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WMO-IOC-ICSU WORLD CLIMATE RESEARCH PROGRAMME (WCRP): REPORT AND REVIEW

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Summary. This report informs IOC of the results and implications of WCRP Review by Sponsors and IGFA, presents a concise summary of main WCRP activities since 2007 with a focus on the role of oceans in climate, and proposes a path for further strengthening the role of WCRP in the IOC Sciences Programme. A specific proposal is made to develop a joint WCRP-IOC sponsored Task Group on Assessment of Sea-Level Variability and Change.

General Background

IOC is a co-sponsor of the World Climate Research Programme (WCRP), together with the World Meteorological Organization (WMO) and International Council for Science (ICSU). These three major international organizations established WCRP to address two objectives: to determine the predictability of climate and to determine the effects of human activities on climate for use in an increasing range of practical applications of direct relevance, benefit and value to society.

This report informs IOC of the results and implications of WCRP Review by Sponsors and IGFA, presents a concise summary of main WCRP activities since 2007 – the year of IOC 24th Assembly - with a focus on the role of oceans in climate, and proposes a path for further strengthening the role of WCRP in the IOC Sciences Programme. More complete information on WCRP activities including its activities linked to oceanography is available from the WCRP and CLIVAR websites (http://wcrp.wmo.int and http://www.clivar.org) and from the most recent WCRP Accomplishments Report 2007-2008 (http://wcrp.wmo.int/documents/WCRP_AR2007-2008_web.pdf).

Since 2007, WCRP has continued actively supporting and promoting global coordination and integration of climate research, modelling and prediction activities through sponsoring approximately 40 conferences, workshops, meetings and symposia focused on all aspects of Earth's climate system (i.e. oceans, atmosphere, cryosphere and land-surface), with a major emphasis on: 1) seasonal to interannual climate prediction/projection; 2) regional forecasts and their application in climate change adaptation, mitigation and risk and vulnerability assessments; 3) coupled climate system models that represent interactions among the physical, chemical and biological aspects of the climate system; 4) regional capacity building and use of climate observations, assessments, and predictions for resources management and decision making; and 5) new climate scenarios for future climate change and variability assessments, such as future IPCC and ozone assessments.

WCRP continues to inform the UNFCCC process, which is particularly important for the development of the climate regime beyond 2012. WCRP also made great strides in transferring the scientific information and knowledge about the Earth's climate system for policy decisions through the IPCC, the UNFCCC Conference of Parties and its Subsidiary Body on Scientific and Technological Advice (SBSTA). The major part of the scientific and technical contributions used in the IPCC Fourth Assessment Working Group I Report was provided by WCRP affiliated scientists. Through the Program for Climate Model Diagnostics and Intercomparisons WCRP made a concerted effort to provide world-wide access to its climate predictions/projections and research results enabling scientists including ones from developing and least developed nations to assess the potential consequences of climate variability and change on major economic sectors (e.g. food, water, energy, health, etc.), for their country or geographic regions.

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

As a part of the Earth System Science Partnership, WCRP continued to build on its existing partnerships with other international research programmes such as the International Geosphere-Biosphere Programme (IGBP) on biogeochemical aspects, the International Human Dimensions Programme on Global Environmental Change (IHDP) on social and human dimensions of climate change research, and with the global Change SysTem for Analysis, Research and Training

(START) and regional organizations such as the Asian-Pacific Network (APN) and the Inter-American Institute (IAI) on capacity building, education and outreach.

WCRP Review by its Sponsors and IGFA

In 2008 and 2009, ISCU, WMO, IOC and the International Group of Funding Agencies for Global Change Research (IGFA) sponsored an independent review of WCRP. They also sponsored similar reviews of the IGBP and the Earth System Science Partnership (ESSP). Full text of the Review team is now available on the ISCU website (http://www.icsu.org).

Main conclusions highlighted in the WCRP Review are:

- WCRP has earned renown for excellence over its lifetime of almost 30 years. This excellence provides a strong foundation for the future.

- Society needs the research that will underpin mitigation strategies and climate adaptation. After almost 30 years of high achievement, the breadth of WCRP programmes has outgrown the ability of society to support all the necessary research, infrastructure, and coordination. Yet the need for WCRP's work is more important than ever.

- There must be a strategy for prioritizing WCRP science and related activities and for conversion of WCRP science into future societal benefits. The WCRP Strategic Framework 2005-2015 "Coordinated Observation and Prediction of the Earth System" (COPES, please see the publication at http://wcrp.wmo.int/pdf/WCRP_strategImple_LowRes.pdf) provides a framework but lacks 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. WCRP should quickly develop an implementation plan for its activities, taking into account new initiatives that have emerged since the Strategic Framework was published 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. These should be delivered 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.

- 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.

The Review recommended that the WCRP should:

- Immediately focus the 2005 WCRP Strategic Framework 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.

- Rapidly implement its focused Strategic Framework, paying special attention to societal needs while maintaining its science-driven approach.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- In partnership with other global environmental change programmes, 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 Review also recommended that 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.

The draft Review report and its recommendations were made available to and studied in detail by the WCRP Joint Scientific Committee, leadership of the WCRP core projects and working groups. The WCRP team was highly encouraged by the praise and clear recognition of the high value of the Programme for society, but those who commented on the draft Review were not in total agreement with the reviewers on a few points. First, they felt that there was an underestimation of the role of the core WCRP projects. Specifically, they cited the statement that "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." This could be interpreted that the Projects were standing in the way of progress, which was felt not to be the case. The WCRP activities, and most notably the Projects, were continuously evolving through "grass root" efforts of the community of volunteers and did interface with users on many levels. Also there was concern that the "top down" approach would rather alienate the community than generate the grass-roots support that has been a major strength and contributing factor to WCRP success. They stated that prioritization is occurring at the national level by funding agencies and to some extent by the WCRP Projects that initiate and organize the research that is funded by the nations. However, they agreed that WCRP needed to identify its users and decide how, and at what level, it would deliver its research results, but there was a strong sense that the mandate of WCRP for basic research should remain as its major focus and that the delivery of results should occur through partnerships with other groups and institutions whose mandates are to provide climate services.

Even before the draft Review and recommendations were made available to WCRP, the Programme had started work on its implementation plan for the interim period (up to 2013 – 2015, with a focus on completing the tasks formulated in its Strategic Framework COPES) and a forward-

looking strategy beyond that period based on an assessment of the needs in science for the two time horizons. In addition, WCRP is assembling a report that will highlight its achievements since the initiation of COPES. Both the implementation plan and the achievement report are expected to be complete during summer 2009.

WCRP Ocean and Climate Research

A large number of WCRP projects are involved in aspects of oceanographic research. CLIVAR provides the focus within WCRP for understanding the role of the ocean in climate, develops observing systems, promotes reanalysis of existing ocean data, and develops ocean modules of global climate models. CliC contributes to these activities on cryospheric and polar aspects. GEWEX does so in the areas of surface flux research and facilitates regional climate studies. As a co-sponsor of the Ocean Observations Panel for Climate (OOPC), WCRP strives to ensure high-quality and long-term ocean observations for climate research and prediction. WCRP, together with the IGBP, Scientific Committee on Oceanic Research (SCOR) and the international Commission on Atmospheric Chemistry and Global Pollution (CACGP) is a co-sponsor of the Surface Ocean – Lower Atmosphere Study Project that develops the science of biogeochemical interactions between the ocean and atmosphere. The WCRP Observation and Assimilation Panel, the WCRP Modelling Panel and Working Group on Coupled Modelling (WGCM) activities make significant contributions to ocean research, modelling and analysis.

Some examples of recent WCRP accomplishments related to the ocean research include:

- Collaborative intercomparison and assessment of global ocean synthesis (reanalysis) products aimed at determining their quality and potential for ocean initialization in climate prediction.

- Ongoing implementation of an integrated Indian Ocean Observing System in collaboration with IOC and Indian Ocean GOOS.

- Tropical Atlantic Climate Experiment (2006-2011) to improve regional climate prediction.

- Support to and coordination of programmes to monitor the Meridional Overturning Circulation (MOC) in the Atlantic.

- Input to design the Arctic and Southern Ocean Observing Systems, in collaboration with several partners, as a part of the International Polar Year 2007-2008 and its legacy.

- Coordination of key international climate process studies in the Pacific.

- Activities in marginal seas, e.g. in the Baltic (BALTEX).

- Developing the tropical moored buoy arrays to provide key observations for seasonal predictions.

- Design of Version 2 of Coordinated Ocean-ice Reference Experiments (CORE-II) to further develop ocean components of global climate models and a CLIVAR Repository for Evaluating Ocean Simulations (REOS) to support evaluation of ocean simulations by bringing together datasets, analyses/syntheses, tools, papers, and commentaries.

- Assisting the Intergovernmental Oceanographic Commission (IOC) of UNESCO to provide guidelines for the future global deep ocean hydrography and carbon network.

30th Session of the WCRP Joint Scientific Committee
(College Park, MD, USA, 6–9 April 2009)

The Joint Scientific Committee (JSC) for WCRP was held on 6-9 April 2009 in College Park, USA. Its main focus was on the WCRP path forward. The Session also reviewed implementation considerations of WCRP core projects and main working groups, as well as considered the progress of the pan-WCRP activities aimed at delivering on areas of major societal benefit. The IOC President Captain Javier Valladares and Dr. Albert Fischer of the IOC Secretariat attended all four days of the session.

A major outcome of the session is a decision to develop a joint WCRP-IOC sponsored Task Group on **Assessment of Sea-Level Variability and Change** and actively engage the WCRP core Projects in its activities. Prof. Konrad Steffen agreed to co-chair the group on behalf of WCRP together with the former WCRP JSC Chair Dr. John Church. The Task Force will facilitate fundamental research on sea-level variations including their geographical distribution and at the same time will work on producing tangible practical outcomes for IOC Member States. Draft Terms of Reference for the Task Group are given in the Annex to this Report.

Noting that the role of oceans in climate is a central theme of WCRP research and recognizing the major contribution of the International CLIVAR Project Office (ICPO) to the successful implementation of WCRP activities in this domain, the JSC urged national sponsors to continue support for the ICPO.

Paving the Way for Future Global and Regional Climate Predictions and Assessments

Following the very-well received Fourth Assessment Report (AR4) of the WMO/UNEP IPCC, WCRP has been actively engaged in setting the stage and paving the way for new and improved climate predictions and projections for a variety of future assessments including the Fifth IPCC Assessment Report (AR5).

Assessment of gaps in AR4: In conjunction with the IGBP and the Global Climate Observing System (GCOS) WCRP organized a major workshop in October 2007 to use the findings of the IPCC Fourth Assessment Report in helping to guide future strategies for climate change observations, research and assessment. This Sydney Workshop looked specifically at the most critical gaps in basic science and at deficiencies in the information about climate change used for the estimation of impacts, design of adaptation measures, and assessment of vulnerability, particularly on a regional scale. Workshop identified two priority items that currently limit our confidence in projections of climate change. They are our poor understanding of ice sheet behaviour and its implications for sea-level rise, and gaps in knowledge about the hydrological and carbon cycles. It also made suggestions on the research necessary to improve performance of regional climate change models. Workshop participants developed a risk management framework to better link science questions with societal concerns in various regions and various sectors.

New climate change scenarios and main AR5 outputs: During its 25th session (Mauritius, 26–28 April 2006), the IPCC decided that rather than directly coordinating and approving new scenarios itself, the process of scenario development should now be coordinated by the research community. WCRP-affiliated scientists contributed to specification of so called Representative Concentration Pathways (RCPs), which include time paths of emissions and concentrations of the full suite of greenhouse gases and aerosols and chemically active gases as well as land use/land cover changes. WCRP representatives participated in the IPCC expert meeting in September 2007 in Noordwijkerhout, The Netherlands, which defined the expected principal products of the forthcoming AR5.

Global climate model predictions for AR5: The WCRP's Working Group on Coupled Modelling (WGCM) held a historic meeting in Paris, France, in September 2008. Representatives of climate modelling centres from around the world shaped the next climate model intercomparison

project (CMIP5). Proposed and developed by the WGCM community in conjunction with the IGBP's Analysis, Integration and Modelling of the Earth System (AIMES) project, CMIP5 will provide the framework for climate change modelling research for the next five years and the basis for the next IPCC Assessment (AR5), which is scheduled for publication in 2013. The set of climate model runs will include also decadal predictions, which are becoming feasible due to advances in the ocean observations and data synthesis spearheaded by CLIVAR. It has been agreed, as was done for the IPCC AR4, that WCRP will make results of global climate model runs available to worldwide community through a comprehensive archive.

Supporting impact assessment, adaptation and mitigation: Due to marked decadal and regional climate variability, informed impact assessment, adaptation and mitigation require climate predictions and projections on a regional scale. The comprehensiveness of such predictions needs to be significantly improved to provide meaningful information for decision making. In 2008 the WCRP established a Task Force on Regional Climate Downscaling (RCD) to

- design a benchmark framework to better evaluate and possibly improve different RCD techniques,
- organize an international coordinated framework to produce an improved generation of RCD-based climate change projections over regions world-wide for input into impact and adaptation studies within the AR5 timeline and beyond, and
- promote greater interactions between the climate modeling and end-user communities and promote greater involvement of the scientific community from developing countries.

WCRP organized an expert meeting on RCD in Toulouse in February 2009 and proposed a COordinated Regional climate Downscaling Experiment (CORDEX), which will be a long-term programme to develop multiple dynamical and statistical downscaling models that would use forcing GCMs from the CMIP5 archive to generate regional climate projections for many areas of the world with an initial focus on Africa. IOC may be interested in being kept aware of the outcomes of CORDEX and use its results for assessing the impacts of the climate change on regional seas.

Development of Climate Modelling

World Modelling Summit for Climate Prediction (Reading, UK, 6-9 May 2008): At the Summit the world's leading climate researchers from within WCRP, IGBP, and the World Weather Research Programme discussed progress in state-of-the-art climate modelling capabilities and laid plans for the future. Current generation climate models have serious limitations in simulating regional features such as rainfall, mid-latitude storms, and ecosystem dynamics. The Summit concluded that these limitations are mainly due to our inability of representing properly these features in the climate models. To address the problem powerful enough computers are required capable of simulating years of Earth's climate in days of computer time. The Summit statement reports on the potential for progress that could be made and called for creation of The Climate Prediction Project, which would include formation of a coordinated international modelling program. The effort will involve ocean modelling.

Advances in Seasonal to Decadal Prediction

With the successful development of Argo and other observational techniques, WCRP works towards engaging the predictive potential of the ocean in the tasks of extending the predictive skill of seasonal forecasting systems and determining climate predictability at decadal time scales.

In June 2007, the First WCRP Seasonal Prediction Workshop was held in Barcelona, Spain, bringing together climate researchers, forecast providers and application experts to address the

current status of seasonal forecasting and the application of seasonal forecasts by users. As an important outcome, workshop participants developed recommendations and summarized best practices in the area of seasonal prediction. During the Workshop, the WCRP Climate-system Historical Forecast Project (CHFP) was launched. This project is a multi-model, multi-institutional experimental framework for the assessment of state-of-the-science seasonal forecast systems, and to evaluate the potential for untapped predictability due to interactions between the components of the climate system that are currently not fully accounted for in seasonal forecasts. Main thrusts in these experiments are to improve account of ocean data in the predictions and generate the predictions using ensembles of coupled global climate models with a well-resolved ocean.

In 2007, a new cross-cutting WCRP initiative was endorsed to advance the science of decadal prediction. Using state-of-the-science coupled models, a first series of experiments focuses on short-term climate prediction for the next 30 years. Early results point towards the possibility of routine decadal climate predictions using a method that considers both internal natural climate variations and projected future anthropogenic forcing. Evidence for the existence of decadal predictability has arisen from research on the El Niño phenomenon and other global-scale oscillation systems including hurricane activity, surface-temperature and rainfall variations. Perspectives of the decadal predictability research are intimately linked with assimilation of oceanographic observations.

Addressing Challenges of Observation, Data Collection, Assimilation and Reanalysis

OceanObs'09: WCRP is a Sponsor of OceanObs'09 organized by IOC and European Space Agency (ESA). Chairs of the OOPC and CLIVAR Global Synthesis and Observations Panel are Co-chairs of the Conference, which is extremely important for WCRP and will be discussed by the Assembly under the item 4.4.2.

Reanalysis, the reprocessing of all available historical data, both in situ and satellite observations, produces a coherent description of the changing states of the atmosphere, ocean or other components of the climate system leading to a coherent description of the Earth's climate. Originally, only atmospheric reanalyses had been developed but the method is advancing so rapidly that it is now being used for oceans and sea-ice observations. Products of global reanalysis have provided the basis for advances in many areas, including climate now-casting and diagnostic studies of complex systems such as monsoons or the El Niño-Southern Oscillation. Global reanalysis is also the foundation for regional reanalysis projects and downscaling to study local climate and climate impacts. In addition, the development of comprehensive Earth system models requires to expand the scope of reanalysis and conduct coupled atmosphere-ocean data assimilation. As the science of reanalysis grows, there is an urgent need to align financial and infrastructural resources for data handling and processing and to foster sustained international cooperation. Advances and challenges in this rapidly evolving field were discussed at the Third WCRP International Conference on Reanalysis held on 28 January to 1 February 2008 in Tokyo, Japan.

WCRP Observation and Assimilation Panel (WOAP) held its third session in Boulder, USA in September October 2008. The Session report (http://wcrp.wmo.int/documents/Report_WOAP3_Nov2008.pdf) contains a number of recommendations aimed at development and improvement of climate data records which can be used for studies and assessments of climate variability and change, such as for IPCC. In particular, WOAP noted several areas of activity, which cause a concern. They include continuity of the microwave SST data record, which is under risk, and a potential lack of continuity in the climate record for high quality ocean color.

Building Capacity and Supporting Adaptation Planning

One of WCRP's major concerns is to make the climate informational products useful and easily accessible to the broad science community and to society as a whole. WCRP is pursuing this goal through a multi-pronged approach with the following major thrusts:

- Training young scientists and scientists in the developing world;
- Training climate practitioners to be able to better analyze and interpret climate information products for adaptation planning and risk reduction;
- Developing a dialogue with decision makers, politicians and the development community to find common language and understanding of the latest climate research findings;
- Providing opportunities for young scientists to develop an Earth system science approach to climate research in the future.

WCRP and the International Centre for Theoretical Physics (ICTP of Italian Government, UNESCO, and the International Atomic Energy Agency) organized a training seminar (Trieste, Italy, 2007) on analyzing and interpreting the international ensemble of climate simulations for the 20th and 21st centuries completed as part of the Third WCRP Coupled Model Intercomparison Project CMIP3 and containing simulations undertaken in support of the IPCC AR4. The 30 participants from developing nations worked on their own projects utilizing the WCRP CMIP3 archive in a way that was relevant and helpful to their home nation or organization. The young talents also learnt to understand the uncertainties associated with RCM-based regional climate change projections.

WCRP together with the IGBP project IMBER held a first-of-its-kind ClimEco Training Seminar for Young Marine Scientists in Brest, France, April 2008. The participants learned about the interactions between physical climate, marine biogeochemistry and ecosystems. The workshop helped to entrain young scientists across disciplines in the Earth system research.

Major Ocean-related Activities by WCRP Projects

CLIVAR: The WCRP core project on Climate Variability and Predictability (CLIVAR) is the main focus in WCRP for studies of climate variability. Its mission is to observe, simulate and predict the Earth's climate system, with a focus on ocean-atmosphere interactions enabling better understanding of climate variability, predictability and change to the benefit of society and the environment in which we live.

Examples of CLIVAR recent accomplishments related to oceans:

- Coordination of climate model scenario experiments for IPCC. Key inputs on changes in climate extremes to IPCC AR4.
- Model intercomparison activities aimed at improving seasonal predictions and ocean model performance.
- Coordination of field studies to help improve parameterization schemes for atmosphere and ocean climate models and their interactions.
- Synthesis of ocean data and information.
- Advocacy for real time data and high quality delayed mode observational data for operations and research.

- Development of an electronic African Climate Atlas, a tool for research on African climate.

- Organizing and sponsoring training workshops on seasonal prediction in Africa, climate impacts on ocean ecosystems, climate data and extremes and ENSO.

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

Examples of CliC accomplishments related to oceans:

- Developing the IGOS Theme on Cryosphere (IGOS-Cryo) in partnership with SCAR, and achieving the broad consensus on the planned development of cryospheric observations for years to come. In May 2007, the 15th WMO Congress approved Canada's proposal to create a Global Cryospheric Watch based on the IGOS-Cryo recommendations. These activities will lead to better observations of marine cryosphere including all forms of sea ice and ice shelves.

- Coordinating strong input from the climate research community to the scientific programme of IPY 2007-2008. This included a concept of polar satellite snapshot aimed at obtaining unprecedented coverage of both polar regions including Arctic and Southern Ocean with observations from space.

- Drawing the attention of the world's scientific community to the role of the cryosphere in the climate system, such as developing a chapter on Snow, Ice and Frozen Ground for the IPCC Assessment Report 4 (2007). The report highlights the contribution of melted water to recent sea-level change.

SOLAS: SOLAS held its second open science meeting in Xiamen, China in March 2007 and its third summer school for 2007 (see http://www.solas-int.org/). Both events were also supported by SCOR. Its third Open Science Conference will be held in Barcelona, Spain, 16-19 November 2009. Over 300 participants are expected to present their findings on biogeochemical and physical feedbacks between the ocean and the atmosphere. The fourth SOLAS summer school will be held in Cargèse, Corsica, in August 2009.

WCRP Activities During the International Polar Year (IPY) 2007-2008

The main goals of WCRP in IPY are to address existing gaps in the knowledge of polar processes, develop understanding of the role of polar regions in Earth's climate system and an ability to better predict global climate. Many of the IPY project leaders and participants are members of WCRP projects and groups.

WCRP contributions to IPY scientific achievements related to oceans:

- Establishing a basis for an Arctic Ocean Observing System and sustaining Arctic observing networks (through the International Arctic Science Committee and its Arctic Ocean Sciences Board).

- Establishing an Arctic hydrological cycle observing system to advance polar hydrology and enable global studies of ocean freshwater balance.

- Promoting a sustained survey of the Southern Ocean forming the foundation of the Southern Ocean Observing System (SOOS, with SCAR and SCOR).

- Proposing for the first time a satellite snapshot of the polar regions by major space agencies, especially with the Synthetic Aperture Radars and reconstructing snapshots of the polar cryosphere and polar oceans, atmosphere, including stratosphere and mesosphere, as a benchmark for an integrated 'atmosphere-cryosphere-ocean' study.

- Obtaining a potentially record-long ice-core based climate history reconstruction (Chinese contribution).

- Strengthening interoperable data exchange and information archival.

- Building capacity for generation and use of climate information products and services in Polar Regions in cooperation with the WMO project on Climate Information and Prediction Services (CLIPS).

Major Ocean-related Meetings Cosponsored With Partners:

International Symposium "Effects of Climate Change on the World's Oceans" (Gijón, Spain, May 2008): Together with SCOR and GLOBEC WCRP was a co-sponsor of the recent 'Gijón Symposium', organised by IOC, PICES, and ICES. More than 200 scientists from 48 nations gathered in Gijón to review the state of research and knowledge in the full spectrum of ocean topics. Three top priorities were identified which require urgent attention. Firstly, a greater engagement by marine scientists is needed to address climate change issues including climate variability and change and their impact on ecosystem structure, biodiversity, fisheries, and species' and society's adaptation to these changes. Secondly, it is essential to sustain the global scale observing system already implemented, to compile available data into quality controlled and easily accessible data bases, and to agree and implement a plan to expand the system beyond its present physical and biochemical variables. Thirdly, a critical need for sustained funding to support sustained observations was identified.

Met-Ocean Committee of the International Association of Oil and Gas Producers (OGP), the JCOMM and WCRP Workshop on Climate Change and the Offshore Industry (Geneva, Switzerland, May 2008): The very successful workshop, attended by approximately 60 participants, opened the dialogue on climate change between specialists from oil companies and environmental research organizations. The following areas for future research towards the adaptation of the offshore industry services to climate change were identified: understanding of the performance of climate models at various resolutions, time scales and in various regions; advanced regional downscaling methodologies; standards for (meta-)data; non-stationary extreme value analysis techniques for key metocean parameters such as wind speeds, wave heights, sea-level, sea-ice coverage, and explicit inclusion of uncertainty in extreme value analyses.

El Niño-Southern Oscillation (ENSO): Dynamics and Predictability (Puna, Big Island, Hawaii, USA, June 2008): Sixteen graduate students in oceanography, meteorology and geology from 12 countries gathered at the jointly organized WCRP/CLIVAR – IGBP/PAGES summer school to learn from lecturers on a broad swath of ENSO-related topics: ENSO theory, phenomenology, predictability and it's sensitivity to past and future climate change. The students worked on their own research projects and in teams, studying the effects of ENSO on the Antarctic Peninsula, the rapid end of the 2008 La Niña event, the geographical reaches of a tropical drought some 4,200 years ago, and many other themes.

CLIVAR/GOOS Indian Ocean Panel (5th Session, 12-14 May 2008, Bali, Indonesia; 6th Session, 3-5 June 2009, La Reunion, France): Programmes of these meetings included all aspects associated with the development of the Indian Ocean Observing System.

World Climate Conference -3 (WCC-3, Geneva, 31.08-04.09.2009): WCC-3 will not be just "another" climate conference. WCC-3 will establish an international framework to guide the

development of climate services which will link science-based climate predictions and information with climate-risk management and adaptation to climate variability and change throughout the world. WCRP community is deeply involved in the preparations of the Conference. Prof. Martin Visbeck, a Co-chair of CLIVAR is the Chair of the WCC-3 Program Sub-Committee. One of the working sessions of the Conference is entitled “Climate of oceans and coasts” and is of direct relevance and interest to the IOC.

Cooperation between the WCRP and IOC Science Programme

WCRP has been a leader in international oceanographic research since its founding in 1980. All three of the WCRP’s completed research projects have included a strong oceanographic component. Tropical Ocean Global Atmosphere (TOGA, 1985-1994) created the physical basis for explaining El Niño-Southern Oscillation (ENSO) in the ocean and atmosphere and established the first elements of the presently operational observing system in the Pacific Ocean and parts of the Indian Ocean. World Ocean Circulation Experiment (WOCE, 1990-2002) was the first comprehensive survey of the global oceans. This largest ocean-dedicated experiment in the history of oceanography greatly improved our ability to observe and model the world oceans and made important contributions to a large range of research and operational marine activities. Publication of the comprehensive ocean atlas of WOCE data, covering the Southern Ocean, Atlantic, Pacific and Indian Oceans will be completed over the coming years. During the decade of the Arctic Climate System Study (ACSYS, 1994-2003) the increased regional pace of climate change in the Arctic was predicted. A possibility of slowing down of the thermohaline circulation due to changes in the Arctic Ocean freshwater balance was demonstrated. Today WCRP actively develops ocean observations, data synthesis, modeling and prediction. This work is organized through WCRP core projects, panels, working groups, cosponsored activities, and first and foremost, through CLIVAR.

Since the completion of the Joint Global Ocean Flux Study (JGOFS, 1988-2003), IGBP conducts research on the ocean biogeochemistry through the Integrated Marine Biogeochemistry and Ecosystem Research (the IMBER Project) and two projects that focus on interactions (mostly, biogeochemical) between the oceans and atmosphere (Surface Ocean-Lower Atmosphere Study – SOLAS, a WCRP cosponsored project) and Land-Ocean Interactions in the Coastal Zone (LOICZ, cosponsored by IHDP). A considerable volume of oceanographic research included in IMBER and SOLAS is stimulated and coordinated by SCOR, as well. Additional biogeochemical ocean research is carried out by GEOTRACES, GEOHAB, and GLOBEC, and the two latter projects are cosponsored by the IOC.

WCRP is currently considering its future post-2013, and in this context, what structure would best allow it to remain at the forefront of climate research and address societal needs. These deliberations will undoubtedly lead to closer collaboration with IGBP and other partners in order to address the Earth System as a whole. With respect to ocean science, the outcomes of the upcoming World Climate Conference 3 and OceanObs 09 will serve to guide WCRP in how to best focus its activities to ensure that international coordination of research on all aspects of ocean physics that are vital for climate and visa versa is facilitated.

Keeping in mind the shared interest of all its sponsors, including the IOC, that WCRP research covers areas that lead to maximal societal benefits, consistent with its COPES strategy (2005-2015) and overall objectives of the Programme, WCRP is seeking ways in which it can address aspects of ocean research that are of critical importance to IOC Members. These issues are the subject of our established dialogue with the newly appointed Head of the IOC Ocean Sciences Section, Dr. Luis Valdes and they were very well expressed in the address of the IOC President Captain Javier Valladares to the JSC-30 in April 2009.

The assessment of climate change impact, and adaptation to it, remain the most urgent issues of the modern applied environmental science. Mitigation of the impacts of the climate change and variability on the oceans and coasts and adaptation to them are a High-Level Objective (HLO) of the IOC Medium-Term Strategy. By facilitating global and regional climate

predictions and projections as part of CMIP5 and CORDEX, WCRP provide the basis for their interpretation in terms of impacts on the oceans and coasts. To contribute to the HLO, IOC might wish to consider establishing with WCRP a series of targeted research and implementation activities in the area of oceanography. The proposed joint activity on sea-level rise (see Terms of Reference in Annex), is an excellent example of how this collaboration might work. Another topic might be related to prediction of the state of the oceans, including regional scales and individual seas. SCOR and IGBP may also wish to participate in these activities. IOC Regional Sub-Commissions and Committees and groups involved in polar oceanography such as AOSB and SCAR also might find it interesting for them to extend the activities to their areas of responsibility. The identified activities could cooperate with existing constituencies involved in ocean observations and data synthesis, such as JCOMM, GOOS and GCOS. Activities might also be associated with ocean and sea modeling, in which the experience of the CLIVAR WGOMD in validating ocean models will be highly relevant. Some of them may be able to capitalize on the outcomes of GODAE and continue its work on ocean data assimilation. The definition and scope of the projects and partners will have to be defined in a broad and inclusive consultation and preparation for such a series of activities will require intense cooperation between WCRP and the IOC Science Section and the engagement with appropriate partners.

Draft Terms of Reference for the WCRP/IOC Task Group on Assessment of Sea-Level Variability and Change[1]

The Task Group will address issues relevant to sea-level rise, both its global average and also its variability in space and time. The overall goal of the group will be to improve our ability to monitor, explain, predict global and regional sea level and all environmental factors related to it, and use this information for informed decision making.

Specifically, the Task Group will:

- Review the sea–level rise research across WCRP, other Programmes and relevant parties, liaise and collaborate with them as appropriate to stimulate and facilitate the development of scientific understanding, observation and modelling techniques necessary to assess and predict global and regional sea-level change.

- Facilitate quantification of the rate of sea-level rise and the processes contributing to it.

- Advise on the development of in-situ and satellite observing systems required to improve our understanding and projections of sea-level rise.

- Recommend transition into sustained operation of those systematic sea-level-related observing systems that are sufficiently mature and provide a rationale for their prioritization.

- Facilitate development of a basis for quantification of extreme sea levels for the future.

- Provide regular updates on the present status and projections of sea-level rise.

- Facilitate the use of improved observations, understanding and projections of sea level rise by various groups assessing the impacts of sea-level rise and the associated risk.

The group will primarily work via email, telephone hook-ups and face-to-face meetings during (or immediately adjacent to) other conferences/meetings. The group may convene broader community workshops. The initial mandate is from 2009 to 2013.

Intergovernmental Oceanographic Commission (IOC)
United Nations Educational, Scientific and Cultural Organization
1, rue Miollis
75 732 Paris Cedex 15, France
Tel.: +33 1 45 68 10 10
Fax: +33 1 45 68 58 12
http://Ioc.unesco.org

[1] Language versions of the Draft Terms of Reference of the WCRP-IOC task group are available in document IOC-XXV/2 Rev.