)). The WCP and associated elements of WMO do provide a pathway to impact for climate science, but there are others as well.

#### Box 3 TOGA: an Example of WCRP Research Enhancing Climate Predictability

WCRP research has played and will continue to play an important role in strengthening climate predictions at the regional scale. The contributions of WCRP's Tropical Ocean-Global Atmosphere (TOGA) programme provide an excellent example, leaving as a legacy knowledge and capability on practical prediction of El Niño. Such predictions have advanced as a result of WCRP research and form the basis for many applications in South America, Africa, and Asia by NMHSs and by ocean services agencies. The measurement techniques developed and demonstrated in TOGA have subsequently been incorporated into operational arrays that now contribute to the Global Ocean Observing System.

The operational service delivery mechanisms that have been developed by WMO jointly with IOC for weather prediction and analysis products are potentially available to deliver sub-seasonal to inter-annual climate prediction research services (see, for example, the work of JCOMM). As noted above, however, the connection between WCRP and these operational mechanisms could be strengthened. To address this gap, the WMO Executive Council approved in June 2008 a WMO initiative to support adaptation to climate variability and change. The initiative links research and observations more closely with operational service delivery that is quite mature for numerical weather prediction products but in need of climate prediction products. This restructuring reflects the priority placed by WMO on improving such connections, and is envisaged to bridge between end-user needs and the supporting research, observations, and application development. In association with this initiative, WMO is developing an "Enhanced Prediction Framework."<sup>9</sup>

The links of WCRP science to the operational aspects of climate prediction on time scales from seasonal to inter-annual to decadal need to be developed further. Some help will come as seamless forecasting is extended to longer time scales (already a focus of activities between WCRP, the World Weather Research Programme [WWRP] and other related WMO programmes).

It is important to listen to end-users at the earliest stages of research project development. At present, predictions generated by the operational numerical weather and climate prediction centres of the WMO network are delivered to the WMO Regional Climate Outlook Fora (RCOF), which are organized under the Climate Information and Prediction Services (CLIPS) of WCP, with only a limited feedback from the regional scientists or from the fora to the operational centres and WCRP Projects. With such a top-down approach, it is difficult to develop regionally relevant predictions for parameters or events that are critical for decision-making (such as long dry spells within a rainy season over semi-arid tropics). In this situation, the contribution of WCRP is restricted to facilitating the generation of predictions of events or phenomena of interest to WCRP scientists.

To achieve the objective of the WCRP Strategic Framework that "WCRP will facilitate predictions for use in practical applications of direct relevance, value, and benefit to society," it seems clear that strengthened collaboration would be extremely useful between WCRP and relevant activities in WCP (e.g., WMO Regional Climate Centres and Regional Climate Outlook Fora, CLIPS,<sup>10</sup> and JCOMM). By

<sup>9</sup> See Section 3.2.10 of EC XV Report ([http://www.wmo.ch/pages/governance/ec/documents/1032\\_en.pdf](http://www.wmo.ch/pages/governance/ec/documents/1032_en.pdf)). This framework would coordinate enhanced climate, weather, water, and environmental prediction services.

<sup>10</sup> Since its inception in June 1995, the CLIPS project of WCP, greatly assisted by such international research organizations as the International Research Institute for Climate and Society (IRI), has been active around the world, particularly in temperate and tropical latitudes. CLIPS has focused on (i) promotion of operational climate prediction services, particularly on seasonal to interannual time scales, in an end-user-targeted manner; (ii) providing an active interface between the research and operational communities; (iii) promoting consensus-based climate outlook product generation, particularly through its support to the Regional Climate Outlook Forum (RCOF) process and development of WMO El Niño/La Niña Updates; and (iv) capacity building of NMHSs in providing climate services through a worldwide programme of CLIPS Training Workshops.



connecting with end-users through such activities, WCRP will gain a better understanding of priorities for what needs to be predicted and with what level of skill and this will certainly raise fundamental scientific questions to be addressed.

This is an opportune moment for WCRP to update its Strategic Framework with respect to end-user interaction and to develop an associated implementation plan that addresses the challenges of linking its climate analysis and prediction products to appropriate service delivery mechanisms. This will need to be done in collaboration with the Joint Scientific Committee of WWRP, which is developing an implementation plan that links to WCRP through joint activities that reflect the seamless nature of weather and climate prediction. These links include the joint sponsorship of activities of the Working Group on Numerical Experimentation (WGNE), and common interest in parameterizing processes such as precipitation formation, the role of aerosols, and convection.

### 2.2.3 Summary of User and End-user Interactions

WCRP is already connected to some major user groups such as research scientists and there are initiatives underway that will improve the connection to others such as NMHSs and ocean service agencies. For connecting to end-users (whose needs should ultimately influence WCRP research directions), structures already exist upon which to build a WCRP implementation plan.

## 2.3 Setting Priorities

A better connection to end-users and their many needs demands a clear, programme-wide WCRP research prioritization strategy. The Sydney meeting on needs arising from the IPCC AR4 (WMO, 2008) highlighted a broad range of research topics on which progress is needed before the next assessment. This was a necessary but not sufficient step in the prioritization process. The challenges on which WCRP could contribute are numerous—more than can be handled by the current Programme. Yet the Review Panel is not aware of a major coordinated response within WCRP (or IGBP, for that matter—see ICSU-IGFA, 2009) on prioritization of its activities as a result of the Sydney workshop. The Panel has heard complaints from WCRP that it was not given sufficient credit for its contributions to AR4. And WCRP is already engaged with developing new scenarios, model runs, and reanalysis in preparation for AR5. Yet, there is a risk that WCRP's overall contributions to AR5 will be eroded unless high priority is put on these preparations. There is a good deal of urgency for quick action. The report from IPCC Working Group I is due in early 2013, with the other Working Groups delivering into early 2014. With papers needing to be published to be considered in the assessment, the relevant research should already be underway, or proposed to be funded in 2009.

The Sydney workshop is not the only activity feeding urgent and societally relevant needs for prioritization by the Programme. The May 2008 World Modelling Summit on Climate Prediction, organized by WCRP, WWRP, and IGBP made a series of recommendations for developing a global system for climate prediction for implementation in the next decade.<sup>11</sup> One of the major outcomes was that climate modelling and prediction research requires the establishment of an international climate research facility, including a number of high-end computing facilities dedicated to climate, leading to systems at least 1,000 times more powerful than currently available computers.

While these recommendations are to some extent linked to some from the Sydney meeting, there remains the need to develop a clear WCRP-wide strategy for analyzing and responding to the outcomes of such meetings.

In general, the involvement of significant stakeholders other than the scientists themselves (such as the UNFCCC Subsidiary Body for Scientific and Technological Advice—SBSTA) in priority setting needs to be strengthened. This can be built on existing processes such as the Sydney dialogue (WMO, 2008),

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<sup>11</sup> See <http://wcrp.ipsl.jussieu.fr/Workshops/ModellingSummit/index.html>

and existing connections with work of IRI, for example. The process for priority setting also needs work. While the WCRP Strategic Framework is a fine scientific document, it gives little attention to the drivers that will determine priorities or the details of how these will be weighed. Lastly, WCRP will need to develop a sense of timing of priorities. As noted earlier, any changes agreed now will be stretched to influence the IPCC's Fifth Assessment Report, in particular for Working Group I.

## 2.4 Programme Implementation

The Review Panel is concerned about the status of implementation of the WCRP Strategic Framework (WMO, 2005), which runs between 2005 and 2015. In addition, based on information gleaned from the 2008 JSC meeting, the Panel is concerned about the integration of this implementation with that of the component activities (see Appendix B of WMO, 2005). It remains unclear the degree to which the Strategic Framework is going to be implemented through the component parts (i.e., an aggregation of the existing implementation plans of the Core Projects) or whether WCRP will decide an implementation pathway, and change the role of the component parts so that they are responsible for aspects of the implementation but no longer have activities that are not consistent with the Strategic Framework. The emergence of pan-WCRP activities is consistent with the latter, but there is little evidence of rationalisation and change of the Projects in light of this Framework. If it is through the former path, there is a real risk that the Strategic Framework will deliver only that which the component Projects were going to deliver by 2013 anyway.

In another example that is of concern to the Panel, the WCRP Modelling Panel (WMP) and WCRP Observations and Assimilation Panel (WOAP) have been in place since 2004, coexisting with other groups with similar mandates. We understand that WCRP is developing intermediate-term and long-term strategies that aim to address these kinds of similarities, but in the mean time, the Review Panel has not seen any evidence of rationalisation and progressive consolidation of their work programme under the Strategic Framework, or evidence of stopping activities in the component Projects in favour of consolidated actions under this Framework. And now the recent World Climate Modelling Summit proposes a WCRP-led Climate Prediction Project in collaboration with WWRP and IGBP. How this relates to the other modelling activities in WCRP will need to be quickly resolved and rationalized.

Another key element of implementation is adequate support for observations. WCRP places high priority on obtaining and using the highest possible quality observations for climate research. WCRP projects and contributors have stimulated atmospheric re-analysis of observations performed by several major numerical weather prediction centres of WMO (National Centers for Environmental Prediction, European Centre for Medium-range Weather Forecasting, Japanese Meteorological Agency). WCRP projects and contributors are now closely involved in the development of ocean re-analysis and in the consideration of whole-Earth-system re-analysis. Furthermore, WCRP exploits observations and re-analyses in its input to the IPCC assessment reports and other wide-ranging policy advice.

WCRP and its three sponsors play an important role as a partner of GCOS, which is an observational system of systems that relies on existing observing, data management, and information distribution networks, both operational and research, and on further enhancements of these systems. GCOS was an outcome of the second World Climate Conference (WCC-2, 1990) and was designed to fill a gap in systematic climate system observations required by WCRP and the rest of the World Climate Programme. It still has unfulfilled coverage and commitment goals, and WCRP can help in this regard by strengthening its dual role as user and promoter of Earth system observations. As a user, WCRP needs the best quality comprehensive and long-term observations, and will need to continue to work with all relevant observational programmes to ensure adequate support for the full system. As a provider, WCRP plays a key role in ensuring that climate research information needs are met broadly, and can use its relationships with other climate programmes to help build GCOS towards completion.

The WCRP JSC is now examining programme implementation anew, with the aim of consolidating activities where necessary. But how this fits with an agreed plan to continue the Projects in their present form until 2013 we cannot tell. The Projects have been asked by the JSC to identify contributions to the WCRP Strategic Framework, but it is not clear to the Panel what the process is for changing in response to identified needs. The Projects need to focus on how they can be most responsive to needs.

## 2.5 Broadening the Scientific Base

The strategy to understand and model the Earth system as developed within the WCRP Strategic Framework necessitates further strengthening of WCRP's links with the other GEC Programmes. This is particularly needed to account for biogeochemical cycles, including atmospheric chemistry, but also to learn from the study of past climates. The WCRP-IGBP collaboration is crucial to investigate both short-term and long-term climate changes and the role of the particular components of the climate system.

WCRP-IGBP collaboration is already taking place through shared projects such as (i) SOLAS, (ii) Atmospheric Chemistry and Climate (AC&C) cross-cutting project between the International Global Atmospheric Chemistry (IGAC) project of IGBP and the SPARC project, (iii) Integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS) of IGBP with GEWEX, and (iv) CLIVAR with the IGBP Past Global Changes (PAGES) project. In addition, common meetings and sub-projects already exist between WGCM and the IGBP Analysis, Integration and Modelling of the Earth System (AIMES) project (see 2.3.2 of ICSU-IGFA [2009] for more examples).

Such partnerships could be expanded in the future. WCRP has a long experience of development and evaluation of climate models coordinated at the international level. IGBP will certainly benefit from this strong experience. In particular, WCRP plays a key role in organizing and coordinating experimentation and simulations required for the IPCC as well as the intercomparison experiments that evaluate climate models. This role is important and should be continued. As climate models evolve towards Earth system models, WCRP will need to work closely with IGBP in particular to ensure the most effective framework for this modelling work.

In addition to necessitating closer ties with IGBP, the science is pushing WCRP toward expanded collaboration with other GEC programmes. For example, the Sydney workshop report (WMO, 2008) provides a substantial and up-to-date discussion of the most advanced scientific, technical and related socio-economic findings on climate change as learned from AR4. The report emphasizes important challenges for future research such as the near-term future (~ 30 years), attribution studies of decadal climate change, process studies to improve climate change projection, and regionally detailed projections for adaptation. In all these topics, WCRP is expected to play a crucial role, in collaboration with the other GEC programmes.

The development of ESSP has made the GEC programme landscape more difficult. If ESSP is seen as a separate, competing science programme, then its existence will erode the health and effectiveness of programmes like WCRP as they become more societally relevant. This would not be an effective mode. What is at issue is the extent to which WCRP should take the lead on particular GEC-wide programmes. Clearly, WCRP has the track record in leaving legacies in modelling and observations, among all the GEC programmes. It has a poorer record in constructive interdisciplinary research and in bridging to social and human sciences. Moreover, WCRP itself will need to take some responsibility for the diffusion and communication of its science. The roles and relationship of ESSP and WCRP need better definition. The Panel acknowledges that its sentiments toward ESSP are not fully aligned with those of the Panel that reviewed ESSP—and that these differing views will need to be reconciled by the GEC community and sponsors sooner rather than later.

Beyond the four GEC Programmes and ESSP lie a range of other international programmes and activities that have climate-related components or other general expertise from which WCRP science might benefit if the connections are forged. Some of these groups already partner with WCRP—such as SCAR (on CliC and on an ice-sheet modeling workshop—also with the International Arctic Science Committee—IASC) and SCOR (on SOLAS). The many scientific Unions of ICSU also bring discipline-specific interests to the table and have intersecting interests in such topics as capacity building in developing countries.

In addition to expanding in these directions, the science base of WCRP has been assisted in the past and will benefit in the future from close coordination with the other WMO research programmes like the Atmospheric Research and Environment Programme and its components such as WWRP and the Global Atmosphere Watch (GAW), as well as with programmes of IOC. In relation to IOC (and ICSU), WCRP could consider collaborations with ocean ecosystem projects such as GLOBEC and its successor the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project, as well as with the Ocean Carbon Coordination Project (OCCP) and research on ocean acidification, for example.

## 2.6 Building Capacity

### 2.6.1 Human Capacity

Capacity building was not in the original objectives of WCRP. However, for sustained success, a multi-pronged approach for building capacity is needed. This is particularly important because the participation of all scientists in WCRP projects is on a voluntary basis. WCRP will need to raise the priority of, and explicitly engage, with projects and activities involving developing countries as part of an overall strategy to raise its profile in facilitating and creating relevant applications for climate science. Some steps are evident in the strategy related to seasonal prediction, but this must extend WCRP-wide. The engagement with developing-country scientists and other under-represented groups will need to have as an objective enduring capability and enhanced capacity, along with the normal scientific objectives. An important aspect of engaging such scientists in the activities of WCRP will be a focus on practical applications of direct policy relevance and benefit to developing countries. In order to make this work, WCRP will have to adopt specific targets and develop an image of “success”. These measures need to take account of durability and sustainability. One such example of targets comes from the IPCC AR4 Working Group I, which adopted the following composition: 25% had earned their highest degree within the last 10 years (at the time of their appointment); 75% had not previously been IPCC lead authors; and 35% were from developing countries and countries with economies in transition.

There are various types of involvement: evaluation of models, attending meetings, and planning of projects. Each is considered in the remainder of this section.

#### ***Involvement in Model Evaluation***

Section 3.4 of the WCRP Strategic Framework document states:

“An important aspect of both the scientific research of WCRP and the applications of that research should be the involvement of developing country scientists in the evaluation of both useful seasonal forecasting skill and climate model simulation skill in their regions. Such evaluations will feed back onto the scientific research of WCRP and the IPCC and other assessments, involve the developing country scientists in that research, and give a basis for future use of seasonal forecasts and climate projections for their regions.”

Since, at present, the centres generating forecasts are primarily in the developed countries, clearly the first essential (and relatively easy) step is to involve developing country scientists at the regional interface with applications where usefulness and relevance are tested. At this point it is also useful to monitor the uptake and influence on policy and decision making. WCRP projects such as the first atmospheric model intercomparison project have already contributed substantially by taking advantage

of assessments by scientists from developing countries in the tropics.<sup>12</sup> We note that as a programme with both global and regional activities, CLIVAR has long promoted the need to encourage regional analysis of global simulations through its regional panels (e.g., in South America through the CLIVAR Variability of the American Monsoon Systems project.)

However, the participation of scientists from the developing world need not be restricted to analyzing results generated at centres elsewhere. Rather, the ultimate aim should be to build the capacity to a level at which they can actively participate in the exciting scientific research and generate predictions with comparable skill at national or regional centres—with the overarching goal of improving skill in what is used by stakeholders. To achieve this, WCRP will need to promote collaboration of institutions and centres in the developed world with scientists and institutions in the developing countries.

### ***Involvement in Meetings***

The perspectives of scientists from the developing world need to be better represented in planning and coordination meetings and workshops. There are past cases where WCRP meetings and projects have neglected the existence of strong scientists in developing countries. For the most part, though, WCRP Projects do attempt to bring scientists from developing countries (and young scientists) to meetings, workshops, etc. For continuing participation, specific goals need to be set (for example, IPCC has specific targets for participation—mentioned earlier). And such participation could be achieved with the help of a number of programmes, including those of WMO, Global Change System of Analysis, Research, and Training (START) of ESSP, Inter-American Institute for Global Change Research (IAI), Asia-Pacific Network for Global Change Research (APN), IOC, and the World Bank. START, for example, supports visits of scientists from developing countries to leading universities and laboratories.<sup>13</sup> In addition, WMO has a programme that supports such visits. WCRP collaboration with such programmes could lead to building of capacity in WCRP science with additional sources of funding from these programmes.

### ***Involvement in Planning***

It is important to involve young scientists—and scientists who are women or from minority groups—in the planning and work of WCRP including its component parts. This is one way of ensuring that the next generation, and a broader group among the current generation, is ready to lead the formulation and implementation of major projects to meet the new challenges to WCRP. WCRP is making positive strides in this area,<sup>14</sup> and related UN goals provide guidance that could help WCRP structure its overall approach.<sup>15</sup> In addition, the WCRP National Committees are a potential untapped resource for nominations of under-represented groups.

## **2.6.2 Resource Capacity**

Resources are needed both to support the value-adding functions of the Secretariat and the IPOs to support the science undertaken by WCRP Projects and other groups. For example, the Secretariat is facing difficult resource issues as basic costs increase and more is asked of the Programme (Eera, 2006). Institutional funding is not keeping up with the increased expenses. This is part of a broader trend among the GEC programmes in which support for research coordination has stagnated over the last decade, representing a net decline in real terms because of inflation. IGFA has shown concern over this issue, and provided useful background financial information to the Panel.

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<sup>12</sup> Scientists of these countries also benefited enormously from the re-analysis products that were made freely available by the U.S. National Centers for Environmental Prediction.

<sup>13</sup> WCRP has secured a grant with START to expand their joint efforts on capacity building and involvement of developing country scientists.

<sup>14</sup> More than 65 early career scientists were sponsored by WCRP to attend the SPARC General Assembly, and many of these were from developing countries. This was more than double the number of young scientists that were supported at the previous assembly. In the SPARC Chemistry-Climate Model Validation Report (see <http://www.pa.op.dlr.de/CCMVal/>), of the 18 chapter lead authors, one-third are young scientists and five are women.

<sup>15</sup> See, previous paragraph, or, for example, section 4.2.2 of <http://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles-appendix-a.pdf> or paragraph 14 of <http://icsc.un.org/resources/pdfs/general/standardse.pdf>.

On the research support side, WCRP helps its research community advocate for cutting-edge facilities for observations, modelling, and process studies. These facilities include satellite and airborne instrumentation, computers, data assimilation, and web-based outreach. A recent example of WCRP's assistance with advocacy is its co-sponsorship of the World Modelling Summit for Climate Prediction, which enabled the community to organize its thoughts into a powerful message to take to potential financial backers.

A systematic and special effort is needed to strengthen the advocacy for core funding as well as for specific capabilities such as enhanced and new satellite observations and new petabyte computing as recommended by the World Modelling Summit. Without more funds for the component parts of the Programme, it is likely that WCRP researchers will not be able to continue to deliver the excellent science that has been its hallmark. In parallel with the push on advocacy, a special effort is needed to determine the needed support for the coordination function of the Secretariat and from where such support can be obtained. It would make sense to consider funding sources outside traditional government channels.

## 2.7 Enhancing the Impact

It has generally been recognized that WCRP is not very visible (see, e.g., Section 2.1), especially to end-users of climate science such as policy makers. This erodes its impact. In many cases, WCRP is also little known at the national level, notwithstanding the fact that WCRP has greatly contributed to the IPCC. This situation has recently caused some difficulty for national research communities with respect to receiving government or other funding for WCRP project-related research. And it is now of particular concern that the overall WCRP budget, which supports meetings and activities of the Joint Planning Staff, is declining in spite of ever-growing societal needs for WCRP-type research.

Since inception, WCRP has concentrated on how to produce scientifically valuable outcomes that determine the extent to which climate can be predicted, and the extent of human influence on climate. This strategy has undoubtedly been of great service and value for climate science including IPCC and WMO/UNEP Ozone Assessments and appreciated by the participants in WCRP research. Nonetheless, enhanced outreach to the broad research community within ICSU would be valuable.

Like the research community, NMHSs and ocean service agencies also value WCRP's work. These services play a role in providing daily forecasts and other related information to end-users. They are also (direct) users of climate research outcomes. Their community is organized by WMO and IOC. Consequently, WMO and IOC are in an important position to help in communication and outreach of WCRP science through the programmes they operate and with the support of countries and particularly of NMHSs and ocean service agencies. WMO and IOC can help to enhance the visibility of WCRP through these channels.

Until recently, however, WCRP has not focused much on its visibility to society in general and policymakers in particular. A recent upswing in interest in visibility is reflected in the 10-year (2005-2015) WCRP Strategic Framework (WMO, 2005). This Framework explains the effort WCRP is now making to apply research outcomes to society.

### 2.7.1 Progress to Date

In 2007, WCRP revised and substantially updated its home page. This is now better designed and user-oriented. Considering the growing role of web sites, the home page would be expected to continue playing a non-negligible role in enhancing the visibility of WCRP. Some non-English speaking countries (such as Japan) are trying to address the visibility issue by opening their national WCRP home pages in their own language based on the WCRP home page but supplemented with information on national WCRP-related activities.

In another example, WCRP has been involved in organizing international symposia such as the World Modelling Summit, mentioned earlier, and “Effects of Climate Change in the World’s Oceans” in collaboration with IOC Ocean Sciences Section. This latter symposium, held in Gijón, Spain, in May 2008, was attended by 400 experts from 48 countries. WCRP and IOC worked together in the preparation of the scientific programme, which included four workshops and 10 thematic sessions. WCRP and IOC took direct responsibility in one workshop and two Theme sessions. Best symposium papers will be published in a volume of the Journal of Marine Science in Spring/Summer 2009 and a scientist from each of WCRP and IOC will be invited editors of this volume.

In general, the current practices of the Programme with respect to visibility are necessary but not sufficient to improve the situation, in part because they are ad hoc. The payoff of additional, strategically selected efforts would be greater appreciation of the Programme and its outputs. This, presumably, would translate to increased resources and a stronger impact. Two upcoming conferences offer particular opportunities in this regard.

### 2.7.2 World Climate Conference Three

The First World Climate Conference in 1979 established the World Climate Programme and launched WCRP, as well as IPCC. The Second World Climate Conference in 1990 initiated negotiations within the UN, resulting in the adoption of the UNFCCC in 1992 and the establishment of the internationally co-sponsored GCOS.

The World Climate Conference-3 (WCC-3) will be held from 31 August to 4 September 2009 in Geneva. The theme is “Climate Predictions and Information for Decision-Making: Managing Risk on Seasonal to Multi-Decadal Time Scales.” This theme is, for the most part, directly or very closely based on research outcomes covered by WCRP and specifically its CLIVAR project. Consequently, a number of scientists involved in WCRP projects including CLIVAR will be invited. Since the focus of WCC-3 is on strengthening the science of prediction (focusing on the next three decades and the mechanisms to deliver the needs of end-users), this is an opportunity for WCRP.

WCC-3 would provide an excellent additional opportunity for WCRP to play a leading role as the major provider of scientific findings on which the above outcomes from the High-Level Segment would be built. In this regard, WCRP is coordinating closely with a related WMO programme—WWRP—to ensure that an “Enhanced Prediction Framework” is a major outcome of the conference. This would contribute to enhanced transfer of WCRP research to services by linking to the WMO initiative to support adaptation to climate variability and change (section 2.2).

### 2.7.3 UNFCCC

WCRP has been involved in organizing side events in climate change conferences under the UNFCCC and will need to plan for representation at Conference of the Parties (COP)15 in Copenhagen in December 2009. In addition, WCRP has played a leading role in organizing side events and other fora in conjunction with meetings of SBSTA. The 2007 SBSTA26 event, for example, provided a forum for the GEC community to discuss how to effectively apply climate science information to adaptation and sustainable development. At a 2008 SBSTA meeting, WCRP participated in roundtables and side meetings, and provided the keynote speaker at a session on UNFCCC’s Nairobi Work Programme.<sup>16</sup> These kinds of activities provide direct opportunities for policy makers to learn how WCRP is trying to address climate change issues and for the Programme to communicate with research communities, managers, and policy makers.

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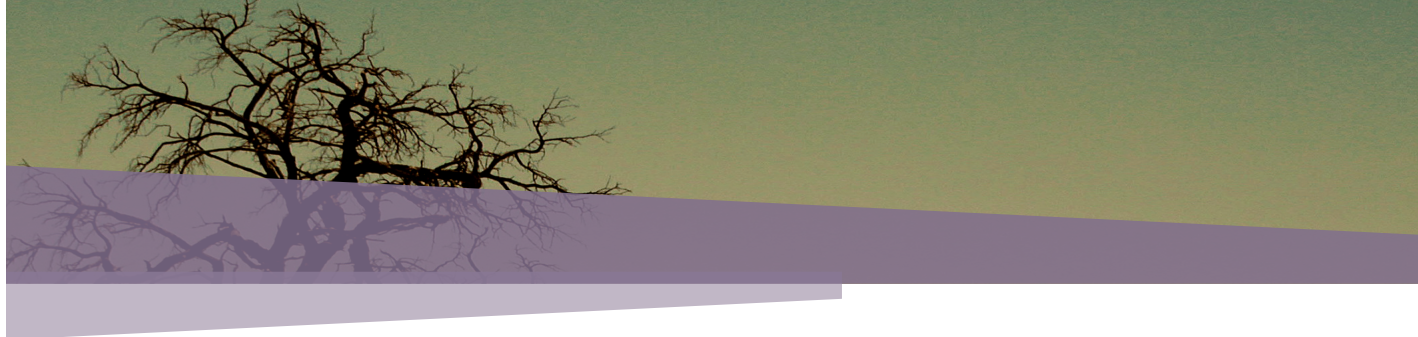
<sup>16</sup> See [http://unfccc.int/adaptation/sbsta\\_agenda\\_item\\_adaptation/items/3633.php](http://unfccc.int/adaptation/sbsta_agenda_item_adaptation/items/3633.php)

## 2.8 Governance

The tri-partite sponsorship of WCRP by WMO, IOC, and ICSU dates back to 1991 when the IOC Assembly decided that IOC should become full and equal partners with WMO and ICSU in the further development and implementation of WCRP. Subsequent to IOC Executive Council approval in March 1992, a formal co-sponsorship Agreement signed by all three sponsors came into effect on 1 January 1993.

Fifteen years since the Agreement was last updated, the impacts of climate change are now more urgent, the vision for WCRP has changed, and the stakeholders and requirements for climate research are different. There is a need for the sponsors to regularly review their mutual responsibilities so that programme-related issues are identified and addressed and WCRP can deliver the insights and information that society needs to cope with climate change.





## 3. Recommendations

The Review Panel has carefully considered the questions raised in Chapter 1 and Annex 3 and the evidence summarized in Chapter 2. It is clear that, for the first period of its existence, WCRP was successful in providing relevant information for society. But as we have learned more and seen the accelerating impact of climate change, it is equally clear that WCRP must change more rapidly to remain relevant. Thus the Panel's recommendations deal with a broad set of issues of science, relevance, and implementation. To remain relevant, WCRP will need to answer these major recommendations with plans, goals, and indicators, underpinned with prompt and strategic action. Further, we urge WCRP's sponsors to put in place a process to review the Programme's response to the recommendations.

The format of each subsection of this final chapter is the same: it presents the Panel's major recommendation and then summarizes the issues underlying the recommendation.

### 3.1 Focusing the Strategic Framework—Connecting with End-users

**Recommendation 1:** WCRP should immediately focus its 2005 Strategic Framework<sup>17</sup> to better capture the WCRP role in providing the science that underpins research on climate predictability, adaptation, and mitigation, thus strengthening the links with key end-user groups.

The Panel believes that the best statement of WCRP's main objectives is that in the 2005 WCRP Strategic Framework (COPES): "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." In particular, WCRP has a key role to play in providing the fundamental science that underpins adaptation and mitigation research and to contribute, through partnerships with others, to the better understanding and documentation of the level of predictability or skill of information as it is used by decision makers and policy developers. But this role will not be met unless WCRP focuses its Strategic Framework on enhancing a number of pathways to key end-user groups in order to make the connection from science to applications and decision-making. Given the acceleration of the impacts of climate change, this focusing should be done immediately—both by the Programme and its Projects.

For example, it is no longer sufficient to know the skill with which we can capture the El Niño-Southern Oscillation (ENSO). Now we must understand how this predictability manifests itself

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<sup>17</sup> Coordinated Observation and Prediction of the Earth System (COPES).

in broader societal terms, such as water availability through hydrological systems. WCRP should also have a sub-objective that explicitly takes the Programme across the basic-applied interface. A two-way exchange of information with end-users is needed that uses goals, targets, milestones, and timelines. And this road will not be easy. For example, in events such as the 1997 El Niño over Zimbabwe, failure of predictions based on the known links with ENSO led to loss of credibility. Clearly, it is important to gain further insight into the mechanisms governing seasonal to interannual variations over different regions. The establishment of a WCRP Task Force on Seasonal Prediction is a step in the right direction, but a broad approach will be required. This should be done in coordination with existing outside frameworks.

## 3.2 Implementing the Focused Strategic Framework

**Recommendation 2:** WCRP should rapidly implement its focused Strategic Framework, paying special attention to societal needs while maintaining its science-driven approach.

WCRP is to be commended for its past successes. These have laid the groundwork for current understanding of climate and climate change. But now, as the world is changing, the Programme's emphasis as reflected in a focused Strategic Framework should address societal needs in the context of the successful science-driven approach. The previous approach needs to be adjusted if WCRP is to build its relevance for all users and be seen to be responsive to stakeholder needs. That is, to provide the information that society needs in a rapidly changing world. Such adjustments will require shifts in priority and closer coordination with outside frameworks.

Without sufficiently rapid change, WCRP may lose its relevance and the associated societal support. Consequently, the Review Panel considers it a matter of urgency that these changes be based on an update of WCRP's Strategic Framework. WCRP should quickly develop an implementation plan for its activities, taking into account new initiatives that have emerged since the Strategic Framework was completed in 2005 as well as the observations of accelerated climate change. These changes place new demands on the science to be relevant.

WCRP should shift its implementation paradigm from one that builds from the parts offered by Core Projects and other activities to one that has clear and focused high-level objectives and clearly articulated deliverables while recognizing the sensitivities of achieving these objectives through the voluntary engagement of thousands of scientists. These objectives should be served primarily through WCRP-wide cross-cutting activities with the Core Projects focused on those components of the cross-cutting activities that are unique to their mandate. In particular, the modelling and the observing system research should be predominantly WCRP-wide activities. The implementation should also encourage development of process studies within the broader strategic framework rather than within individual programme components. And by building into the cross-cutting activities a clear link to relevant service-delivery organizations (WMO and IOC), the WCRP research community will forge a better link with the broader set of end-users.

Strengthening technology transfer links to service delivery can be greatly assisted by closer cooperation with other parts of the World Climate Programme. Consequently, WCRP should include in its implementation plan those activities that promote the efficient transfer of research outcomes to operations and end-users by strengthening its interaction with other components of WCP.

### 3.3 Setting Priorities

**Recommendation 3:** WCRP should introduce clear priorities into WCRP as a whole, collaborating with other Global Environmental Change programmes to take into account urgent science required for IPCC and other societal demands.

The Panel believes that a tight focus on IPCC needs and other climate-related societal demands (e.g., water availability, sea level change, impacts on agriculture, drought, hazards) will help the Programme both become more relevant and achieve better funding. WCRP, IGBP, GCOS, relevant parts of GEO, and other climate-related programmes (denoted hereafter as “the climate programmes”) should thus immediately use the specific tasks that have been required to be completed for the upcoming IPCC and other relevant national and international assessments to set their priorities. Time is already short to feed into IPCC Assessment Report 5—a science-to-policy process that has perhaps the most societal impact right now—but the climate programmes should make every effort to develop the best founded and most relevant information in time for this and each of the upcoming assessments.

This proposed focus and process is designed to pay respect simultaneously to (i) the individual priorities determined by the climate programmes, which have their own needs and goals, (ii) the new information available from the 2007 IPCC report series that was not available to these programmes when they created their current Projects and when priorities were set, and (iii) the urgent priorities that are widely agreed by the community to have arisen from that assessment. The Panel recognizes that by agreeing to such a tight focus, WCRP may have to delay work within some existing Projects. But given the societal importance, it is essential to move in this direction.

We believe that a positive experience in working in a time-bound and focused fashion will lead the climate programmes to evolve to cooperate more tightly or indeed enter into a more structured set of ongoing common projects. For example, the Panel was impressed with the focus on specific time-bound tasks that came from the Sydney meeting (WMO, 2008) and subsequent discussions. Examples of where WCRP needs increased focus include better understanding of cloud/aerosol radiative forcing, ice sheet dynamics, and rising ocean acidity.

WCRP will need to work with other international programmes sponsored by WMO, IOC, and ICSU, and with national and regional partners to agree on what should be the initial focus for input to IPCC and determine how well the existing Programmes are meeting that focus. Emphasis should be given to the Projects and parts of projects that are meeting the foci thus identified. Some of these tasks are joint – between or among programmes – and some are for single programmes. The main point is that the work must be coordinated among all of the relevant programmes.

### 3.4 Broadening the Scientific Base – Links to IGBP and Other Programmes

**Recommendation 4:** WCRP should lead the initiative on Earth system modelling, in collaboration with IGBP and other programmes, utilizing the full richness of relevant disciplines, and explicitly addressing scientific problems that lie at the interfaces with these disciplines.

The proposal at the World Modelling Summit to assign high priority to a major strengthening of climate prediction capabilities for the 21st century reflects the need to prepare models, observations, and other infrastructure for climate adaptation and mitigation research. Modelling is a crucial link between observations and scientific insights on the one hand, and delivery of forecasts, predictions, and scenarios to stakeholders on the other. Just as climate modelling moved from atmosphere to coupled models in the 1980s, models now need to fully incorporate the relevant range of land, ocean, atmosphere, cryosphere, and ecosystem processes.

To ensure that models incorporate the full range of disciplinary knowledge and expertise, WCRP will need to work more closely with relevant programmes such as IGBP (as already recognized in their joint sponsoring [with WWRP] of the World Modelling Summit). WCRP can help catalyze this greater breadth by extending its scientific base in observations, modelling, and process studies. In particular, WCRP will need to accelerate the merging of its expertise in climate system modelling into the broader realm of Earth system modelling.

As part of broadening the disciplinary base of models, WCRP should extend science to include the concept of generalized prediction. This means understanding the extent to which climate is predictable on a broad range of time and space scales and for all elements of climate, particularly for the terrestrial and ecosystems domains. The Review Panel welcomes the joint initiative of WCRP and WWRP to develop a white paper on a seamless approach to weather/climate prediction and services delivery. In some domains WCRP might lead; in some domains it might contribute. In order to do this efficiently, WCRP needs to grow its capability in climate modelling considering the recommendations of the World Modelling Summit and in partnership with others. The main challenge for WCRP modelling is to provide the science that is necessary for the climate information end-user community. Other challenges include developing the capacity of WCRP science and models to predict CO<sub>2</sub> dynamics and interchange with the ocean and land, and well as ocean acidification on time scales from inter-annual to decadal. This will be achieved in conjunction with IOC programmes.

## 3.5 Observations

**Recommendation 5:** WCRP should consolidate and strengthen its focus as a user and promoter of observations as well as its support of the components of the Global Climate Observing System.

WCRP places high priority on obtaining and using the best quality observations for climate research. It is thus essential that the observational base be comprehensive and fully supported for the long term; yet GCOS still remains short of its coverage and commitment goals. In order to help GCOS advance toward completion, WCRP must strengthen its important dual role as both user and promoter of Earth system observations.

As a user, WCRP needs the best quality comprehensive and long-term observations, and must continue to work with all relevant observational programmes to ensure adequate support for the full system.

As a promoter, WCRP plays a key role in ensuring that climate research information needs are met broadly, and can use its relationships with other climate programmes to help complete GCOS. The future research-to-operations observing system transition would be greatly assisted by a stronger involvement of WCRP in working with coordinating bodies such as JCOMM to secure funding and implement the required international coordination mechanisms. The same is true for transitioning research satellite observations into operational status.

In addition to promoting the health of new data sources, WCRP is also positioned to advocate for the availability and long-term archiving of climate data in general, and the data from its own Projects in particular.

## 3.6 Building and Sustaining Capacity

**Recommendation 6:** WCRP should set specific strategy and goals for building its scientific capacity in diversity of age and gender and for participation of developing country scientists in planning and research.

The success of WCRP depends on broad engagement with scientists and on engaging the next generation of scientists in shaping the direction and participating in the programmes of WCRP. In its focused Strategic Framework, WCRP should explicitly include an objective and targets related to the involvement of young scientists (and those who are women or from minority groups), using UN goals as a context. Consideration should be given to fora dedicated to young scientists (e.g., at the World Climate Conference-3.)

In addition, WCRP should continue increasing its development of scientific capacity in developing countries. While some of the needs of the developing world have been considered adequately (primarily because links with such needs facilitates funding from national and international organizations), there are past cases where WCRP meetings and Projects have neglected to include strong scientists in developing countries. Collaboration opportunities exist to turn this around, and the Panel was pleased to see the Programme's active role in attracting strong participation from early career scientists from developing countries at the SPARC General Assembly.

It is clear the developing nations need and desire access to the latest GEC research to shape policy and to aid their development. WCRP should enhance its work through START and also work through other mechanisms to use its expertise in coordination, facilitation, and even enhanced regional projections that allow developing countries access to climate model information. This will require additional resources, but there are particular opportunities in the developing world as funding agencies focus resources on climate adaptation.

**Recommendation 7:** WCRP should build its resource capacity by enhancing support for coordination and advocacy for research and infrastructure needs. This will necessitate expanding its funding sources outside traditional targets and working through IGFA.

A high priority should be placed on building resource capacity in the three areas of need: coordination and other Secretariat functions, research projects, and the large infrastructure of modelling and observational systems coordination.

To help bolster research and infrastructure funding, WCRP must build a systematic approach for the advocacy for new projects as well as for enhanced and new satellite observations and enhanced high-end computing that is consistent with the needs. Government funding will remain the center of this effort, but the Panel believes that WCRP's resource model needs to be re-examined and that extra-budgetary support should be sought for new actions. Nontraditional sources such as foundations will need to be part of this approach.

For coordination, funding is not keeping up with the extent of the Programme and the high expectation of its future role. For example, zero-growth budgets have led to a 30% decline in Secretariat support over the last 10 years. The Panel believes that IGFA should take the lead in determining the proper level for coordination support and working with individual members and

other funders to find that support. The recent interest shown by several nations in hosting Secretariat functions for the IPCC shows that nations are willing to invest in coordination, if they are convinced that they will get a return on that investment.

For these approaches to be successful, measures must be put in place to track progress. And the advocacy and fundraising by WCRP should not be considered in a vacuum. By addressing issues raised earlier in this chapter, WCRP will build the societal appreciation and buy-in for its work that should enhance its ability to attract the necessary resources.

## 3.7 Outreach and Visibility

**Recommendation 8:** WCRP should expand its strategic outreach activities to target greater visibility and better uptake and utilization of WCRP outputs for the climate research community, the policy world and private sector, and more broadly to the general public.

In view of the growing importance of climate to society, WCRP needs to expand its work with its sponsors, Core Projects, and the other GEC components to develop strategic outreach activities. WCRP should work with WMO and IOC programmes, and with other ICSU programmes such as IGBP to make a strong case for outreach. The strategic approach should include both enhancing visibility and finding ways to achieve better uptake of WCRP outputs—including strategic joint promotion with sponsors on international conferences and symposia such as the effects of climate change in the oceans.

Engagement in key policy and stakeholder meetings is an important aspect of outreach. In this regard, two upcoming major climate-related meetings will be of major importance. The upcoming World Climate Conference-3 affords an excellent opportunity for the international climate science and policy community to focus on the needs that can be met by WCRP, and to show what WCRP has already done. WCRP should play a major role in organizing the scientific programme and should be considering now what it can recommend for a substantial outcome for the WCC-3. The UNFCCC also needs the science input of the WCRP as transmitted by the IPCC. WCRP can play an important outreach role at the upcoming Conference of the Parties meeting in Copenhagen in 2009 and should be planning for that now.

## 3.8 Governance

**Recommendation 9:** WCRP's sponsors should meet regularly to review their mutual responsibilities for the Programme in light of society's increasing need for climate understanding, mitigation, and adaptation.

Things have changed in 28 years since WMO and ICSU initiated WCRP. Today, society has a greater need than ever for better understanding of climate and how to mitigate and adapt to a changing climate. WCRP has played a central role in providing basic information for societal needs, and will have to play an expanded role as the recommendations in this report indicate. The sponsors, including IOC, need to regularly review their mutual responsibilities so that programme-related issues are identified and addressed and WCRP can deliver the insights and information that society needs to cope with climate change.

## 3.9 Determining Global Environmental Change Research Priorities

**Recommendation 10:** WCRP, in partnership with other GEC programmes, should develop a framework for future joint research operation, with the initial focus on the elements identified in this Review. A sponsor-convened 12-month study is proposed to initiate and plan the process.

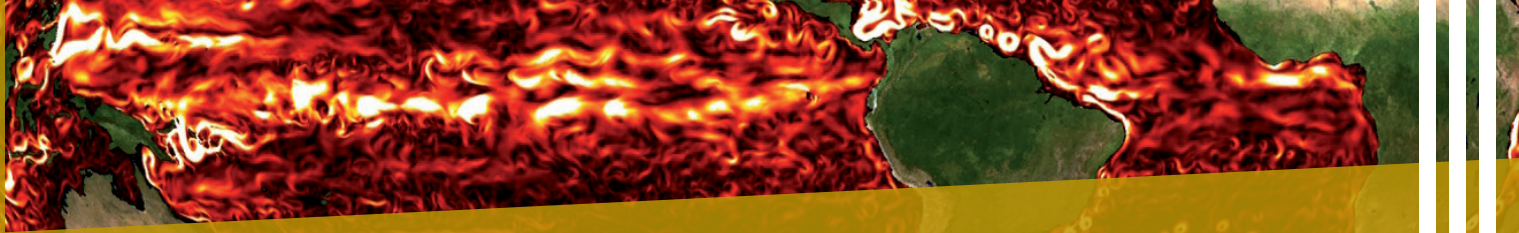
The Panel considered implications from the increasingly complex future for climate and global environmental change research, including those aspects that are of direct interest and relevance to WCRP. The feedback from the scientific community and discussions with the IGBP Review Panel suggested the domains of IGBP and WCRP would become increasingly intertwined, and that, from the science provider perspective, further integration was desirable. From the client and stakeholder perspective, the response was less obvious, with concern about adding complexity to organizational and structural arrangements and diffusing focus when such arrangements are already complex. It is also clear that relationships with IHDP and DIVERSITAS have become closer and there are increasing opportunities for joint action.

The Panel believes there is value in developing a framework for such future joint research actions, involving all Programmes within the GEC family. The Panel recognizes the ESSP Review recommended strengthening governance and consideration of the Partnership becoming a Programme. The Panel believes it would be counterproductive for ESSP to become a Programme and that the value added by the Partnership is not clear given that existing Programmes could host ESSP Projects. Despite the engagement of WCRP leadership with ESSP, and the Programme's sponsorship of four ESSP Projects, the engagement of WCRP scientists in ESSP has not been strong, and can be contrasted with the strong cooperation between the IGBP and WCRP in a number of areas.

A number of options were considered for addressing the complexity of relationships among GEC Programmes, partnerships, etc. The Panel believes it is premature to consider a single GEC programme, and does not believe there is value in merging WCRP with IGBP. However, as the Panel considered the next decade and beyond, it concluded that the GEC Programmes do need to develop a shared vision of the future and the trends/drivers that will shape their work, including that of WCRP. The Panel believes the GEC Programmes should undertake a joint study to develop a framework for future climate and global environmental change research. This GEC framework could consider:

- the societal, economic, and environmental drivers that together will shape the future of the GEC Programmes.
- a set of high-level scientific objectives that capture existing strategy, at the appropriate level, and those thrusts that are needed to respond the future demands.
- possible initial landmark actions within this framework, based on major work that is under-way in existing projects and new landmark actions that must draw on more than one of the programme capabilities.
- infrastructure requirements for the framework, including observations, and areas that are ready for (i.e., would be advantaged by) a framework that is broader than the existing frameworks.

The 12-month study that facilitates the development of this framework would be convened by ICSU in collaboration with other GEC sponsors and IGFA.



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## List of Acronyms

AIMES	Analysis, Integration and Modelling of the Earth System (IGBP)
AMMA	African Monsoon Multidisciplinary Analyses (WCRP-GEWEX)
AOPC	Atmospheric Observations Panel for Climate (WCRP)
APN	Asia-Pacific Network for Global Change Research
AR4	Fourth IPCC Assessment Report
AR5	Fifth IPCC Assessment Report
CliC	Climate and Cryosphere Project (WCRP)
CLIPS	Climate Information and Prediction System (WMO)
CLIVAR	Climate Variability and Predictability project (WCRP)
COP	Conference of the Parties (UNFCCC)
COPEs	Coordinated Observation and Prediction of the Earth System (WCRP)
CO <sub>2</sub>	Carbon Dioxide
DIVERSITAS	A programme on global biodiversity science
ENSO	El Niño-Southern Oscillation
ESSP	Earth System Science Partnership
GAW	Global Atmosphere Watch (WMO)
GCOS	Global Climate Observing System
GEC	Global Environmental Change
GEO	Group on Earth Observations
GEWEX	Global Energy and Water Cycle Experiment (WCRP)
GLOBEC	Global Ocean Ecosystem Dynamics (IGBP, SCOR, and IOC)
GOOS	Global Ocean Observing System
IAI	Inter-American Institute for Global Change Research
IASC	International Arctic Science Committee (ICSU)
ICSU	International Council for Science
IGAC	International Global Atmospheric Chemistry (IGBP)
IGBP	International Geosphere-Biosphere Programme (ICSU)
IGFA	International Group of Funding Agencies for Global Change Research
IHDP	International Human Dimensions Programme on Global Environmental Change
iLEAPS	Integrated Land Ecosystem-Atmosphere Processes Study (IGBP)
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research project (IGBP-SCOR)
IOC	Intergovernmental Oceanographic Commission of UNESCO

IPCC	Intergovernmental Panel on Climate Change
IPO	International Programme Office
IRI	International Research Institute for Climate and Society
JCOMM	Joint Technical Commission on Oceanography and Marine Meteorology (WMO and IOC)
JPS	Joint Planning Staff of WCRP
JSC	Joint Scientific Committee of WCRP
NMHS	National Meteorological and Hydrological Service
OCCP	Ocean Carbon Coordination Project (IOC-SCOR)
OOPC	Ocean Observations Panel for Climate
RCOF	Regional Climate Outlook Fora (WMO)
SBSTA	Subsidiary Body for Scientific and Technological Advice (UNFCCC)
SOLAS	Surface Ocean-Lower Atmosphere Study (IGBP-WCRP)
SPARC	Stratospheric Processes and their Role in Climate Project (WCRP)
START	Global Change System for Analysis, Research, and Training (ESSP)
TOGA	Tropical Ocean-Global Atmosphere Programme
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WCC-3	World Climate Conference Three
WCP	World Climate Programme (WMO)
WCRP	World Climate Research Programme
WGCM	Working Group on Coupled Modelling (WCRP)
WGNE	Working Group on Numerical Experimentation (WCRP)
WMO	World Meteorological Organization
WMP	WMO Modelling Panel
WOAP	WMO Observations and Assimilation Panel
WOCE	World Ocean Circulation Experiment
WWRP	World Weather Research Programme (WMO)



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# ANNEX 3

## Terms of Reference

### Preamble

The International Council for Science (ICSU) is a sponsor of the four global environmental change programmes: the World Climate Research Programme (WCRP; together with WMO and IOC), the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP; together with ISSC) and DIVERSITAS – An International Programme on Biodiversity Science (together with UNESCO, SCOPE and IUBS).

The Global Change Research Programmes are central to ICSU's mission of strengthening international science for the benefit of society. ICSU with UN sponsors are also responsible for the Global Climate, Ocean and Terrestrial Monitoring Systems. The scientific research and the global monitoring efforts provide crucial information for assessments such as the Intergovernmental Panel on Climate Change (IPCC) and the Millennium Ecosystem Assessment (MA).

General reviews of the ICSU Global Environmental Change Research Programmes, as well as the global observing systems and all other relevant ICSU Interdisciplinary Bodies and Joint Initiatives, were conducted in 2002-2003 within the Priority Area Assessment on "Environment in Relation to Sustainable Development" as a component of the development of an ICSU Strategic Plan 2006-2011.

The ICSU General Assembly in October 2005 approved the ICSU Strategic Plan 2006-2011, which calls for a review of the Global Environmental Change Research Programmes. The reviews of IGBP and WCRP will follow the review of the Earth System Science Partnership (ESSP). All reviews are conducted jointly with the International Group of Funding Agencies for Global Change Research (IGFA) and, in the case of WCRP, with the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

### Review of the Global Environmental Change Research Programmes in 2007-2009

The four Global Environmental Change Research Programmes have been reviewed in the past: DIVERSITAS; management review by IGFA in 2003; IGBP in 1987, 1991 and 1996; IHDP in 2005; and WCRP in 1995.

ICSU will review DIVERSITAS, IGBP, WCRP and ESSP in the period 2007-2009 through the appointment of individual Review Panels. The reviews will be conducted jointly by ICSU and the International Group of Funding Agencies for Global Change Research (IGFA). In addition, other co-sponsors must also be involved in the reviews. In the case of DIVERSITAS, these are IUBS, SCOPE and UNESCO and for WCRP they are IOC/UNESCO and WMO.

The reviews should be both reflective and forward-looking. They should evaluate past performance of the Programmes, review operational structures and assess future plans. The reviews will thus help guide the scientific research, which is vital for advancing our understanding of the functioning of Planet Earth. Such understanding is essential if we are to predict future trends in the development of the Earth as a system.

Research findings underpin many international Assessments such as the Intergovernmental Panel on Climate Change (IPCC), the Millennium Ecosystem Assessment (MA) and the planned biodiversity assessment (IMoSEB). Through such assessments, scientific research is supporting several global conventions such as the UN Convention on Climate Change (FCCC), the UN Convention on Biodiversity (CBD) and the UN Convention to Combat Desertification (CCD). Thus, global change research provides excellent examples of policy relevant science.

WCRP has existed since 1980, IGBP since 1987, DIVERSITAS in its current form since 2002, and IHDP in its current form since 1996. During this period, the world has changed and careful decision making now requires more than mere reductions in scientific uncertainties related to the functioning of global environmental systems. Through mechanisms and forums such as the Millennium Development Goals and the World Summit on Sustainable Development, science now also needs to enlighten and assist policy efforts to simultaneously enhance environmental sustainability, social and economic development and the alleviation of poverty.

The Earth System Science Partnership (ESSP) has taken on the challenge of truly integrating natural and social sciences around common research questions and educating a new generation of scientists to address complex issues outside of disciplinary research structures. In doing so, it is hoped that a new generation of scientists can be trained to tackle complex, multidisciplinary issues.

## Terms of Reference

ICSU, in collaboration with the other sponsors and IGFA, will conduct individual reviews of the International Geosphere-Biosphere Programme (IGBP) and the World Climate Research Programme (WCRP). The links between the Programmes and other ICSU Interdisciplinary Bodies and Members will be considered as part of these reviews. For WCRP, special attention will be given to the interaction with other programmatic elements of WMO and IOC.

The review will focus on both internal and external interactions. The major questions to be considered by the Review Panel are given below. The overriding objective of these reviews is to evaluate the extent to which the international programmes adds value to their respective areas of research and to the national programmes that contribute to them.

The primary question that the review should answer is: “What do scientists, sponsors and the end-users get out of participating in and supporting these international programmes that they would not have gained if the international programmes did not exist?”

The additional questions below are provided for guidance. In considering the questions, the review should go beyond providing simple “yes” or “no” answers and give the reasons for conclusions reached and, where appropriate, recommendations for improvement.

### **1. Scientific impact, balance and relevance**

1.1 What are the indicators of success against which the Programme can be evaluated? What was accomplished as a result of the international Programme that would not have been achieved without its existence? What was achieved by the Programme in comparison with investment in a number of separate national efforts (i.e., the added value of international planning and coordination). Has the Programme helped build the scientific framework necessary to address global environmental change issues?

1.2 Has the Programme developed strategic scientific and implementations plans that address key issues perceived as priorities by the scientific community? Has the Programme augmented intrinsic scientific merit, including its effectiveness in integrating the best relevant disciplinary research?

1.3 Was the Programme a driving force in opening up new domains of science, providing opportunities for innovative research and enhancing inter/multidisciplinary research of high quality?

1.4 How well does the programme synthesize and integrate between its Core Projects and other Global Environmental Change Research Programmes and ESSP?

1.5 How well is the Programme integrated and ‘mapped’ with national climate and global environmental change programmes? Did the international Programme have an impact on national programmes, e.g., in terms of stimulation and supporting the creation of an international framework through which wide-ranging research goals and priorities could be set? For IGBP, is effective use made of input from the National Members?

1.6 Has the Programme fulfilled its original mandate and should a closing date be decided on? If not, should the Programme continue to focus on the original mandate or should this be changed? What should be the nature of any future Programme? If a change is proposed, suggest wording for a mission statement.

1.7 In view of the increasing collaboration between IGBP and WCRP, how can this be further strengthened?

## **2. Policy relevance**

2.1 Has the Programme developed strategic plans that address key issues perceived as priorities by the policy communities? If so, how has the policy relevance been asserted?

2.2 Did the Programme, and its component parts, communicate and interact effectively with, and provide useful input to, international policy processes, e.g., international assessment activities (IPCC, MA, etc.) and the Multilateral Environmental Agreements (UNFCCC, CBD, CCD, etc.)?

2.3 Does the Programme have relevance for the Millennium Development Goals and Science for Sustainable Development? If so, has this potential been utilized?

## **3. Organization and governance**

3.1 Has the governance structure been sufficient to ensure appropriate priority setting and efficient coordination for the overall Programme, Core Projects and cross cutting initiatives (as appropriate)? How effective was the scientific planning process and the guidance and coordination of its Core Projects?

3.2 Is the membership of the governing body of the Programme representative in terms of scientific expertise and geographical and gender balance?

3.3 Is the relative attention of the Programme between the Core Projects and the ESSP balanced?

3.4 Is the Secretariat organized in such a way as to optimize the use of personnel and financial resources? Are funds used in an optimal way in support of priority activities?

3.5 The ICSU Priority Area Assessment on Environment and its Relation to Sustainable Development recommended that “support for programme/core project planning and coordination should be increased from about 0.5% to 1% of the total research budget”. Does the Review Panel support this recommendation and if so, how can it be achieved?

3.6 What impediments can be addressed to increase the efficiency of the Programme? Are there other models that could be applied that could make the Programme more effective?

3.7 Is the hybrid model on a non-governmental/governmental Programme (WCRP) appropriate and are there ways to make better use of the distinctive features of the sponsors? For IGBP, would there be any merit with a governmental co-sponsor, such as UNEP or UNESCO?

3.8 How strong and effective are the links to regional inter-governmental networks (e.g., IAI, APN)?

## **4. Visibility and communication**

4.1 Are the Programme’s visibility and communication efforts sufficient? Have target audiences been clearly identified?

## **5. Interaction with other bodies**

5.1 Has the Programme developed appropriate links with other ICSU Interdisciplinary Bodies and how has the Programme benefited from the expertise within ICSU Scientific Unions and National Members? For, WCRP, how has it contributed to and benefited from other components of the World Climate Programme?

5.2 Are the links to the global observing systems (GCOS, GOOS, GTOS, IGOS-P, and the GEOSS process) adequate? How do these observing systems engage with and contribute to the research communities embodied in IGBP and WCRP?

## **6. Capacity Building**

6.1 Has the Programme succeeded in involving the scientific communities in all parts of the world, including developing countries? Has it been able to attract the interest of young scientists and fostered a new generation of scientists collaborating in a truly interdisciplinary research environment?

6.2 Is START a valuable resource for the Programme in capacity building and have START activities substantially contributed to the advances of the Programme? How well did the Programme collaborate with other relevant global change research programmes that emphasize capacity building (e.g., IAI and APN)?



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WMO Executive Council

### **IOC**

IOC Executive Council

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<sup>18</sup> In addition, members of ICSU, IGFA, IOC, and WMO commented on the draft report.



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Cover / p 5. ASTER image of glaciers in the Bhutan Himalayas. NASA /GSFC /METI /ERS DAC /JAROS ,and U.S. /Japan ASTER Science Team

Cover : Tropical Rainfall Measuring Mission data showing tropical cyclone Nargis at the southern coastal region of Burma on 3 May 2008. Image: Hal Pierce, NOAA/Goddard Space

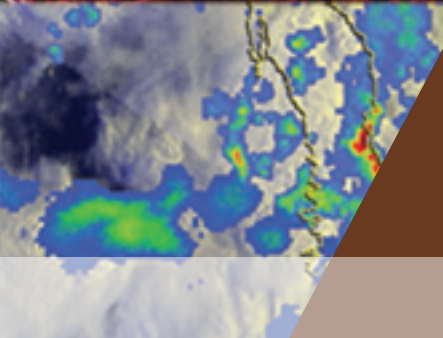
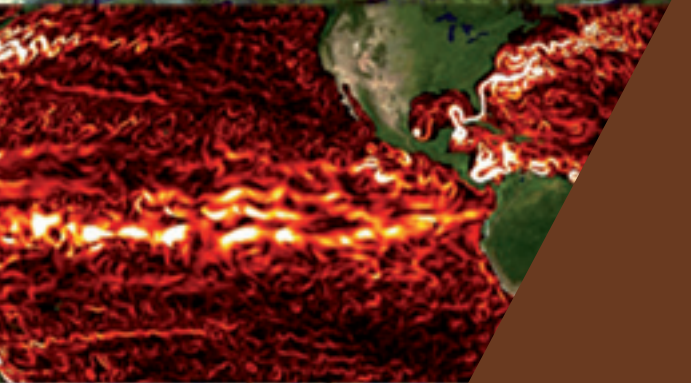
Cover / P 9. Photo: Simon Skygate

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Cover / P 30. Simulated near-surface 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 project funded by NASA (see <http://ecco2.org/>).

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