Newsletter of the Climate Variability and Predictability Programme (CLIVAR)

Exchanges

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CLIVAR SPECIAL EDITION
SCIENTIFIC STEERING GROUP MEETING

Consejo Superior de Investigacion Cientifica Royal Botanical Gardens, Madrid, Spain, from 19-22 May 2009

CLIVAR is an international research programme dealing with climate variability and predictability on time-scales from months to centuries. CLIVAR is a component of the World Climate Research Programme (WCRP). WCRP is sponsored by the World Meteorological Organization, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO.

WCRP
World Climate Research Programme

Editorial

This double number of CLIVAR Exchanges combines it's 49th and 50 editions and so passes something of a milestone. To "celebrate", albeit in a modest way, we are publishing the reports of all CLIVAR's Panels and Working Groups to the recent 16th meeting of the CLIVAR Scientific Steering Group (SSG), held in Madrid, Spain from 19-22 May 2009. The aim is to give a something of a picture of where CLIVAR is currently engaged in the coordination and promotion of international collaborative projects on climate research. The edition therefore starts with a summary article on the SSG meeting itself which is followed by reports from CLIVAR's ocean basin panels, the American and Asian monsoon and African Climate Panels, its global modelling groups and its global synthesis and observation panel, it's interaction with IGBP PAGES (Past Global Changes) and the Expert Team on Climate Change Detection and Indices.

We also feature two science papers on the Pacific-Decadal Oscillation and the impacts of El Niño Modoki on Australian rainfall, a briefing on the outcomes of the recent US CLIVAR Summit Meeting and on the EU CLARIS project and a summary of the Working Group on Ocean Model Development's Workshop on Ocean Mesoscale Eddies. Finally we have an article from the Humanitarian Futures Programme at Kings College, London, UK as a foretaste of an anticipated longer contribution from them in the next edition of CLIVAR Exchanges.

The CLIVAR SSG meeting was something of a watershed for the International CLIVAR Project Office (ICPO) since it was the last major activity that Roberta Boscolo directly organized for us as an ICPO member before departing for a post with the Joint Planning Staff (JPS) for WCRP in Geneva. Roberta has had a long association with the ICPO having worked for it for much of the time since it moved to the (then) Southampton Oceanography Centre in 1998. For much of this time she has been hosted by the Consejo Superior de Investigacion Cientifica Instituto de Investigations Marinas in Vigo, Spain. We are indeed grateful to them for the contribution to CLIVAR that they have thereby made. Prior to her involvement with CLIVAR, Roberta had also worked within the World Ocean Circulation Experiment (WOCE) IPO, located at Southampton. She has thus developed much expertise over the years on WOCE, CLIVAR and WCRP more widely and contributed to the organization of many CLIVAR meetings and activities, not least for the Atlantic, Indian and Pacific Ocean basin panels that she had most recent responsibility for. Her departure thus leaves a major gap at the ICPO that is keenly felt. Nevertheless we wish her well and look forward to continuing to interact with her in her new role as a member of the JPS staff.

Many thanks indeed for everything you have done for CLIVAR and the ICPO, Roberta!

Howard Cattle

Roberta Boscolo – In pastures new with the Joint Planning Staff for WCRP

Summary of CLIVAR SSG–16. Building consensus on CLIVAR science implementation

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Introduction

The 16th session of the CLIVAR Scientific Steering Group (SSG-16) was held in the meeting rooms of the Royal Botanical Gardens, Consejo Superior de Investigacion Cientifica (CSIC), Madrid, Spain, from 19-22 May 2009. The SSG co-chairs (Jim Hurrell, Tim Palmer, and Martin Visbeck) led the meeting, which included 35 delegates comprised of other SSG members, chairs and members of CLIVAR panels and working groups, representatives from other core WCRP projects, and other invitees. The meeting had two primary foci: first, to build consensus on overall imperatives for CLIVAR science and its implementation over the coming 5 years, and second to assess the progress of panels and working groups in terms of advancing CLIVAR science. Summaries of panel and working group activities are published in this edition of Exchanges. The SSG is grateful to Dr Roberta Boscolo for acting as local organizer of the meeting. Through her efforts the meeting was an extremely successful and sociable event.

Opening of the meeting

The SSG and other attendees were pleased and honoured to have the meeting opened with an address from the Spanish Secretary of State for Climate Change, Ms. Teresa Ribera, which stressed the importance of ongoing climate research and the IPCC process. Ms. Ribera was accompanied by the President of AEMet, Francisco Cadarso. Delegates were also welcomed with addresses from Dr Gonzalo Nieto, Director of the Royal Botanical Gardens and Dr Rafael Zardoya of the Museo Nacional de Ciencias Naturales. Tim Palmer provided the response and thanked the Spanish hosts for their good wishes on the success of the meeting.

WCRP strategy, outcomes of JSC-30, other WCRP core project inputs and the Year of Tropical Convection

To help set the context of the meeting, Dr. Ghassem Asrar, Director of WCRP, outlined current thinking on the future directions for WCRP as well as the CLIVAR-relevant actions and outcomes of the 30th meeting of the Joint Scientific Committee (JSC) for WCRP (Maryland, USA, 6-9 April 2009). He emphasized that programme development within WCRP is taking place on two time horizons – to 2013 ("the intermediate term") and beyond ("the longer term"). For the former, the WCRP Strategic Plan 2005-15 "Coordinated

Observation and Prediction of the Earth System (COPES)" defines the pathway with its themes[1] fully integrated in the core projects' work. Regarding the longer term, a new WCRP structure is required to achieve a more effective interface with the users of climate information products, building on the outcomes of World Climate Conference-3 (WCC-3) (Geneva, Switzerland, 31 August – 4 September 2009) as well as continuing to promote and facilitate research at the frontiers of climate science.

In order to focus the way forward, at JSC-30 the core projects and other WCRP observational and modeling groups highlighted their contributions to the COPES framework. Moreover, they presented preliminary science goals and implementation plans for the intermediate term. All of this information is being fed into an overall WCRP Implementation Plan and Accomplishments Document, to be distributed at key events such as WCC-3.

As outlined by Jim Hurrell in his introduction to SSG-16, one key task for the meeting was to review the science goals and implementation plans for CLIVAR that he presented at JSC-30, with the goal of refining and reaching consensus on the top priorities.

Before this, however, the rest of the first morning was dedicated to presentations by representatives of the other three core projects of WCRP: the Global Energy and Water Experiment (GEWEX), Climate and Cryopsphere (CliC) and Stratospheric Processes and Climate (SPARC). Each presentation highlighted future foci and synergies with CLIVAR. The status of the WCRP / World Weather Research Programme (WWRP) "Year of Tropical Convection (YOTC)" was also outlined by Duane Waliser. An Implementation Plan for YOTC would be finalized in July 2009 at a planning workshop in Honolulu. Dr Waliser also presented a proposal for a Joint WCRP/WWRP Task Team on the Madden Julian Oscillation (MJO) as a follow-on from the previous US CLIVAR MJO Working Group (www.usclivar.org/mjo.php). From a CLIVAR perspective, the SSG agreed the MJO Task Team could be hosted within the Asian Australian Monsoon Panel (AAMP) and potentially the Variability of the American Monsoon (VAMOS) panel also.

Development of the ocean observing system

The status of the ocean observing system was reviewed by Ed Harrison, Chair of the Ocean Observations Panel for Climate (OOPC). He noted that implementation of in situ instrumentation has slowed and that it is not clear how long the system can be sustained via the science community. There are also R&D, data sharing and data system challenges including those associated with extending the system to include biogeochemical and ecosystem variables. There has been good progress with ocean synthesis but demonstrating the essential requirement for ocean observations for coupled climate predictions remains a challenge. However, it is encouraging that the community response to the call for the OceanObs'09 Symposium (Venice, 21-25 September 2009) White Papers has been strong with over 100 proposals accepted and more than 70 papers received at the date of SSG-16.

1 The WCRP cross cutting themes are: Anthropogenic Climate Change, Atmospheric Chemistry and Climate, Decadal Prediction, Seasonal Prediction, Monsoons, Climate Extremes, Sea Level Rise and the International Polar Year.

Imperatives for CLIVAR research

The afternoon session, chaired by Martin Visbeck, began with Jim Hurrell's summary of a preliminary list of CLIVAR imperatives contributing to the implementation of the COPES strategy. To facilitate the discussion, small teams of the attendees had been tasked in advance to present 2-3 slides on each imperative. These presentaitons led to considerable discussion that continued into the "round table" session of the next morning. The outcome was the following structure, key topics and actions:

Imperative I - Anthropogenic climate change

Topics: Natural variability versus forced change; climate sensitivity and feedbacks; regional phenomena; extremes.

Actions: Complete CMIP5 – see the WGCM report, this issue

Imperative II – Decadal variability, predictability and prediction

Topics: Determine predictability; mechanisms of variability; role of the oceans including the impact of ocean variations on land, temperature, precipitation, etc; adequacy of the observing system; initialization; prediction uncertainty; drought;

*Action*s: Build links pan-WCRP; complete CMIP; complete the Climate System Historical Forecast Project (CHFP) - see the WGSIP report, this volume – complete the Coordinated Ocean and sea ice Reference Experiments (COREs) – see WGOMD report, this volume)

Imperative III – Intraseasonal and seasonal predictability and prediction

Topics: Monsoons; El Nino-Southern Oscillation; tropical Atlantic variability; MJO/Intraseasonal variability; prediction uncertainty.

Actions: Build links pan-WCRP; complete CHFP.

Imperative IV – Improved atmosphere and ocean components of Earth System Models

Topics: Analysis and evaluation; climate process teams (process studies).

Actions: Build links pan-WCRP, IGBP; complete COREs

Imperative V – Data synthesis, analysis, reanalysis and uncertainty

Topics: Ocean; coupled data assimilation systems

Actions: Build links with IGBP – carbon, biogeochemistry, ecosystems

Imperative VI – Ocean observing system

Topics: Advocacy for sustained observations; development, implementation and system design.

Actions: continue links with OOPC; Build links with IGBP – carbon, biogeochemistry, ecosystems.

Imperative VII – Capacity building

Topical workshops, summer schools, expert training.

In order to develop the process further, tiger teams were established to develop short (5 page or less) summaries of the key science questions, implementation plans and the associated timelines for each of the seven imperatives. These summaries will provide further input to the WCRP Implementation Plan and also guide CLIVAR activities over the next several years.

WCC-3 and a proposed pan-WCRP Science Conference

Martin Visbeck briefed attendees on WCC-3 during the late morning session of day 2. Martin is a member of the

WCC-3 International Organizing Committee and serves as Chair of its Programme Sub-Committee. The overarching theme of WCC-3 is "Climate prediction and information for decision-making focusing on scientific advances in seasonal to interannual timescales, taking into account multi-decadal prediction". 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. The presentation led to some debate over whether the primary need was to better connect with users or to improve models and develop the science. Further information on WCC-3 is at www.wmo.int/wcc3/.

The SSG also debated whether a second, international CLIVAR science conference should be promoted, or whether it would be more in line with current developments in WCRP planning to hold a pan-WCRP conference, with perhaps special sessions on CLIVAR and other WCRP projects. On balance there was more support for holding a pan-WCRP science conference, perhaps in early 2011. This idea is being developed further.

National presentations

The meeting featured a number of presentations on national CLIVAR efforts. On the first morning, David Legler, Director of the US CLIVAR Office highlighted progress on drought research and decadal prediction activities, as well as a number of other activities of US CLIVAR. These activities and associated WCRP cross-cuts (e.g. extremes and decadal prediction) have been very visible and active within the US. It was agreed that there is room for greater coordination between US and international CLIVAR, for instance through US CLIVAR activities on the Atlantic Meridional Overturning Circulation and prospects for evaluation of the next set of Coupled Model Intercomparison project (CMIP5) runs. A report on the recent US CLIVAR Summit canbe found on page 38 of this issue.

Before lunch on the second day, the meeting attendees were pleased to have presentations on CLIVAR-relevant activities in Spain covering:

- Activities of AEMET relevant to CLIVAR, by Beatriz Navascués, AEMET, Madrid
- Climate Research in the Institute of Geosciences (IGEO), by Marisa Montoya & Ricardo García Herrera, Facultad de CC Físicas, Universidad Complutense, Madrid
- Activites of the Catalan Institut of Climate Sciences, by Xavier Rodó

Following these presentations, attendees were treated to a visit and tour of AEMet, including a welcome and overview by its President, Francisco Cadarso. Later that evening a number of meeting attendees were provided with a guided tour of the Royal Botanical Gardens led by its Director, Dr Nieto.

An additional national presentation, given later in the meeting by Wenjie Dong, provided an overview of "CLIVAR China". The mission and objectives of CLIVAR China are to understand the mechanism of climate variability over China and Asia from seasonal to centennial time-scales through observation, analysis and modeling and to improve operational climate predictions at the Chinese Meteorological Agency. Current priorities are a project on ocean-atmosphere-land interaction over Asia and the Indian-Pacific Ocean (AIPO); the mechanisms of onset and cessation of the Asian Monsoon over China; and climate extremes and hazards, in particular related to drought, typhoons and flooding.

In addition, the SSG heard a presentation from Dr Piero Lionello on progress with the European Science Foundation-supported MedCLIVAR activity, currently funded to 2011. MedCLIVAR's scientific priorities are to describe past evolution of climate and assess current climate variability over the Mediterranean region, understand the mechanisms responsible for Mediterranean climate variability, and provide climate predictions in relation to future emission scenarios. Since its start in 2006, MedCLIVAR has held three strategic workshops and one Summer school, has assigned 23 scientist exchange grants, and has sponsored or co-sponsored 5 scientific meetings. The activity includes scientific publications (including a book on Mediterranean Climate Variability) and the organization of EGU sessions and other scientific events.

Reports from CLIVAR Panels and Working Groups

The third day of the meeting was primarily taken up with presentations on, and discussion of, key progress and issues for the SSG and mechanisms for coordination across the programme. The discussions were stimulated by short presentations from the CLIVAR panels and working groups. Summary reports of progress are in accompanying papers in this edition of Exchanges. A range of recommendations and actions emerged and these will be provided in detail in the formal report of the SSG meeting (in preparation).

Wrapping up

The final morning of the meeting largely centered on future strategy and agreement on scientific and implementation priorities over the next few years. All recommendations and actions coming out of the meeting were also reviewed. The overall impression was that CLIVAR remains a very active and successful programme with lots of national, regional and global activities that will remain at the heart of WCRP for the foreseeable future. Thus, the JSC vision of a smooth transition into a new structure post-2013 was welcomed by the SSG and its panels and working groups. The next SSG will be held at NCAR, Boulder, Colorado during the week of 17-21 May 2009.

The full set of meeting papers are at www.clivar.org/organization/ssg/ssg16/ssg16.php

Presentations are at www.clivar.org/organization/ssg/ssg16/SSG16-presentations.php.

Atlantic Implementation Panel Activity Report

Ruth Curry, Laurent Terray, Roberta Boscolo and members of the CLIVAR Atlantic Panel
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The Atlantic Implementation Panel (AIP) has been proactive in coordinating observational and modelling efforts aimed toward 1) developing a sustained Atlantic ocean observing system, 2) assessment of coupled models and assimilation products, and 3) advancing knowledge of predictability on seasonal to decadal timescales. The ongoing Atlantic programmes, which AIP promotes and facilitates, are clustered around three central themes focused on the tropical Atlantic, Atlantic meridional overturning and the South Atlantic. In addition the AIP maintains a broad overview of the Atlantic Ocean observing system.

1. Tropical Atlantic studies

The observational network presently includes the Prediction and Research Moored Array in the Atlantic (PIRATA[1]) and components of two major field campaigns (the Tropical Atlantic Climate Experiment, TACE[2] and the African Monsoon Multidisciplinary Analysis, AMMA[3]) which link tropical Atlantic and West African monsoon research. Seasonal to interannual predictions and improved dynamical characterizations of the African and South American monsoon systems are fundamental elements of these programmes. Significant effort is also directed toward evaluating decadal predictability through the region's contribution to Atlantic multi-decadal variability (AMV).

AIP sponsored a meeting in Toulouse, France (Feb 2009) which brought the three groups together. AIP members Peter Brandt, Bill Johns, Laurent Terray and Paulo Nobre were part of the scientific organizing committee. A report of the meeting is at http://www.clivar.org/organization/atlantic/TACE/TA_meeting_report_feb2009.pdf

Issues pertaining to model biases are considered a primary hurdle to constructing predictive models. At AIP's urging, this was made a particular focus of the Toulouse meeting. AIP members Laurent Terray and Ping Chang are working closely with CLIVAR's Working Group on Seasonal to Interannual Prediction (WGSIP) and WCRP's Task Force for Seasonal Prediction (TFSP) on tropical Atlantic modelling issues.

2. Atlantic Meridional Overturning Circulation (AMOC) studies

The AMOC monitoring system will be significantly enhanced in the next 1-5 years primarily through two new programs (EU-THOR, see below, and US AMOC). These will expand the existing trans-basin and boundary current arrays (e.g. RAPID/MOCHA, Line W, MOVE, 53°N) with particular focus on the Nordic Seas overflows and on the latitudinal connectivity of AMOC variability in the North Atlantic and to a lesser extent in the South Atlantic. AIP plays an active role in the coordination of programmes to measure and monitor the Atlantic MOC. In September 2008, during the 9th meeting of the Panel at Woods Hole, the US-AMOC science team met with AIP to discuss recommendations for implementing programme objectives. An AMOC progress report was released in October 2008, endorsed by AIP. A workshop held in Annapolis, MD in May 2009 with AIP participants Ruth Curry, Yochanan Kushnir, Molly Baringer and Ping Chang then laid the groundwork for design and implementation of additional components for the monitoring system. A major European programme in this area (EU-THOR ThermoHaline Overturning at Risk) was officially launched with a meeting held in Hamburg in January 2009. The program aims to establish an operational system that will monitor and forecast the development of the North Atlantic THC on decadal time scales. Through the assimilation of systematic oceanic observations at key locations into ocean circulation models it will provide a set of geo-observational products that will be used to forecast the development of the system using global coupled ocean-atmosphere models. AIP member Svein Oesterhus represented the panel at an EU-THOR workshop held from 25-26 June 2009 in Torshavn, Faroe Islands.

A number of AMOC projects will address decadal predictions (e.g. US AMOC, EU-ENSEMBLES, EU-THOR, EU-COMBINE). A practical consideration is the development of the CMIP5 protocol (see the report of the Working Group on Coupled Modelling, this issue), which will lead to a large effort to start decadal prediction simulations in 2009/2010. A workshop to set standards for initialization and perturbation techniques will be held in Utrecht, the Netherlands in Nov 2009 (see item 5 below).

3. South Atlantic studies

AIP has long recognized the need to further develop the observing system for the South Atlantic. A SAMOC (South Atlantic Meridional Overturning Circulation) workshop in 2007 laid groundwork for monitoring heat and mass transports in the South Atlantic. A boundary current array (4 PIES) has been installed by NOAA/AOML at 34°S to monitor transports for 2009-2013 in conjunction with an XBT line (Garzoli, Meinen, Baringer). The eastern boundary current transports are being monitored by Bonus-GoodHope (Speich) which includes intensive biogeochemistry and atmospheric sampling components. However these are fledgling efforts -- not suitable for measuring the net MOC, for example, and it is expected that the US-AMOC science team will likely recommend that a full basin transport array be implemented in the South Atlantic. At the recent Annapolis workshop, however, there was less enthusiasm for carrying out a South Atlantic line (akin to the RAPID array) compared to focusing resources on the North Atlantic, particularly the Subpolar gyre.

WAVES (southWestern Atlantic climate Variability Experiment) has been proposed to study ocean-atmosphere-land coupled phenomena associated with western S. Atlantic/ South American climate variability. A white paper was produced by Paulo Nobre in August 2008 and submitted to the Brazil Ministry of Science and Technology (MCT). It has also been put forward to an international alliance among Brazil, Uruguay, and Argentina, as the basis

1 *http://www.pmel.noaa.gov/pirata*
2 *http://tace.ifm-geomar.de/index.html*
3 *http://amma-international.org/index*

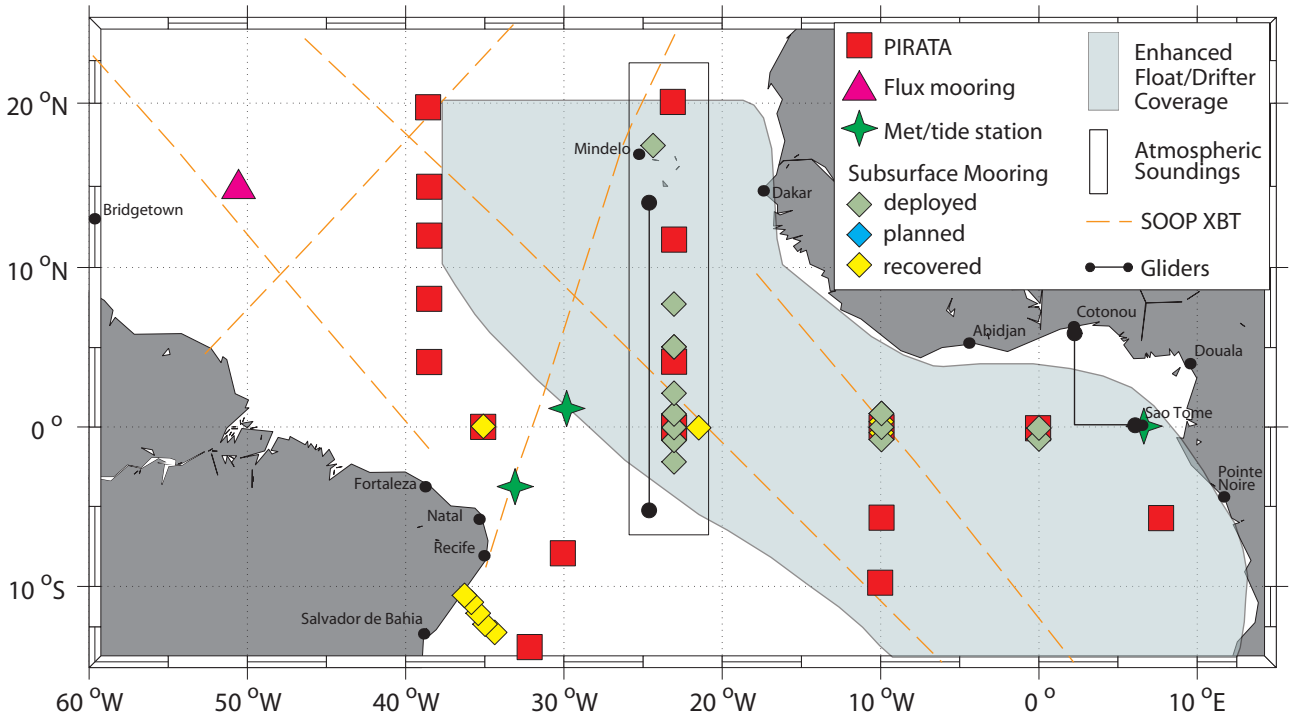

Figure: The TACE observing system and PIRATA array.

for a programme named OCEATLAN. Decisions on these proposals are pending.

4. Atlantic Ocean observations and links to synthesis and modelling

AIP reviews the Atlantic observing network of profiling floats, XBT lines, repeat hydrography/carbon surveys, surface drifters, surface and subsurface moorings, identifies gaps and makes recommendations to fill them working with the Ocean Observations Panel for Climate (OOPC) in particular. It also continues to promote and receive progress reports on process studies such as CLIMODE (the Subtropical Mode Water experiment) which is now in its data synthesis phase. Several white papers for the OceanObs'09 Symposium (Venice, 21-25 September 2009) have been promoted by AIP.

In the eastern tropical Atlantic, TACE (Germany, France and the US) and the PIRATA South East extension (S. Africa) have helped to address the sparsity of surface and subsurface measurements in the eastern South Atlantic (see figure), but large gaps in the distribution of floats, drifters and surface moorings still exist. A second ATLAS mooring for the SE extension is sorely needed to maintain continuous observations. Developing the South Atlantic observing system remains a challenge.

For the future, AIP members will work with CLIVAR's Global Synthesis and Observations Panel and the CLIVAR Working Group on Ocean Model Development to motivate collaborations between observational and synthesis groups. A list of Atlantic climate indices and of members to lead evaluation efforts has been developed.

Finally the panel continues to maintain its links with the Arctic Sub-arctic Ocean Flux Study (ASOF). ASOF 2, which is under the leadership of Tom Haine and Bogi Hansen, is being organized to undertake synthesis of the flux measurements acquired in its observational phase (from 2002-2008). A meeting of the ASOF SSG was held in Halifax, Nova Scotia, Canada (Nov 2008) to construct a science plan, which will be ratified in Fall 2009. Ruth Curry is liaison to this group.

5. Future activities

Future activities being organized by AIP include:

- A workshop on Earth System Initialization for Decadal Predictions: 4-6 November 2009, Utrecht, the Netherlands
- A South Atlantic Meridional Overturning Circulation (SAMOC) second meeting: Paris, 2 - 3 July 2009.

Indian Ocean Panel Activity Report

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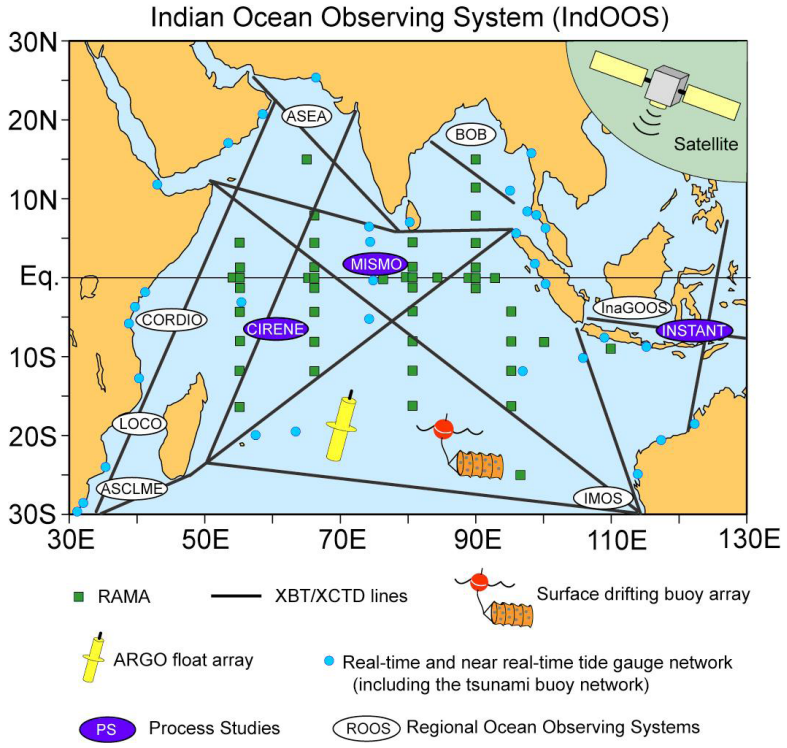
The Indian Ocean Panel (IOP) was established in 2004, and has met on five occasions: February 2004 (Joint with AAMP) in Pune India, March 2005 in Hobart Australia, February 2006 in Honolulu USA, April 2007 in Pretoria South Africa, and May 2008 in Bali Indonesia. The Panel is coordinating implementation of the Indian Ocean Observing System (IndOOS) and research activities using data from IndOOS and modeling outputs. The Panel's activities (e.g. meetings) are supported jointly by IOC-Perth Office and WCRP, a cost-sharing arrangement that is expected to continue. IOP is the science sub-group of the Indian Ocean GOOS Regional Alliance. IOP in collaboration with Alliance-partners is developing regional applications of research and re-analysis products.

1. The Indian Ocean Observing System (IndOOS)

IOP contributes to various aspects of CLIVAR, including its foci on tropical variability, monsoons, decadal variability and the role of ocean in climate. It works to facilitate building the ocean observing capability in the tropical Indian Ocean and to stimulate related data and model based studies. IOP has developed the Implementation Plan for IndOOS (downloadable from http://eprints.soton.ac.uk/20357/.) and is coordinating its implementation. IndOOS is being developed in response to the urgent data requirements of science and society more widely. It is a multi-platform long-term observing system, which consists of Argo floats, surface drifting buoys, tide gauges, mooring array, VOS based XBT/XCTD lines and satellite measurements as a backbone observation network for sea surface conditions (see figure). Its critical component, the Research moored Array for African-Asian-Australian Monsoon Analysis and prediction (RAMA), which is the Indian Ocean counterpart to the TAO/TRITON array in Pacific and PIRATA in Atlantic, is planned for a target deployment of 46 moorings. As of March 2009, 22 mooring sites of the 46 planned locations have already been occupied (47%) for RAMA, with equipment and/or ship time contributions from US, Japan, India, China, Indonesia, France as well as from regional activities such as the Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project. An additional ten moorings are expected to be deployed in 2009 and hence the implementation will soon be close to 70% of the full array. An IndOOS Data Portal site has been set up at http://www.incois.gov.in/Incois/iogoos/home_indoos.jsp/. All the available in situ observation data for IndOOS are listed with the link to data providers. During the last IO-GOOS meeting in December, 2008, the establishment of IndOOS Resources Forum (IRF) was adopted. IRF is an essential activity to secure the ship-time and other resources for IndOOS, and the detailed structure and roles of IRF will be discussed in the IOP 6th meeting, which will be held in June 3-5, 2009.

2. Applications of IndOOS data to research

IOP seeks to strengthen the cooperation with the Indian Ocean regional observing systems, which provides the channels for applications of IndOOS data. With the rapid progress of IndOOS, new data available has helped to improve our understanding of various phenomena of climate importance, such as the ocean dynamics associated with Indian Ocean Dipole, ENSO influences on the Indian Ocean, dynamics of the equatorial currents at intra-seasonal, semi-annual and annual time scales, upper ocean response (SST and mixed layer depth) to MJO and cyclone forcing and its potential feedbacks. More detailed information and a full list of publications can be found on the IndOOS bibliography site



at http://www.clivar.org/organization/indian/IndOOS/biblio.php. The observations and research coordinated by IOP significantly contribute to the WCRP's cross cutting topics, especially those on the monsoon and seasonal to decadal predictions. The data stream from IndOOS will be vital for monsoon research and prediction, particularly from the view point of monsoon-ocean interaction. With the aid of IndOOS data and deeper understanding of the monsoon dynamics, seasonal prediction skill in the African-Asian-Australian monsoon region will be improved. IOP is seeking to apply IndOOS data for drought prediction, which is one of the hot topics in the IOP 6th meeting. There is a need to strengthen links to CLIVAR's African and Asian-Australian monsoon activities, and the panel acknowledges the efforts of CLIVAR's Variability of the African Climate System Panel to facilitate deployment of moorings through ASCLME. The panel has also proposed simple indices to describe Indian Ocean variability to CLIVAR's Global Synthesis and Observations Panel. A Community White Paper on the Indian Ocean observing system has been submitted to OceanObs'09. Several other papers have been submitted as Additional Contribution papers.

3. Links to biogeochemical and ecosystem research

IOP has also developed strong linkage with the Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER) project, which is a regional program under IGBP IMBER. Experts from the SIBER project have participated in IOP meetings. IOP and SIBER have sent representative members to each other's meetings to enhance the collaboration. They will cooperate to implement both the physical and biogeochemical components of the IndOOS infrastructure.

4. Indian Ocean field studies

IOP, together with Asian-Australian Monsoon Panel has endorsed the Thermocline Ridge of the Indian Ocean (TRIO) project, initiated by the French ocean community. TRIO will explore air-sea interactions at synoptic (cyclones and tropical storms), intra-seasonal (Madden-Julian Oscillation) and inter-annual timescales in the 5°S-15°S band of the Indian Ocean. TRIO focuses initially on modelling studies and analysis of existing data, and then will conduct research cruises in late 2010 or early 2011. This will also help the implementation and maintenance of RAMA. In conjunction with TRIO, CINDY2011 (Cooperative Indian Ocean Experiment on intraseasonal variability in the year 2011) and DYNAMO (Dynamics of the MJO, the US contribution to CINDY), are also planned to take place in 2011 by leading scientists in Japan and the US, respectively. IOP maintains oversight of such field programs from both a scientific and logistical point of view.

Pacific Panel Activity Report

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The Panel has engaged in a wide variety of activities over the past 18 months relating to seasonal to decadal prediction, sea level rise, anthropogenic climate change and monsoons. It is also pursuing a number of new activities.

1. Seasonal to decadal prediction

Seasonal to decadal prediction lies at the heart of the panel's activities. Thus in November 2007, the panel organized a workshop on "Western Tropical Pacific: Hatchery for El Niño - Southern Oscillation (ENSO) and Global Teleconnections" held in Guangzhou, China, in association with its 4th session. Co-sponsored by WCRP, IGBP PAGES and IPRC, it also organized a two-week summer school held on the Big Island, Hawaii in July 2008 on "ENSO: dynamics and predictability" which centred on training students in ENSO theory, numerical modeling and seasonal prediction techniques. A further workshop (Section 3 below) looked to the issue of ENSO in relation to climate change. Members of the panel have also contributed to two white papers on "Decadal Climate Prediction: Challenges and Opportunities" and "Ocean Initialization for Seasonal Forecasts" for the OceanObs'09 Symposium (Venice, 21-25 September 2009) and were involved in a proposal submitted to the US National Science Foundation NSF for a new Science and Technology Center on "Decadal Regional Climate predictions". An ENSO metrics project, supported by the panel compiled extensive list of useful indices and diagnostics to evaluate seasonal climate prediction models. The panel is also maintaining a website[1] that allows easy access to recent seasonal predictions whilst a joint Pacific Panel review paper on ENSO-MJO interactions is in preparation. Additionally, panel member Rodney Martinez has written a report on the CLIVAR Pacific Panel deliverables benefiting climate applications and services. The panel is currently cooperating with the North Pacific Marine Science Organization (PICES) in organizing its workshop on "Exploring the predictability and mechanisms of Pacific low frequency variability beyond inter-annual time scales", part of the PICES annual meeting to be held in Korea on 23 Oct - 1 Nov 2009. The panel maintains contact with IGBP's Integrated Marine Biochemistry and Ecosystem Research (IMBER) project, through its panel member Dick Feely

1 http://www.clivar.org/organization/pacific/pacific_ENSOforecasts.php

2. Sea level

A panel member (Bo Qiu) led a recent study on the decadal predictability of sea-level anomalies in the North Pacific. This showed that a reasonable skill can be obtained for lead times of up to 8 years in the Kuroshio Extension region. The panel helped to disseminate these results, which have potential relevance to predictions for Pacific Island nations, during conferences and workshops on climate predictability.

3. Anthropogenic climate change

Two Pacific panel members (Wenju Cai and Scott Power) organized the WCRP/CLIVAR workshop "ENSO and climate change" in conjunction with the Greenhouse 2009 conference in Perth Australia, 23 - 26 March 2009. A joint paper assessing the current status of our understanding of ENSO and climate change is in preparation.

4. Southwest Pacific region and the South Pacific Convergence Zone

The panel is currently spearheading new activities to improve understanding of the South Pacific Convergence Zone (SPCZ). Among these activities is a planned international workshop on the SPCZ for 2010 on one of the South Pacific Islands. The panel is strongly involved in the CLIVAR-endorsed Southwest Pacific ocean Circulation and Climate Experiment (SPICE) which itself includes an SPCZ component.

Panel members were also heavily involved in the planning of the Australian government sponsored Pacific Climate Change Science Program (PCCSP) initiative. This is a funded $20 million science program to help Australia's neighboring island countries gain a better understanding of how climate change will impact the region. Working with partner countries, the PCCSP will track recent and current climate trends, investigate regional climate drivers (such as the South Pacific Convergence Zone), provide regional climate projections, and improve understanding of ocean processes including acidification and sea level rise.

5. New activities being planned include

- Coordinated SPCZ analysis in observations, AMIP, CMIP3, CMIP5 runs and high resolution AGCMs (end 2010)
- Analysis of decadal prediction skill of PDO and NPGO in the ENSEMBLES dataset (end 2010)
- Elucidating the mechanisms that lead to an extension of the oxygen minimum zones in the Pacific with the prospect of a dedicated workshop
- Provide international platform for the scientific and logistical coordination of SPICE, the Northwest Pacific Ocean Circulation Experiment (NPOCE), OKMC, and Japanese activities in the low latitude Pacific western boundary currents (2010-2012)
- Elucidate the physics of enhanced greenhouse warming in high-end climate sensitivity models with focus on tropical Pacific (2010-2012)

And the following workshops:

- A workshop on "The South Pacific Convergence Zone: dynamics, impacts and future changes" to be held in the south-west Pacific, summer 2010
- An ENSO and applications workshop, combined with a panel meeting, Ecuador, 2010
- The International Symposium on Boundary Current Dynamics, Qing Dao, China, June 2010

The Pacific Panel

Southern Ocean Panel Activity Report

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The Panel was established in 2000 and has met on five occasions: the most recent meeting being in Sydney, Australia, in February 2009. The Panel is contributing to a regional implementation plan for sustained observations relevant to climate in the Southern Ocean, the SOOS (Figure 1). The success of the activity is reflected in increasing investment in the observing system from several countries. The Southern Ocean Panel is co-sponsored by the Scientific Committee on Antarctic Research, the Climate and Cryosphere Project (CliC) and the CLIVAR.

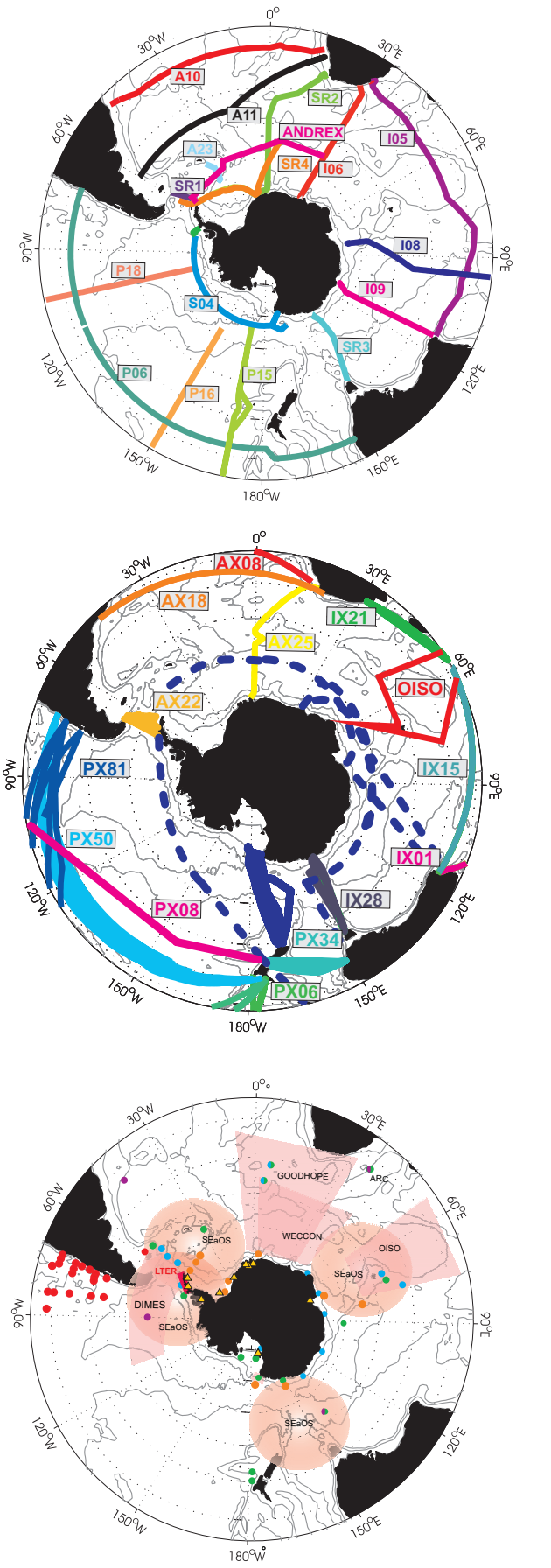
1. Anthropogenic Climate Change

The variability of the Southern Ocean at various time scales has been documented from observations of hydrography, sea-surface height, and direct measurements of currents. The Argo network coupled with elephant seal data has dramatically increased the total, and importantly, the seasonal hydrographic coverage in the upper 2000m of the water column and has helped to provide evidence for significant warming and freshening. Bottom water variations have been observed as well and point to large-scale warming, possibly linked to changes in the subpolar westerlies, the Antarctic cryosophere, and/or large-scale heat and freshwater fluxes.

A much better understanding of the formation, subduction, circulation, and variability of Subantarctic Mode Water and Antarctic Intermediate Water has grown over recent years, and in particular the greater role that eddies play in the evolution of mode water has emerged. Analyses of IPCC AR4 models suggest that observed changes in mode and intermediate water properties are broadly consistent with a "fingerprint" of anthropogenic climate change. IPCC models suggest mode and intermediate waters migrate to lighter densities with climate change, but the range between models remains very large.

2. Atmospheric Chemistry and Climate

The Southern Ocean has been shown to contain large amounts of anthropogenic CO2 and the question of the future of this carbon sink is being debated. Air-sea CO2 fluxes may decrease in years to come as the surface ocean warms and if the Southern Annular Mode (SAM) trends continue, the latter driving enhanced upwelling of the ocean store of natural carbon. This saturation of the carbon sink is a topic of current debate. A related matter is the rising acidity levels and the susceptibility of certain regions to species decline resulting from the dissolution of carbonate skeletal material. Some polar regions, e.g. the Ross Sea, may be the first to suffer ecosystem stress from ocean acidification.



Elements of the Southern Ocean Observing system: top -repeat hydrographic sections, centre - ship-of-opportunity lines in the Southern Ocean, bottom - other multi-year observations.

3. Southern Ocean Processes

There has been progress in describing the patterns of interannual variability of sea ice cover and the impact of the changes in atmospheric circulation (related to SAM and ENSO in particular) on the ice-ocean system.

CliC and the CLIVAR Southern Ocean Panel will pursue joint work on the Southern Ocean freshwater balance. CliC would contribute the cryospheric elements with the aim of jointly producing an assessment document with error bars. The Southern Ocean panel would contribute the ocean hydrographic elements and the two groups would work together to resolve and understand the fluxes at the boundaries.

We also now have an improved understanding of the interaction of the oceanic mesoscale with bottom topography (and subsequent loss of geostrophic balance) and the implication for a significant physical coupling between the upper and lower cells of the Southern Ocean overturning. The mixing and fluxes operating in these cells are the subject of a CLIVAR process study called DIMES (Diapycnal and Isopycnal Mixing in the Southern Ocean).

4. Sea Level Rise

Recent remote sensing provides the first realistic assessments that melting of the Greenland Ice Sheet and the Antarctic Ice Sheet are contributing to sea level rise. Sea level rise from 1993-2006 is close to the upper limit of the IPCC AR4 assessments. IPCC projections do not explicitly account for ice sheet dynamic changes. Better ice sheet models are required. Ice sheet instability could markedly increase sea level rise beyond the IPCC projections. With only slight additional warming, the Greenland Ice Sheet surface melt could increase more rapidly than precipitation and thereby lead to irrevocable decay of the ice sheet over a few hundred to one thousand years. The scenario of the most rapid rate of melt only occurs if dynamic instability is taken into account.

Errors in the ice sheet mass budget estimates are still large – they are set to improve if existing satellite systems are maintained. In addition, the processes of enhanced land-ice discharge are not well understood. Ice sheet models need development, improved physics and testing. As a result, projections of future sea level rise remain highly uncertain. In the IPCC AR4 report the major source of sealevel uncertainty is dynamic change to the ice sheets.

5. The Southern Ocean Observing system (SOOS)

The panel is committed to the development and implementation of the SOOS. Only ten years ago the total sum of the observable data from the Southern Ocean was extremely limited. We have progressed in the last decade to a point where we can realistically test the models with observations. However, we are still not able to quantify the eddy saturation limit for the Southern Ocean or answer certain fundamental carbon uptake questions for the region. Nonetheless, we have greater confidence in our estimates of baroclinic transport rates, ocean overturning and large-scale hydrography.

By connecting the ocean basins and the upper and lower limbs of the ocean overturning circulation, the Southern Ocean plays a critical role in the global ocean circulation, biogeochemical cycles and climate. Feedbacks involving

ocean circulation, sea ice, ice shelves and the carbon cycle have the potential to significantly affect the rate of future climate change and sea-level rise, but remain poorly understood. Limited observations suggest the Southern Ocean is changing: the region is warming more rapidly than the global ocean average; salinity changes driven by changes in precipitation and ice melt have been observed in both the upper and abyssal ocean; the uptake of carbon by the Southern Ocean has slowed the rate of climate change but increased the acidity of the Southern Ocean, while the ability of the region to continue to absorb CO_2 is a topic of active debate; and there are suggestions of ecosystem changes. However, the short and incomplete nature of existing time series means that the causes and consequences of observed changes are difficult to quantify. Sustained, multi-disciplinary observations are required to detect, interpret and respond to change. Advances in technology and understanding mean that it is now feasible to design and implement a Southern Ocean Observing System (SOOS) to meet this need. SOOS will provide the long-term measurements required to improve our understanding of climate change and variability, biogeochemical cycles and the coupling between climate and marine ecosytems. A community white paper detailing the rationale and strategy for a SOOS has been submitted to OceanObs'09 (Venice, 21-25 September 2009), led by a SCAR expert group but with involvement from the panel.

The panel has recommended that the community should engage a synthesis of observations collected during the 20th century in the Southern Ocean, beginning with physical parameters but extending to ecosystems. Surface temperature (ocean and land), deep-water characteristics, carbon content, and sea ice extent are a priority. Innovative methods should be designed to combine observations and model results to be able to better estimate the magnitude and variability of the changes over the 20th century and understand their causes. This will in part be achieved through the Southern Ocean State Estimate (SOSE) project. Atmospheric counterparts or reanalyses with an Antarctic and Southern Ocean focus are needed as well, eventually merging the cryosphere, the atmosphere, and ocean fluxes.

Asian–Australian Monsoon Panel (AAMP) Activity Report

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The 9th Session of the CLIVAR's Asian-Australian Monsoon Panel (AMMP9) was held at the China Meteorological Administration (CMA), Beijing, China from 22-25 October 2008. AAMP9 was held jointly with the WMO International Workshop on Monsoons IWM4, the Fifth Asian Monsoon Years (AMY 2007-2012) International Workshop and the 2nd Pan-WCRP Workshop (the first such was a 3-day meeting held in Irvine, California in June 2005). This was a unique opportunity to bring together scientists with a CLIVAR focus and forecasters with a World Weather Research Programme (WWRP) focus (operational forecasting and application researchers). The AAMP was actively involved in the 2nd Pan-WCRP Workshop, and participated in the discussion on cross cutting activities and in the development of the proposed joint activities. The panel plays a leading role in the coordination of AMY in general and the modelling activity under AMY in particular. Bing Wang (former AAMP co-chair) is currently the co-chair of the AMY Science Plan, and Harry Hendon is co-chair of the AMY modeling group. It is anticipated that a first AMY modeling workshop will be held in conjunction with the next AAMP meeting.

1. Modelling of the MJO

The Madden-Julian Oscillation (MJO) plays a key role in monsoon variability but is not well simulated or predicted. Only recently has there been a realistic simulation of the boreal summer ISO, including the simulation of the tilted convection, as seen in Figure 1. The MJO is therefore providing an increasing focus for the panel, which agreed at the Pan-WCRP Workshop to help formulate and refine the development of a WCRP/WWRP Project on Simulation and Prediction of the Monsoon Intra-Seasonal Oscillation (MISO), as proposed by Tetsuso Yasunari. This activity would be complimentary to a numerical prediction experiment for the MISO/MJO currently being facilitated by AAMP and endorsed and supported by the APEC Climate Center (APCC), CLIVAR/AAMP, the Scientific Steering Committee of AMY 2007-2012, the WCRP/International Monsoon Study (IMS), WWRP THORPEX (The Observing System Research and Predictability Experiment), and the Working Group on Numerical Experimentation (WGNE). The work plan was developed by APCC's Climate Prediction and Application to Society (CliPAS) activity and the US CLIVAR MJO Working Group, both of which include members of AAMP. The scientific objectives are to determine potential and practical predictability of ISO in a multi-model experiment (MME), reveal new physical mechanisms associated with intraseasonal variability that cannot be obtained from analysis of a single model, determine the ISO's modulation of extreme hydrological events, and better understand the interannual variability of the ISO and its contribution to interannual climate variation. Requests to centres to contribute hindcasts and long control runs have been circulated with a May 2009 deadline for participation commitment, and December 2009 for data submission.

2. MJO Task Force

The AAMP is also actively promoting the formation of the MJO Task Force. The Task Force is a follow-on to the US CLIVAR MJO Working Group and will cross-cut many WCRP and WWRP efforts, including CLIVAR AAMP and the CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP), the GEWEX Modeling and Prediction Panel, and THORPEX. It will also be relevant to the scientific goals of programs such as the Year of Tropical Convection (YOTC), AMY, CASCADE (a project on scale interactions in the tropical atmosphere), and CMMAP (the Center for Multiscale Modelling of Atmospheric Proceses). The Task Force would:

(1) Further develop process oriented metrics/diagnostics

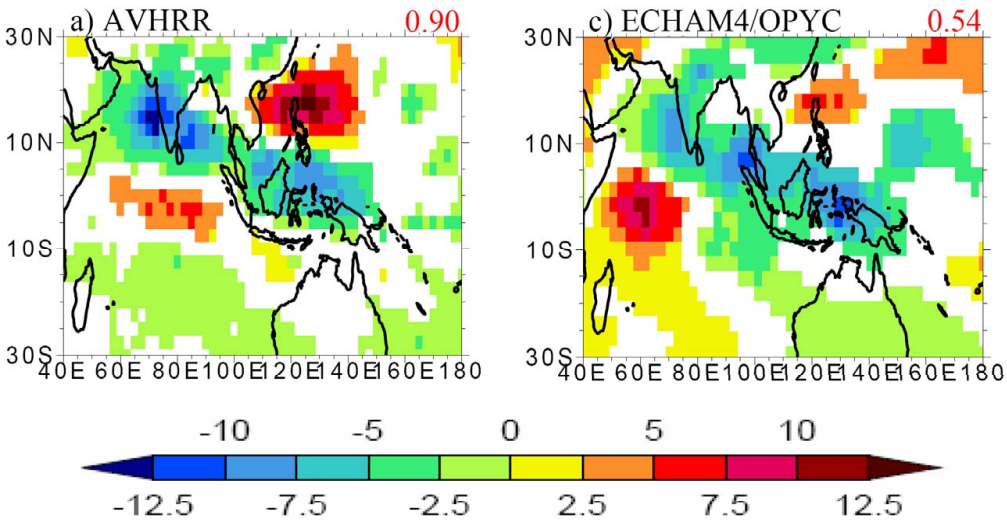

Figure 1. As part of the observed life cycle of the boreal summer ISO, the ECHAM4/OPYC model successfully represents the enhanced convection (Wm^{-2}) associated with the tilted rainband (Sperber and Annamalai, Clim. Dynam, 31, 345-372, 2008).

to better understand the physical mechanisms necessary to facilitate model improvement to simulate and forecast the MJO.

(2) Facilitate and promote the analysis of multi-scale interactions of convectively coupled waves with emphasis on the vertical structure and diabatic heating using high resolution modeling frameworks and the best available satellite data.

(3) Promote the ongoing evaluation of real-time MJO forecasts (endorsed by WGNE).

(4) Expand efforts to develop and implement MJO forecast metrics under operational conditions, including boreal summer focus and multi-model ensemble development.

(5) Develop experiments for assessing MJO predictability and improving forecast skill of the MJO and closely related phenomena from contemporary/operational models.

The proposal for this Task Force is currently (May 2009) under consideration by WCRP and WWRP.

3. MJO field studies

Together with CLIVAR's Indian Ocean Panel, AAMP is supporting the development of the science plan for two field experiments in the equatorial Indian Ocean that focus on the initiation and dynamics of the MJO: CINDY/DYNAMO (late 2011-2012; Yoneyama/Zhang) and TRIO (Late 2010 early 2011; Vialard/Duvel) – see the Indian Ocean Panel activity report (this issue) for definitions of these acronymns. The goal of these experiments is to enhance understanding of the interaction of convection, large-scale circulation and the ocean.

4. Workshop on Monsoon Intra-seasonal Variability (ISV)

AAMP is developing plans for a joint AMY/AAMP/MJO Task force workshop in 2010 on monsoon intraseasonal variability. This cross-cutting activity will provide a framework for assessing historical MJO predictability from hindcast experiments, the skill of real-time forecasts, and report on recent advancements for simulation of monsoon ISV and the MJO, including results from high resolution global models such as the NICAM that runs on the Earth Simulator. Case studies from Africa, Asia, and Australia demonstrating the use of MJO predictions for decision-making in agricultural systems will be sought. This will help to focus research priorities on issues of immediate relevance for decision making. AAMP have suggested the idea of a model simulation/prediction study to assess the role/impact of land surface processes for monsoon predictability to WGSIP, perhaps as a sub project in GLACE-2. Such analysis/experimentation could be reported at the proposed Workshop.

Variability of the American Monsoon System (VAMOS) Panel Activity Report

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VAMOS implementation includes 3 science components: North American Monsoon Experiment (NAME), Monsoon Experiment South America (MESA) and the VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS). In addition, CLIVAR/VAMOS and the GEWEX Global Hydrology Programme have identified and endorsed the La Plata Basin (LPB) as a climate-hydrology system with components that are potentially predictable and whose variability has important impacts on human activities. Within this structure, VAMOS has a number of focused activities, summarised below, relevant to the WCRP cross cutting topics. Based on an extensive contribution from the VAMOS Modelling Community a particular activity has been to develop, in collaboration with CLIVAR's Working Group on Seasonal to Interannual Prediction, an overall plan[1] on VAMOS Modelling and Data Assimilation for Improved Prediction.

In addition, the Intra-American Seas CLImate Program (IASCLIP) has been proposed to become a new science component of VAMOS for which endorsement by CLIVAR SSG has been requested. At the same time NAME is due to formally 'sunset' as a program in the 2009-2010 timeframe.

1. Seasonal prediction

NAME continues to focus on assessing the performance of dynamical models and other 'consolidated' seasonal forecasts. The two main efforts in this area are the NAME Forecast Forum[2], which was initiated in 2008, and the NAME seasonal forecast page (http://iri.columbia.edu/climate/forecast/NAME/) hosted by IRI. The NAME Forecast Forum focuses on collecting and assessing seasonal forecasts for the NAME region from dynamical models run at leading modelling centres. During 2008, NCEP/CPC, NASA/GISS and Scripps contributed forecasts to the Forum. This effort, and that of IRI, is expected to continue into the foreseeable future. In addition the La Plata Basin (LPB) Regional Hydroclimate Project website (www.eol.ucar.edu/projects/lpb/) contains links to Real-Time Monitoring and Prediction products for the region from different centres (INPE/CPTEC, NOAA/NCEP, University of Sao Paulo, and Argentine National Met Service).

Building on the large body of NAME physical science research, several applications or 'stakeholder outreach' projects have been initiated. Most of the projects underway seek to transfer the increased understanding of the skill and limits of skill of seasonal forecast products to various regional stakeholder groups in both the U.S. and Mexico. In this manner, NAME research is contributing to a better understanding of the regional hydroclimatology and the vulnerability of regional water resources and ecosystem services.

1 See: www.clivar.org/organization/vamos/Publications/Vamos_Modeling_Plan_Jun08.pdf

2 See: www.cpc.ncep.noaa.gov/products/Global_Monsoons/American_Monsoons/NAME/index.shtml

2. Monsoon processes

The NAME research program has been built upon a substantial number of process studies centred on an intensive field campaign during the summer of 2004. Since then numerous datasets, articles, and special issues have been produced. The most recent special issue (now under review in the J. of Arid Environments) focuses on land surface-atmosphere exchanges and eco-hydrological processes in the North American Monsoon region.

A second phase of the NAME Model Assessment Program (NAMAP-II) is also nearing completion and a journal article is now under review within the J. of Climate. Several new research projects are also focusing on the linkage between SST variability in the E. Pacific and Intra-America Seas region and the climate of southern North America. This work represents (is) a transition from the NAME research programme to the newly developing Intra-America Seas Climate Process study (IASCLIP). Lastly, NAME investigators are evaluating the impacts of the several modes of variability, such as the MJO, on monsoon precipitation.

MESA[3] activities include further analyses of the data collected during the South American Low level Jet field campaign of 2003 (SALLJEX); science papers using these data continue to be published regularly. In addition, science activities on data assimilation are underway, an activity reinforced at INPE/CPTEC by the use of the data collected during SALLJEX. Studies on extremes in the South American Monsoon area are also being developed (see below). In addition, and as a component of MESA, INPE have started work to examine anthropogenic influences on the South American Monsoon under various climate change scenarios (see below also), and (in collaboration with IGBP PAGES) paleoclimatic simulations during the Holocene and the last glacial maximum. Other collaborative efforts under MESA include:

- Cooperation with the Global Water System Project on hydrological studies in the Amazon and La Plata regions, directed toward assessments of environmental flows and ecosystem services
- Cooperation with the European Union (EU) via the CLARIS-LPB project (see the article on page 39) for studies on climate variability and change and applications to water resources, human health and agriculture in the La Plata Basin.
- Cooperation with the National Institute for Climate Change (INCT) in Brazil, funded by the Brazilian Research Council CNPq, for studies on applications of climate change for vulnerability assessments in Brazil, including the region of the South American Monsoon System (SAMS).
- Continued cooperation with the LBA (Large Scale in the Biosphere Atmosphere Experiment in the Amazon Basin)

3 The MESA Science and Implementation Plan has been updated and can be found at: www.clivar.org/organization/vamos/Publications/MESA_ImplementationPlan_April_2009.doc

on physical climate hydrological studies and the role of aerosols in Amazon-monsoon precipitation dynamics.

3. Anthropogenic Climate Change

There is presently little consensus on the variability and expected change in character of the warm-season precipitation regime under climate change scenarios. However several recent studies of the occurrence and trends in extreme precipitation events in the N. and S. American monsoon regions suggest that the largest events are becoming more intense, while not necessarily growing in frequency. Many of these events have been tied to land-falling tropical systems in the North American Monsoon region or to Amazon and Subtropical influence in the SAMS region.

Under MESA, new projects on climate change and the SAMS are focusing on the impacts of climate change on extremes, hydroelectric generation, agriculture and human health. In addition, capacity building activities in MESA (linked to LBA and climate change projects in Brazil) are aimed at studies on climate change, detection, attribution, impacts, vulnerability and adaptation measures in SAMS.

Following a recommendation of the 11th session of the VAMOS panel a small Task Force has prepared a white paper[4] to very briefly summarize the current status of the ACC related research along the Americas, identifying the most relevant scientific questions that need to be addressed.

4. Extremes, including drought

At the individual PI level, numerous investigators are investigating the process of long-term drought and potential climate change. Recent studies on tree-ring reconstructions from the U.S. and Mexico as well as climate model scenarios of future climate change have highlighted a pronounced vulnerability of southwestern North America to extended periods of cool-season drought. Studies on extremes have also been performed in the SAMS region, especially on extreme rainfall and dry spells, as well as on seasonal droughts and floods, such as the drought of Amazonia in 2005 and the floods of Amazonia in 2009. In the SAMS region many studies on climate trends have been hampered by the lack of climatic time series with sufficient length and quality to identify trends, especially in the tropical region.

A Task Force on Extremes established in the 11th VAMOS panel meeting has prepared a white paper[5] on guidelines for how the VAMOS community will approach the study of extreme events.

5. Ocean-atmosphere-land interactions in the Southeastern Pacific

The VOCALS program is a component of VAMOS focused on the southeastern Pacific (SEP) climate on diurnal to interannual timescales. The SEP is a region dominated by strong coastal upwelling, extensive cold SSTs, and home to the largest and most poorly-observed subtropical stratocumulus deck on Earth. VOCALS develops and promotes scientific activities leading to achievement of two major objectives in the SEP: 1) elimination of CGCM systematic errors in the region and improved model simulations of the coupled system in the region and the global impacts of its variability, and 2) improved understanding and regional/global model representation of aerosol indirect effects over the region.

The operational phase of the VOCALS Regional Experiment (VOCALS-REx) was completed during October and November 2008. During that period approximately 150 scientists from 40 institutions in 8 nations worked from Chile and Peru. A total of five aircraft - including the NSF C-130, the DoE G-1, the CIRPAS Twin Otter, and two aircraft from the UK- and two research vessels (the NOAA Ronald H Brown and the Peruvian IMARPE José Olaya) sampled the lower atmosphere and upper-ocean. Specific targets were the processes controlling the optical and structural properties of stratocumulus clouds including continental aerosols from smelters and volcanoes, processes controlling the ocean transport of cold, fresh water offshore, and the chemical and physical interactions between the lower atmosphere and upper-ocean. VOCALS-REx gathered unique, multidisciplinary datasets for studies on the physical and chemical couplings between different components of a regional climate system.

The project's webpage (www.eol.ucar.edu/projects/vocals) provides comprehensive information on related activities. GEWEX is co-sponsor of VOCALS. Other connections include the CLIVAR Pacific Panel, SOLAS, and US CLIVAR. As well as in the US, there are national VOCALS programs in Chile, Peru and the UK.

6. Activities being planned, including timeline

The NAME research program is coordinating various legacy data products and projects. Principally, this effort involves a complete synthesis of the contribution of NAME research to the understanding of the North American Monsoon system and the challenges that remain in order to improve seasonal predictions thereof. A preliminary synthesis of NAME research was presented at the recent WMO Monsoon Workshop in Beijing, in Oct. 2008. This effort will be expanded in coming months and contributions will be sought for a special issue of a journal or a unified review paper. A final NAME meeting will be held towards the end of 2009 or early 2010 to formally close the programme

The VOCALS community will be busy during 2009 and 2010 on the analysis of datasets collected during the field campaign, and the modelling of the South Eastern Tropical Pacific.

A workshop, before the PAGES Open Science Meeting (early July 2009 at Oregon State University in Corvallis, USA) will concentrate on sub-orbital variations of the global monsoon, including SAMS. The Paleo monsoon PAGES meeting will take place in Shanghai in 2010.

Modelling activities in VAMOS, including activities related to regional assessment of predictability and variability in global model outputs, in collaboration with CLARIS LPB and WGSIP, will be ongoing in 2009 and beyond.

4 See: http://www.clivar.org/organization/vamos/Publications/VAMOS_ACC_12Nov2008.pdf

5 See: www.clivar.org/organization/vamos/Publications/vamos_extremes_21jul08.pdf

Variability of the African Climate System (VACS) Activity Report

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VACS has a number of key initiatives including development of an African Climate Atlas, stimulating African contributions to the Indian Ocean moored buoy array, and the Horn of Africa Regional Climate Model Intercomparison Project, progress with each of which is outlined below together with a number of wider VACS collaborative activities.

1. VACS African Climate Atlas

The VACS African Climate Atlas based at Oxford, UK, has a focus on the observed and modelled climate of Africa. The Atlas currently has seven parts as follows:

Part I - Climatology
Part II - Anomalies
Part III - TOMS Absorbing Aerosol Index (interactive visualization)
Part IV - ERA40 Pressure Level Climatologies & Composites
Part V - WCRP CMIP3 multi-model archive Analysis
Part VI – FAQs on African Climate
Part VII – Climate change extremes and thresholds

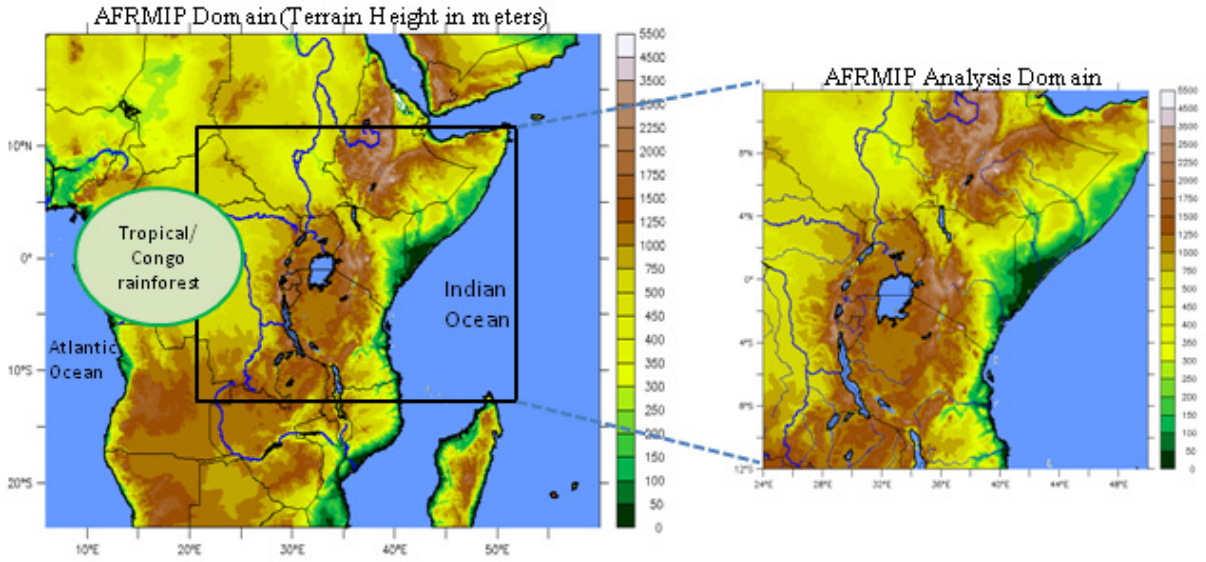
Parts I and II are on the observed climatology over Africa and surrounding tropics. Variables include minimum temperature, maximum temperature, diurnal temperature range, water vapour and cloud cover. Part III deals with mineral aerosols from satellite observations. Part IV features components of the ERA40 Reanalysis Project and Part V the WCRP Climate Model Intercomparison Project-3 (CMIP3) multi-model climate change data archive. Part VI (FAQs on African Climate) is in draft form and Part VII, on climate change extremes and thresholds, has already been widely tested.

2. African contributions to the Indian Ocean moored array

Africa through the ASCLME Project, the University of Cape Town and Rhodes University have made a major contribution to the Indian Ocean Observing System Research moored array for African-Asian-Australian Monsoon Analysis and prediction (RAMA) that is coordinated by the GOOS/CLIVAR Indian Ocean Panel. In 2008, 2 ATLAS moorings were deployed as well as several Argo floats on the ASCLME cruises in the western Indian Ocean and a commitment has been made to sustain this activity during the boreal summer 2009 cruises. This should continue to 2011 or maybe 2012 although Somali piracy has meant that the vessel used by the ASCLME (Nansen) is not permitted to work north of 10°S (20°S in the case of US research vessels). ASCLME is the Agulhas and Somali Current Large Marine Ecosystem project involving 8 eastern African countries from Somali south to South Africa. It has its HQ at Rhodes University in Grahamstown, South Africa.

3. The Horn of Africa Regional Climate Model Inter-comparison Project (AFRMIP)

AFRMIP's priority is to contribute to the broader goals of CLIVAR-VACS. Therefore, the activities of the project are designed to specifically address, through numerical modelling, some of the outstanding science questions on the physical and dynamical processes associated with Greater Horn of Africa (GHA) climate variability and predictability across space and time scales. The motivation behind the AFRMIP project is to undertake comprehensive evaluation and investigation of the deficiencies and uncertainties in regional model simulations of the GHA climate through model inter-comparison. Hence, the specific objectives of AFRMIP can be summarized as, (i) Develop reasonably objective criteria for modifying and improving the parameterizations of various physical processes (e.g convection, radiation, boundary layer, etc) as would be appropriate for improving the performance (skill) of RCMs over the GHA sub-region, (ii) Develop a regional seasonal climate dynamical prediction system for the GHA, and (iii) Generate high-resolution regional climate change scenarios



AFRMIP computing domain (left) and analysis domain (right). Heights are in metres.

to assess the impacts on regional hydro-climatic conditions.

AFRMIP is being coordinated by Dr. Richard Anyah (University of Connecticut, USA) and several well known international regional modelling groups are active participants in the project. The first AFRMIP workshop to plan the modelling activities was held at Rutgers University, USA on 27 and 28 March, 2008. The primary goal of this meeting was to bring together various regional climate modelling experts who had expressed an interest in volunteering part of their time and research resources to contribute toward AFRMIP activities. It was also deemed important to involve these experts right at the start in order to agree the way forward in planning and undertaking all the activities of the Project.

Progress with AFRMIP so far was recently reported in an article published in CLIVAR Exchanges No.48 (http://eprints.soton.ac.uk/65635/01/Exch48.pdf). The regional modelling focus of the IPCC AR5 is on Africa and we anticipate that AFRMIP can make useful contributions to that effort in collaboration with WCRP's wider initiatives in this area of work through its Regional Climate Modelling Task Force. Presentations on AFRMIP were made at EGU, where VACS members also discussed some of the relevant regional modelling efforts in Africa with other modellers (especially Filippo Giorgi and Collin Jones), who are leading regional modelling activities for the next AR5 report.

4. Wider VACS collaborations and initiatives

These include:

- Ongoing relationships with the IGAD (Intergovernmental Authority on Development) Climate Prediction and Applications Centre (ICPAC) and the Drought Monitoring Centre-Gaberone, and provision of input to the regional climate outlook fora.
- Input to ASCLME activities in coastal eastern Africa and the western Indian Ocean.
- Input to climate change policy documents and white papers developed for the South African government Department of Science and Technology.
- Input to AMMA; several VACS members are on the organising committee for the upcoming AMMA conference (July 2009).
- Together with the Carnegie Regional Integration for Science and Education in Africa, organision of PhD training in Indian Ocean modelling/observations at the Universities of Cape Town and Eduardo Mondlane and the Institute of Marine Sciences, Zanzibar. This project will provide training for scientists from nine eastern African/western Indian Ocean countries.

5. Special issue of IJC

The International Journal of Climatology (IJC) has published a Special Issue on "African Climate and Applications" Volume 29, Issue 7, 2009. Available online at: http://www3.interscience.wiley.com/journal/122355158/issue. This issue arose out of a Young African Scientist's Day that was organised by VACS for the WCRP JSC held in Zanzibar in March 2007. About 15-20 young scientists attended from various southern and East African countries and presented their work in a poster session to the JSC. Some of this work was then written up for publication in the special issue of IJC.

6. Future activities

a.) As well as ongoing progress with the key activities outlined above, VACS feels it is very important to stimulate collaboration on the East African monsoon between VACS, the Indian Ocean Panel and GEWEX to move things forward in this important area. VACS has strong links with some of the local players in the region such as the Tanzania Met Agency, the Institute for Marine Sciences in Zanzibar, ICPAC, the Kenya Met Dept and others and so we can help to facilitate activity as well as foster capacity building in the region.

b.) In addition a Research and Training Workshop on Rainfall Onset in East and Southern Africa is proposed for late 2009/early 2010 at a location in Southern Africa.

The workshop is anticipated to involve the 11 VACS Panel members, up to 20 "trainees" and 5 training experts. It aims to:

- Share and progress scientific knowledge on the onset, retreat and related wet and dry spell characteristics of rainfall seasons across East and southern Africa, including their appropriate definition
- Use observed daily climate data to define rainfall onset, retreat, dry spell and wet spell dates for every season over the length of the observed rainfall record
- Establish statistics of rainfall onset and retreat (e.g. trends, variability) for each region and sub-region
- Set up an agreed methodology for determining the predictability on seasonal timescales of rainfall onset and retreat

Working Group on Seasonal to Interannual Prediction (WGSIP) activity report

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The participants of the 12th meeting of the WGSIP at Rosentiel School of Marine and Atmospheric Science (RSMAS), Miami, USA

The 12th Session of WGSIP was held on 12-14 January 2009, hosted by B. Kirtman at the University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS), Miami, USA. The meeting report can be downloaded from http://eprints.soton.ac.uk/65924/. The presentations given by the meeting participants, together with some additional pre-meeting reports, are available on the meeting webpage (http://www.clivar.org/organization/wgsip/wgsip12/wgsip12.php).

WGSIP welcomes A. Scaife as a new member representing the seasonal to decadal prediction activities of the UK Met Office Hadley Centre, as well as the SPARC and C20C projects. C. Saulo was also welcomed to WGSIP, though she was unable to attend the meeting. C. Saulo represents the seasonal prediction activities of CIMA, Argentina, as well as the VAMOS community.

The meeting focused on the major projects that are underway for which the panel is responsible, namely the Climate-system Historical Forecast Project (CHFP) and the decadal prediction component of CMIP5 (Coupled Model Intercomparison Experiment – 5). We heard about relevant activities from all the WCRP Projects: J. Christensen - CliC, R. Koster - GEWEX, A. Scaife - SPARC and this provided a fertile discussion on how to integrate the full climate system to seek improved skill at seasonal and longer timescales. There was discussion on the impact and requirements of the ocean observing system for seasonal prediction and on standard hindcast verification. Linkages with other projects and components of CLIVAR and WCRP were also explored.

The Climate-system Historical Forecast Project (CHFP) is a multi-model and multi-institutional experimental framework for sub-seasonal to decadal complete physical climate system prediction that was launched at the WCRP Workshop on Seasonal Prediction, Barcelona, Spain, June 2007. The seasonal prediction problem extends further than ocean-atmosphere interactions, as primarily addressed by CLIVAR, with potential predictability sources from other components of the physical system. By the physical climate system, we mean contributions from the atmosphere, oceans, land surface cryosphere and atmospheric composition in producing regional and sub-seasonal to decadal climate anomalies. This experimental framework is based on advances in climate research during the past decade, which have lead to the understanding that modeling and predicting a given climate anomaly over any region is incomplete without a proper treatment of the effects of SST, sea ice, snow cover, soil wetness, vegetation, stratospheric processes, and atmospheric composition (carbon dioxide, ozone, etc).

The observed current climate changes are a combination of anthropogenic influences and natural variability. In addition to possible anthropogenic influence on climate due to changing the atmospheric composition, it is quite likely that land use in the tropics will undergo extensive changes, which will lead to significant changes in the biophysical properties of the land surface, which in turn will impact atmospheric variability on sub-seasonal to decadal time scales. It is therefore essential that the past research by two somewhat non-interacting communities (i.e. climate change and seasonal prediction) be merged into a focused effort to understand the predictability of the complete climate system.

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

(i) A baseline assessment of our seasonal prediction capabilities using the best available models of the climate system and data for initialisation.;

(ii) A framework for assessing current and planned

observing systems, and a test bed for integrating process studies and field campaigns into model improvements;

(iii) An experimental framework for focused research on how various components of the climate system interact and affect one another ;

(iv) A test bed for evaluating IPCC class models in seasonal prediction mode.

Information on the CHFP, for contributing and accessing data and participating in diagnostic subprojects is available on the CHFP website (http://www.clivar.org/organization/wgsip/chfp/chfp.php). Over 10 groups are currently participating in the CHFP and there are three distributed data centres that are supporting the experiment: Centro de Investigaciones del Mar y la Atmósfera (CIMA), the Asia-Pacific Economic Cooperation (APEC) Climate Center for Information Services (APEC APCC) and the EU ENSEMBLES Project server. In addition to the distributed data centres, some groups will support their own local servers. Data will be linked from the central CHFP website and data can be downloaded in a common format and grid as it becomes available later this year. The CHFP is designed to be long term with no hard deadlines, particularly as making data available at the distribution centres is still a learning experience. This is also an advantage in that groups can join the experiment when ready and data from new model versions can be included as they become available.

The CIMA server has data available from its website and by the second half of 2009, it is hoped that the server will have tools available so that some analyses can be performed without having to download the data. APCC is contributing its hindcast data from its multi-model ensemble (MME) and the Climate Information Tool Kit (CLIK) has been developed for users to do web-based analysis and downscaling. The addition of externally submitted CFHP data is expected for July-Sept. 2009. The ENSEMBLES Stream 2 matches the CHFP protocol and is publicly available as of March 2009.

The significant role played by land-atmosphere coupling in seasonal predictability requires that close ties must exist between WGSIP and the GEWEX community, particularly as regards the CHFP. WGSIP is also in the process of strengthening links with the stratospheric and the cryospheric community. Since the WCRP Task Force on Seasonal Prediction, which developed the concept of the CHFP, ceased to exist in 2007, WGSIP actively endeavors to maintain close links to the other WCRP projects. Representation from all the WCRP Projects at the 12th Session of WGSIP provided a fertile discussion on how to integrate the full climate system to seek improved skill at seasonal and longer timescales.

The Global Land/Atmosphere System Study (GLASS) panel within GEWEX looks at modelling the interactions between the land and atmosphere on a global scale, though without focusing specifically on seasonal prediction. The Global Land-Atmosphere Coupling Experiment (GLACE) is the main activity on seasonal prediction within GEWEX. GLACE-1 was a successful international modelling project that looked at soil moisture impacts on precipitation. GLACE-2 extends this work to consider the full initialisation forecast problem. GLACE-2 has been endorsed by WGSIP in the WCRP Position Paper on Seasonal Prediction (WCRP, 2008) and the project directly complements the CHFP experimental protocol in that no additional future information is included in the runs.

The SPARC area most relevant for WGSIP is stratospheric-tropospheric coupling. SPARC will interact with WGSIP in experiments looking at improved seasonal prediction skill resulting from a resolved stratosphere. Some groups within SPARC are able to run coupled ocean-atmosphere models for a sub-set of CHFP experiments, and some groups within WGSIP are able to extend their atmospheric model to resolve the stratosphere. A joint WGSIP-SPARC CHFP-related activity has been proposed; the Stratosphere-resolving Historical Forecast Project.

Given the different time scales and geographical distribution of cryospheric components in the climate system, perhaps only the accurate knowledge of varying sea-ice and snow properties can provide predictive skill at seasonal time scales. The CHFP recommendations encourage an interactive ice model, while leaving the nature of the model, whether dynamic or thermodynamic, open. There is an opportunity for running additional CHFP coordinated experiments and diagnostics relevant for the cryosphere.

An area of potential collaboration between WGSIP and CliC would be in sea ice prediction and intialization, where various approaches are currently in use, with no knowledge of how this influences predictability. Another area is spring snow melt and how this influences spring temperature anomalies. This would be relevant to WGSIP, CliC, as well as GEWEX. This has essentially already been done for the warm season in GLACE and similar experiments could be run for the cold season. A proposal is being developed on how to move forward in a CHFP/CliC/GEWEX study of snow cover and soil moisture.

The following numerical experiments associated to the CHFP are in progress, planned or under consideration:

- GEWEX: GLACE-2
- SPARC: Seasonal Prediction Skill Assessment: Troposphere-Stratosphere Interactions
- CliC: Sea-ice predictability experiments, and/or impact of snow cover

WGSIP is a co-sponsor of the WCRP CMIP5 near term climate change simulation experimental protocol and a CMIP-WGCM-WGSIP subgroup has been formed to oversee this framework. WGSIP will be active in addressing the science questions that present themselves and the protocol has been designed to extend beyond the requirements for AR5 and to serve the future science development needs in the area. It has also been designed to mesh with decadal predictability studies already underway in Europe.

Initialization is a central theme of decadal prediction and WGSIP leadership is part of the steering committee for the Workshop on Earth-System Initialization for Decadal Prediction that will be held in Fall 2009. CLIVAR and WCRP as a whole must redouble efforts to identify and include all sources of potential decadal forecast skill. Connections should be maintained between the CMIP-WGCM-WGSIP group and the emerging US CLIVAR Predictability, Predictions and Applications Interface Panel and Decadal Predictability Working Group. WGSIP is also contributing

to the Workshop on Predicting the Climate of the Coming Decades being planned for January 2010 in Miami Florida.

One of the WGSIP terms of reference specifies its role to advise on the adequacy of the CLIVAR ocean observing system in terms of what are the requirements and impacts of the observing system for seasonal prediction. It is currently difficult to demonstrate improvements in ENSO prediction that are the direct result of improvements in the observing system because, in general, model error still dominates the absolute error. Although studies of observing system impact are very much encouraged by WGSIP, it is not appropriate at this time to organize any coordinated experimentation on this topic.

While there is skill in forecasting ENSO in the Pacific Ocean, there is little forecast skill in the Indian Ocean. This could be due to model error, a lack of observations compared with the Pacific, a smaller climate signal, or maybe because there is less predictability in this region. The Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) activity is underway to enhance the observing system in the Indian Ocean, the implementation of which is being coordinated by the CLIVAR Indian Ocean Panel (IOP). How to demonstrate the benefit of the array for forecasts remains an open question that could be addressed by WGSIP, IOP and the Asian-Australian Monsoon Panel (AAMP).

The major priorities of WGSIP in the coming year are:

(i) Ensure that the CHFP experiments are completed and that the data is made available to the research community

a. Continue GEWEX GLACE collaboration

b. Develop SPARC and CliC seasonal prediction experimental protocols

(ii) Continue to promote the Decadal Prediction experimental protocol and encourage wide participation

a. Coordinate with emerging US CLIVAR Working Group for Decadal Prediction and Predictability

(iii) Participate in the organization of WCC-3 and the development of the white papers on seasonal prediction

WGSIP also endeavours to maintain close links with the impacts and applications community. The gap between weather and climate is starting to be bridged by the seamless approach. However, there is also a need to work across this continuum when considering impacts and applications. While WGSIP cannot be charged with developing user products, it should develop better links with the WMO World Climate Programme (WCP), in particular, the World Climate Applications and Services Programme (WCASP).

The 13th Session of WGSIP will be held in Buenos Aires, Argentina in July 2010. The meeting will be during the week preceding a two-week Training Institute "On The Use Of Seasonal Predictions For Applications In Latin America", which is being organised by CIMA, University of Buenos Airies. The central goal of this Training Institute is to increase local and regional capacity on the use of seasonal prediction for applications in the different socioeconomic sectors (agriculture, health, water resources, disaster risk reduction, etc.) of the Americas, particularly Latin America. WGSIP will support this course with some of its members staying on to contribute in the teaching. Representatives of CliC, SPARC and GEWEX, the US CLIVAR WG on Decadal Prediction, WCP, and the CHFP distributed data centres will be invited to join WGSIP at its next meeting.

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WCRP/CLIVAR Working Group on Coupled Modeling (WGCM) Activity Report: Overview and Contribution to the WCRP Crosscut on Anthropogenic Climate Change

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WGCM is charged with coordinating experimentation with coupled models that are aimed at understanding natural climate variability on decadal to centennial time scales and its predictability, and at predicting the response of the climate system to changes in natural and anthropogenic forcing. The WCRP Climate Model Intercomparison Project (CMIP) is a major WGCM contribution to the WCRP Anthropogenic Climate Change crosscutting topic.

Other coordinated modeling activities that are directly related to WGCM and its contribution to ACC include the WCRP Stratospheric Processes And their Role in Climate Project (SPARC), Chemistry-Climate Model Validation Activity (CCMVal) and the IGBP Analysis, Integration and Modeling of the Earth System (AIMES) Coupled Climate–Carbon Cycle Model Intercomparison Project (C4MIP). An extensive list of model intercomparison projects is available on the WGCM website (http://www.clivar.org/organization/wgcm/projects.php). WCRP and WGCM have recently formed a Task Force on Regional Climate Downscaling (TF-RCD) that is in the process of developing a White Paper by the end of 2009 on coordinating regional climate modeling (RCM) experiments forced by the CMIP5 climate change scenarios.

Areas of focus for WGCM include understanding emerging high impact uncertainties in the climate system such as the future evolution of ice sheets and their contribution to sea level rise, cloud-climate feedbacks, climate change and impacts on air quality, and abrupt climate change as seen in the paleoclimate record. WGCM works directly with the GEWEX Cloud System Study (GCSS) and with the Working Group on Numerical Experimentation (WGNE) on evaluating and improving climate models, with the International Detection and Attribution Group (IDAG) on understanding climate variability in the recent observational record during increased anthropogenic activity, the Integrated Assessment Modeling (IAM) Consortium on developing future climate forcing scenarios, and with AIMES on integrating coupled carbon/climate/chemistry and human processes into Earth System Models (ESMs).

CMIP Phase 3 (CMIP3)

CMIP introduced the climate science community to a "new era" of climate change research (Meehl et al., 2007). For the first time, the international climate change research community coordinated a set of climate change experiments that were run by all of the international climate modeling groups. This provided a multi-model dataset that included 20th Century simulations with anthropogenic and natural forcings, three 21st Century SRES non-mitigation scenarios for low, medium and high forcing, and three experiments where greenhouse gas (GHG) concentrations were held constant (at year 2000 values, and at year 2100 values for the A1B and B1 experiments) to quantify climate change commitment (see Figure 1 for summary of globally averaged temperature changes from the different models and experiments). Output from these model experiments was then collected and archived by the Programme for Climate Model Diagnosis and Intercomparison (PCMDI) USA, and was made openly available to the international climate science community for analysis. This was a new concept for the community (before this, climate change model data had only limited distribution), and opened up climate model analysis to thousands of scientists and students from around the world. This open access has produced hundreds of papers in the peer-reviewed literature, and a sample is listed on the PCMDI web page (http://www-pcmdi.llnl.gov/ipcc/subproject_publications.php).

Of the multitude of results that have emerged from the CMIP3 analyses, two are illustrated here. For the first time climate change commitment was quantified with particular relevance for the year 2000 stabilized experiment (orange line in Figure 1). Even when concentrations of GHGs are held constant, the climate continues to warm due to the thermal inertia of the oceans. Committed warming averages 0.1°C per decade for the first two decades of the 21st Century;

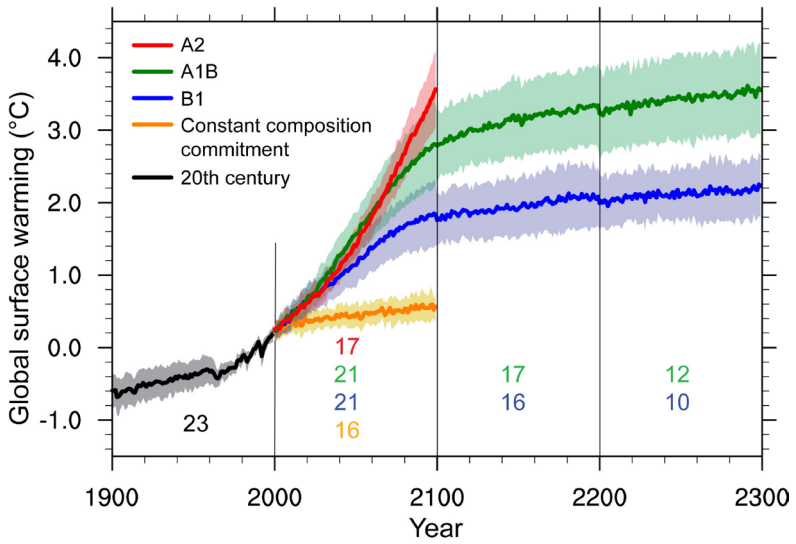


Figure 1: Multi-model means of surface warming (relative to 1980-1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th Century simulation. Values beyond 2100 are for the stabilization scenarios. Linear trends from the corresponding control runs have been removed from these time series. Lines show the multi-model means, shading denotes the +/- standard deviation range of individual model annual means. Discontinuities between different periods have no physical meaning and are caused by the fact that the number of models that have run a given scenario is different for each period and scenario, as indicated by the colored numbers for each period and scenario, at the bottom of the panel. For the same reason, uncertainty across scenarios should not be interpreted from this figure. (IPCC AR4 WG1 Report, Ch. 10, Fig. 10.4.)

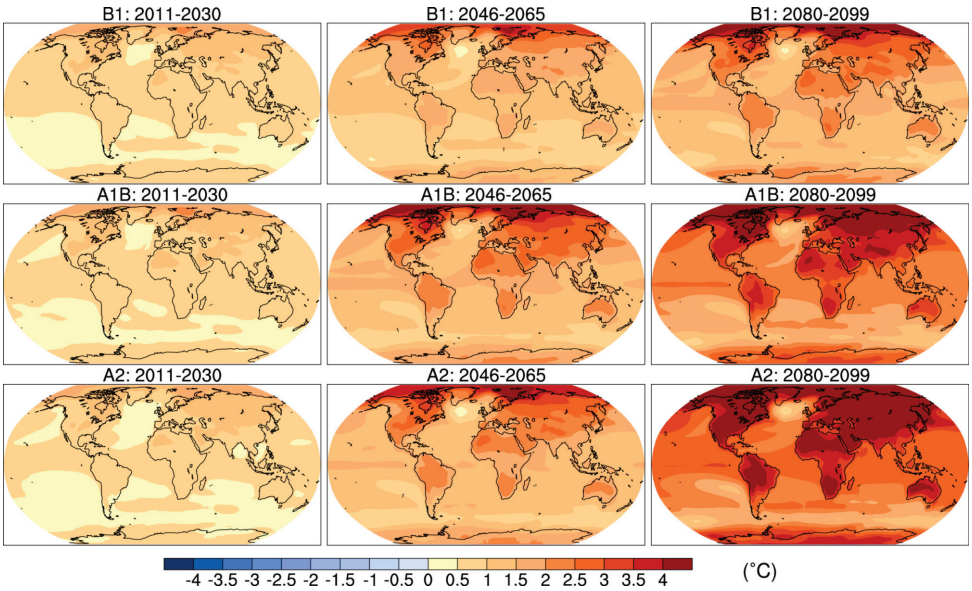


Figure 2: Multi-model mean of annual mean surface warming (surface air temperature change, °C) for the scenarios B1 (top), A1B (middle) and A2 (bottom) for three time periods, 2011 to 2030 (left), 2046-2065 (middle) and 2080 to 2099 (right). Anomalies are relative to the average of the period 1980 to 1999. (IPCC AR4 WG1 Report, Ch. 10, Fig. 10.8)

across all scenarios, the average warming is 0.2°C per decade for that time period (recent observed trend 0.2°C per decade).

Another aspect that was treated more uniformly was the spatial pattern of warming. Figure 2 shows a summary of the multi-model results for surface air temperature change. Note that the pattern of warming is very similar for all time periods and all scenarios, but the amplitude differs. Earlier in the experiments, there is little divergence among the forcing from the scenarios, and both the magnitude and pattern of temperature change are similar among the scenarios. But as the 21st Century continues, the amplitude of warming begins to be differentiated among the scenarios, and it is more clearly seen that continents warm more than oceans (an indicator of growing climate change commitment), the high latitude Northern Hemisphere warms more than everywhere else, and there is less warming in the North Atlantic and circumpolar Southern Ocean.

When considering global temperature change, one of the greatest uncertainties on the high end of the range of temperature change was shown to come from carbon cycle feedback. Therefore, one of the main foci in the next phase CMIP5 is to provide a better quantification of the nature and magnitude of carbon cycle feedback. To reduce uncertainties and make the climate model projections and predictions more useful for informing the adaptation and mitigation decisions that our society will need to make, the global climate modeling community is putting effort in three main areas: (1) the understanding and the assessment of climate predictability and predictions at the decadal time scale, (2) the understanding and the assessement of long-term physical and biogeochemical feedbacks in the climate system, and (3) the evaluation and the improvement of climate models to make climate predictions and projections more reliable at all time and space scales. Figure 3 (from Hawkins and Sutton, 2009) shows how the fractional uncertainty of CMIP3 global mean temperature projections vary due to

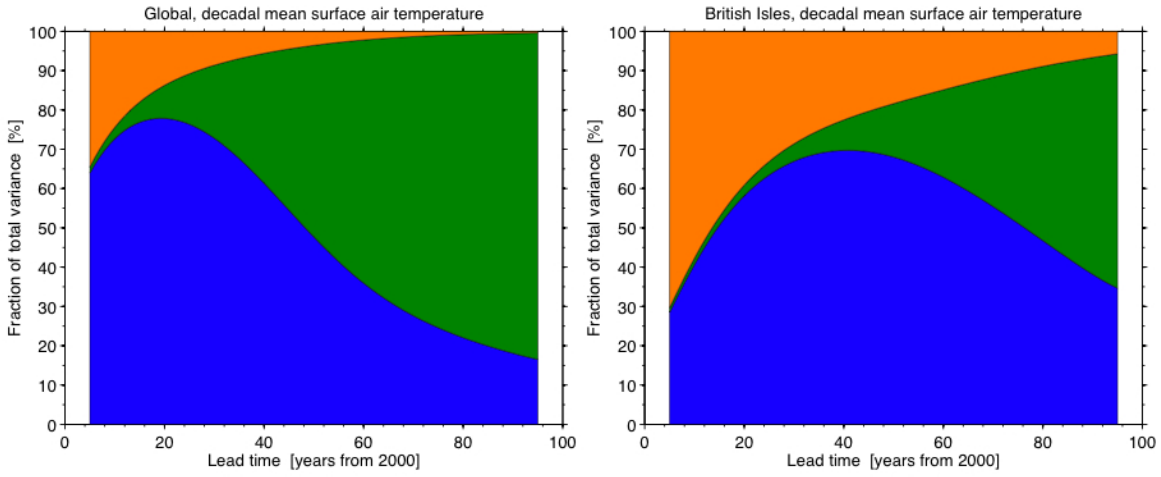
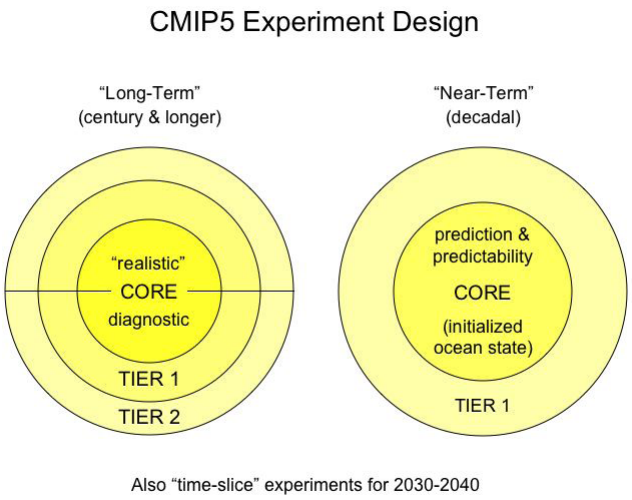


Figure 3: The fractional uncertainty of CMIP3 temperature projections associated with: internal variability (in orange), model uncertainty (in blue), and scenario uncertainty (in green), for the global scale (on the left) and for the regional scale (on the right). (Fig. 4 c-d from Hawkins and Sutton, 2009)



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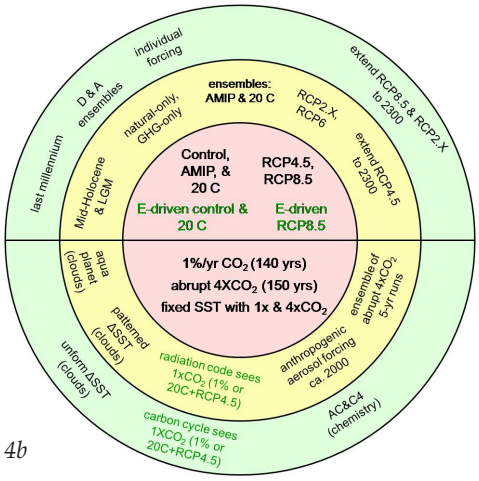

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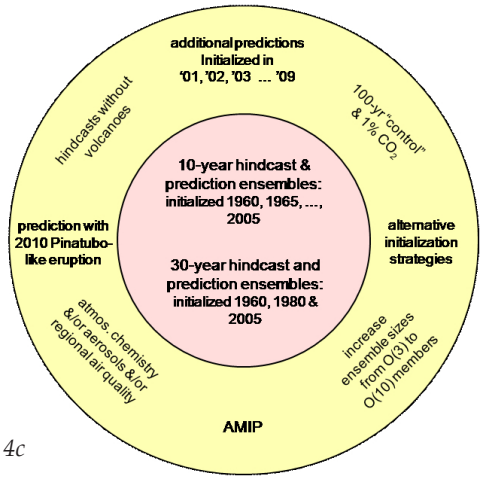

4c

Figure 4: Summary the CMIP5 experimental protocol. Figure 4a is a schematic of the two focus areas of CMIP5. Figure 4b is the detailed summary of the 'Long-Term' (century or longer) simulations and Figure 4c is the detailed summary of the 'Near-Term' (decadal) simulations. The figures are arranged into prioritized tiers of experiments, going from the central 'Core' set of experiments, to lower priority moving outwards from the inner circle. (Taylor et al., 2009)

internal variability (in orange), model uncertainty (in blue) and scenario uncertainty (in green) on different spatial and temporal scales.

CMIP Phase 5 (CMIP5)

The CMIP3 climate change experiments represented the end of the era of non-mitigation scenarios represented by the SRES suite with the main climate change projection time frame being near the end of the 21st Century. The paradigm shift that occurred after the publication of the IPCC AR4 involved a move toward mitigation scenarios (with implied policy actions), better quantification of various feedbacks, (including those involving the carbon cycle), simulations relevant to longer term climate change out to 2100 and beyond, as well as an enhanced focus on shorter term climate change out to about 2035. This paradigm shift grew out of the research assessed for the AR4 that recognized the need to understand and interpret observed climate change in order to understand how much can be attributed to human activity, to internal variability, or to external forcings (natural and anthropogenic). This built on the growing need for climate science to inform adaptation and mitigation decisions.

CMIP5 has two foci, as defined in the CMIP5 strategy (Meehl and Hibbard, 2007; Hibbard et al., 2007) and described in the experimental protocol (Taylor et al., 2009) and summarized in Figure 4. The first is on near-term decadal prediction simulations (10-30 years) and understanding the extent to which future climate depends on the initial ocean-ice state, and to provide higher resolution regional climate change information for adaptation applications. The second is on long-term centennial simulations with both atmosphere-ocean global climate models (AOGCMs) with components of atmosphere, ocean, land surface and sea ice, and Earth-System Models (ESMs) that have all the components of AOGCMs with the addition of a fully coupled, interactive carbon cycle. ESMs will examine the sensitivity, feedbacks and related uncertainties of future climate to natural and forced variability due to the carbon cycle. The longer-term simulations will quantify uncertainty across the model responses, as well as examine feedbacks on longer timescales that provide different amplitudes of future climate change.

For the near term, the CMIP5 experiments will consist of hindcasts to quantify decadal predictability, as well as predictions out to 2035 to address short-term climate change. One of the main science questions involves how best to initialize the ocean, and how much additional regional prediction skill (over and above un-initialized runs) can be obtained from an initialized climate model. This science question bridges the climate change problem to seasonal to interannual prediction, and decadal prediction is bringing together these two communities to address this problem. Another challenging problem related to initialization is how much additional regional predictive skill can be obtained by resolving regional internal decadal variability mechanisms in addition to the climate change produced by commitment and changes in external forcing.

The focus of the long-term integrations is to provide information on how feedbacks in the climate system contribute to the magnitude of climate change in the future for various mitigation strategies. Therefore, these

simulations are relevant to mitigation and adaptation, with climate sensitivity in the different models and the associated magnitude of the feedbacks influencing the resulting modelled climate change. It is on these longer timescales that sea level rise and the role of the melting of ice sheets will come into play. The combination of the various scenarios and feedbacks will also provide information on possible abrupt climate change. A major source of uncertainty in climate change estimates (climate sensitivity, patterns of regional temperature and precipitation changes, etc) is related to cloud processes and feedbacks (see Figure 5 from Dufresne and Bony, 2008). These will be addressed by experiments led by the Cloud Feedback Model Intercomparison Project (CFMIP) community, as well as by the widespread implementation by models participating in CMIP5 of cloud simulator packages that diagnose from GCM outputs some variables similar to those observed from satellites through passive or active remote sensing.

The Integrated Assessment Model (IAM) Consortium, in collaboration with WGCM and AIMES, has developed four scenarios, called Representation Concentration Pathways (RCPs) for the 21st Century (2005 to 2100) and beyond to 2300, based on future concentrations, emissions and land use changes. One is non-mitigated and the others take into account three levels of mitigation. RCP4.5 and RCP6.0 are the medium mitgation scenarios, RCP2.6 is the low mitigation scenario, and RCP8.5 is the high emissions scenario. RCP4.5, for example, targets an approximate radiative forcing of 4.5Wm^{-2} to be achieved by year 2100 relative to pre-industrial conditions. AOGCMs will be forced by specified concentrations, while ESMs with an interactive, coupled carbon cycle will be additionally forced by emissions, a new approach since CMIP3. The suite of long-term experiments also includes a 1% per year increase in CO_2 to diagnose the transient climate response and an abrupt 4xCO_2 increase experiment to diagnose the equilibrium climate sensitivity due to both forcing and feedbacks. Some participants will also be extending simulations to 2300 to look at the longer-term evolution of future climate. There will be additional experiments to examine 'fast' and 'slow' responses across the models, and a set of coordinated atmospheric chemistry experiments led by the SPARC CCMval community including experiments to diagnose the strength of forcing and the related uncertainties due to aerosols. The simulations leading up to the long term integrations will start in 1850, and will be run from 1850 to 2005 with observed natural (solar and volcano) and anthropogenic (GHG, aerosols, ozone) forcings for analyses relevant to climate change detection/attribution. A new aspect of these 20th Century (and 21st Century) simulations will be specified time-evolving land use change so that, for the first time, the contribution of land use change to local, regional and global climate change can be addressed.

The participation of ESMs with a fully coupled, interactive carbon cycle that will examine the sensitivity, feedbacks and related uncertainties of future climate to natural and forced variability due to the carbon cycle is a major development since CMIP3. These models will run several experiments, also contributing to the next phase of C4MIP. In one experiment the carbon cycle response to climate change will be suppressed so that the carbon cycle only responds to the increasing CO_2 concentrations and not the

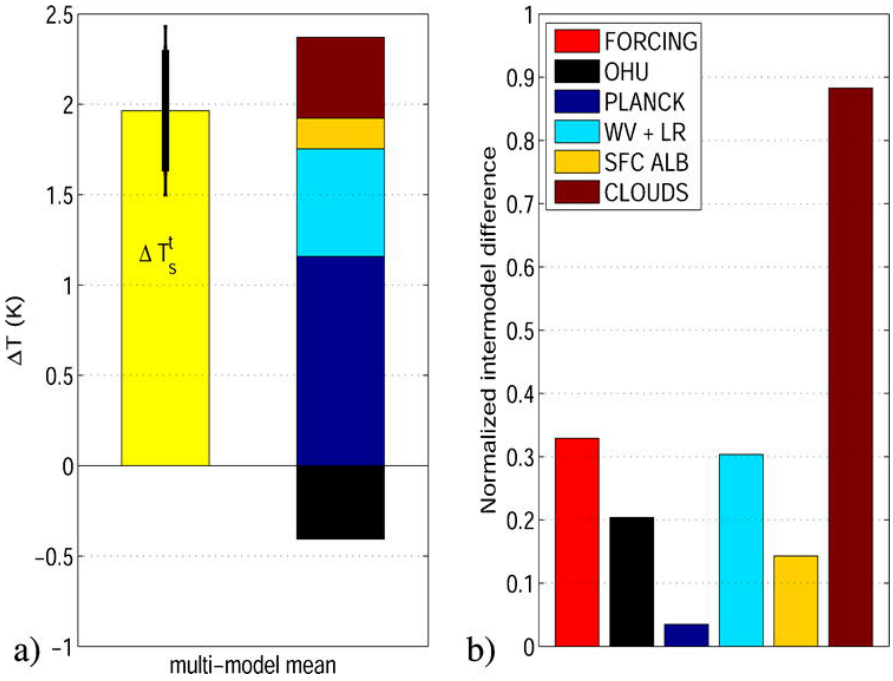

Figure 5: The multi-model spread in Transient Climate Response related to inter-model differences in radiative forcing, feedback and ocean heat uptake. For a CO_2 doubling, (a) multimodel mean ±1 standard deviation (thick line) and 5%–95% interval (thin line) of the transient temperature change (ΔT^t_s) and contributions to this temperature change associated with the Planck response, OHU, combined water vapor and lapse-rate (WV + LR) feedback, surface albedo feedback, and cloud feedback. (b) Intermodel standard deviation of the transient temperature change estimates associated with intermodel differences in radiative forcing, Planck response, ocean heat uptake, and the various feedbacks normalized by the intermodel standard deviation of the transient temperature change ΔT^t_s. (Dufresne and Bony, 2008)

CO_2-induced changes in the climate's radiative balance. In a parallel experiment, the carbon cycle will be decoupled from the increasing CO_2 concentrations and will only respond to the radiative climate response. The surface CO_2 fluxes from these experiments will be used to derive emissions and compared with those of the fully coupled carbon cycle experiments to diagnose the strength of the carbon cycle feedback, to be expressed in terms of 'allowable emissions', and the implications of uncertainties in the carbon flux estimates. Earth-system Models of Intermediate Complexity (EMICs) and Integrated Assessment Models will also be run to reproduce these ESM results and to develop new future scenarios of human economic activity that will then feed back into the design of future CMIP simulations.

Additionally, there will be several experiments to understand the origin of inter-model differences in the climate response to a given perturbation. Some experiments will allow the diagnosis of climate sensitivity and radiative forcings from coupled models. Idealized experiments (e.g. atmosphere-only experiments forced by prescribed SST perturbations, aqua-planet experiments) will make it possible to assess both the robustness and the uncertainties of the climate change response predicted by coupled models, and to better interpret the origin of inter-model differences in the simulation of clouds, precipitation and large-scale dynamics. As noted above, a set of CMIP5 experiments will be addressing climate feedbacks by isolating components of the climate response according to the 'fast' response due to forcing and the 'slow' response due to feedbacks. These experiments inhibit the slow response of the ocean and isolate the fast response of the direct impact of increasing CO_2 concentrations on, for example, clouds, land surface, and stratospheric adjustment. Experiments will also be included that use a regression approach to estimate the equilibrium climate sensitivity and strength of feedbacks that are tied to the global mean temperature.

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Working Group on Ocean Model Development (WGOMD) Activities and Future Directions

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Coordinated Ocean-Ice Reference Experiments continue to be the focus of WGOMD activities. The normal year forcing CORE-I paper (Griffies et al., 2009a) has been published this year and provides the community with an example of how WGOMD can address projects of use and interest to the broader ocean modelling community, where cross-institutional collaboration is required for success. Groups around the world now routinely use the CORE-I protocol to evaluate their ocean-ice models.

CORE-II is the next phase of this experiment and consists of hindcast simulations (1948-2006) forced with the CORE interannual forcing (IAF) dataset (Large and Yeager, 2008). WGOMD has been testing the recent release of version 2 of the IAF dataset examining experimental protocols for CORE-II, and running suites of experiments exploring issues such as boundary forcing, initialization, spin-up, analysis metrics and methods, etc.

WGOMD recognizes that the final experimental design will likely will not satisfy all. The goal is to design a baseline protocol that is both of scientific interest and can be readily implemented, even if that protocol has certain (hopefully minor) shortcomings. Different approaches have been used in terms of initialization and spin up, temperature and salinity restoring and sea-ice initialization and modelling. The CORE IAF is based on a merged reanalysis and observational product and will provide a common framework for running ocean-ice models for hindcast purposes. Notably, CORE-II efforts will feed directly into CLIVAR basin panel activities with the use ocean-ice models to identify mechanistic descriptions of observed variability and change.

Various groups have been working for a number of years with the CORE IAF on studies aimed at contributing to the understanding of mechanisms of observed interannual to decadal variability. This includes looking at the variability of the meridional overturning circulation (MOC), whether it is driven by intrinsic variability or basin-scale changes in the buoyancy forcing and whether there are any detectable long-term trends, the dynamics of the gyre variability of the sub-polar North Atlantic and its effect on the MOC, changes in Tropical interannual variability and in regional current systems that affect local fisheries and the local climate, and attempting to identify oceanic mechanisms that could give predictability. Readers should refer to the CORE-II website (http://www.clivar.org/organization/wgomd/core/core_II.php) for a list of publications.

Significant progress has been made on the development of the Repository for Evaluating Ocean Simulations (REOS), a website that has recently gone live as part of the WGOMD website: www.clivar.org/organization/wgomd/reos/reos.php. The motivation for this website stems from the growing needs of the modelling community to provide benchmark, thorough, evaluations of their simulations, and to make use of observational datasets that have been generated during the past decade. WGOMD is interacting with the CLIVAR basin panels for input on metrics to basin processes, as well as soliciting recommendations and input from the wider ocean observational, data assimilation and modelling community.

The REOS front page gives an overview of what to expect from the website, as well as some useful related links. The Datasets page lists, describes, gives references and provides links to data sites (e.g. SST, altimetry, tracers). The Metrics page has pages dedicated to each CLIVAR ocean basin, as well as summaries of past activities on ocean metrics, such as workshops. The page on Model Evaluation has examples of model evaluation practices, e.g. the evaluation of the CORE-I multi-centennial normal year forcing runs (Griffies et al., 2009a). The page on Tools has descriptions and links to tools available to the community e.g. the co-location Google-Earth OceanDiva tool. Finally, the References page has papers arranged according to topic (e.g. datasets, ocean basin, tracers etc) with links to the paper where possible.

The REOS website will continue to evolve to serve as a resource on how to best evaluate models against observations, not only for ocean modellers, but also bridging the gap between model and observations. We will continue to solicit input from the modelling, observational, and analysis communities, together with guidance and oversight for the contents of this site. As REOS matures through usage and input, navigating the content will also improve. The website will continue to be maintained by A. Pirani, who welcomes comments and suggestions, as well as material to include and make available to the wider community.

A central focus for WGOMD is its contribution to the WCRP decadal prediction crosscutting topic. Together with the Global Synthesis and Observations Panel, WGOMD will provide essential input into the decadal prediction initialization problem. WGOMD members are authors on the OceanObs'09 White Papers by Hurrell et al. (2009) on 'Decadal Climate Prediction: Opportunities and Challenges' and Latif et al. (2009) on 'Dynamics of Decadal Climate Variability and Implications for its Prediction'. WGOMD members are also on the scientific steering committee of the CLIVAR workshop on 'Earth-System Initialization for Decadal Predictions' to be held in the Fall 2009.

Many coupled general circulation models show multi-decadal variability in the North Atlantic as depicted in their Atlantic Meridional Overturning Circulations (AMOCs). There are no long-term observational data for this variability and studies rely on model simulations. Both the mean transport and variability of the AMOC vary significantly across different coupled models. The CORE IAV forcing data set represents one of our best estimates of surface forcing for ocean-ice coupled experiments. We believe that hindcast simulations with these forcing fields can be used to supplement data assimilation efforts to help construct an AMOC time series for the second half of the 20th Century. Indeed, we will explore and document these issues and investigate why different models produce different AMOC behaviour (if any) among the participating CORE-II simulations.

WGOMD continues to support the Working Group on Coupled Modelling in its objectives to develop coupled climate models and model intercomparisons, notably providing recommendations on 'Sampling Physical Ocean Fields in WCRP CMIP5 Simulations' (Griffies et al., 2009b). This document serves the following purposes:

- To rationalize a list of physical ocean model fields to be archived for the Coupled Model Intercomparison Project (CMIP5) supporting the IPCC-AR5.
- To offer guidance to ocean climate modellers for enhancing the scientific relevance of sampled model output.
- To articulate certain needs of ocean scientists aiming to analyze CMIP5 model output, and whose research directly supports IPCC Working Group 1 (WG1) goals.

The eighth WGOMD panel meeting was held on 30 April - 1 May 2009 at the UK Met Office in Exeter, UK. The presentations given by the meeting participants, together with some pre-meeting reports, are available on the meeting webpage (http://www.clivar.org/organization/wgomd/wgomd8/wgomd_exeter.php). The meeting report is in preparation and will be posted on the WGOMD website soon. WGOMD leadership has undergone some changes this year with Stephen Griffies standing down after serving as Chair since June 2004. Helge Drange and Gokhan Danabasoglu are the incoming co-Chairs and WGOMD was very pleased to welcome back Helene Banks after a period of absence. Matthew England has stepped down from the panel and WGOMD welcomes Simon Marsland as a new member.

Since 2004, each WGOMD panel meeting has been associated with a science-based workshop aimed at stimulating discourse and understanding on a particular aspect of oceanography. The CLIVAR Workshop on Ocean Mesoscale Eddies was the fourth workshop organized by WGOMD. It was held on 27-29 April 2009 at the UK Met Office, Exeter, UK. The workshop had the following main goals (see also the separate article on the workshop by Stephen Griffies, this issue):

- To educate the research community regarding the importance of mesoscale eddies in the World Ocean, and correspondingly for establishing features of the ocean climate system
- To identify best practices for parameterising ocean mesoscale eddies in coarse-resolution climate models, and to discuss various research avenues for improved parameterisations;
- To evaluate the ability of state-of-the-science numerical models to accurately represent the ocean mesoscale in eddying simulations.

The three-day workshop consisted of roughly six invited speakers per day. Each speaker presented views on the state-of-the science in ocean mesoscale eddies as seen through observations, models, and theory. Participants of the workshop were invited to contribute posters. WGOMD was awarded a joint 15K USD funding award to support the travel costs of young researchers from NASA, NOAA and NSF that was allocated to 13 successful applicants. A short summary (Griffies, 2009d) can be found within this issue of Exchanges (page 40) and the presentations and posters are available on the workshop webpage (http://www.clivar.org/organization/wgomd/meso/meso.php). An Ocean Modelling special issue in 2010 on Ocean Mesoscale Eddies: Representations, Parameterizations, and Observations is planned as the main deliverable of the workshop.

The 9th WGOMD Session is planned for Fall 2010 and is going to be held in Boulder, USA, hosted by the incoming co-Chair Gokhan Danabasoglu. WGOMD will be organising a workshop to coincide with its meeting on the subject of 'Decadal Variability and Predictability: Understanding the role of the Ocean'. The topics that the workshop will cover include the multi-decadal variability in the North Atlantic as depicted in the AMOC in coupled simulations, its dependence on ocean model physics and numerics, exploration of mechanisms, its climate impacts and fingerprints, and associated predictability.

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Global Synthesis and Observations Panel (GSOP) Activity Report

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GSOP has several charges, including dealing with CLIVAR data and ocean synthesis issues, both with global emphasis and, at the same time, basin aspects, since they provide the regional foci. GSOP is active along both tracks. At the same time GSOP is working toward the initialization of coupled models and toward coupled data assimilation. GSOP has strong links with the Ocean Observations Panel for Climate (OOPC), with cross-participation in meetings. More importantly, GSOP is one of the organizers of the OceanObs'09 Symposium to be held in Venice, Italy from 21-25 September 2009.

1. Ocean synthesis evaluation, coupled data assimilation and decadal prediction.

One of the main contributions to CLIVAR science from GSOP is the evaluation of the current generation of ocean synthesis/reanalysis products providing guidance on their use for study of the global ocean circulation. The evaluation has led to several improvements in the products. It has led especially to several papers comparing different ocean synthesis products and thereby to first specifications of uncertainties in ocean syntheses.

Links to ocean synthesis data have been placed on the "Ocean Synthesis Directory" at http://www.clivar.org/data/synthesis/directory.php while a detailed list of existing syntheses is maintained on the GSOP web pages.

GSOP, particularly through the ocean synthesis project, is also engaging in decadal forecast experiments. One key element is for ocean synthesis groups to provide updated datasets to be used for the decadal prediction experiments. With respect to this, GSOP is co-sponsoring an upcoming workshop with the CLIVAR Atlantic Panel and others on Decadal Forecasts and Initialization. GSOP is also currently in the process of providing all available ocean syntheses as initial conditions for decadal prediction experiments. First such experiments are ongoing and show some success.

GSOP has also begun to investigate possibilities of coupled data assimilation. Respective efforts are spinning up and will grow over the next years.

GSOP has begun discussion with OOPC and the WMO-IOC Joint Commission for Oceanography and Maritime Meteorology (JCOMM) regarding the coordination and assessment of ocean climate data sets and the need to develop implementation plans to produce data sets in support of ocean synthesis and reanalysis projects. (See item 4.)

2. GSOP links to ocean carbon and hydrography.

GSOP is also working on a first pilot carbon synthesis in the Atlantic and is a co-sponsor (together with the International Ocean Carbon Coordination Project (IOCCP) and the IGBP SOLAS-IMBER Carbon Coordination Group) of the Global Ocean Shipbased Hydrographic Investigations Panel (GO_SHIP). The panel brings together interests from physical hydrography, carbon, biogeochemistry, Argo, OceanSITES, and other users and collectors of hydrographic data.

GO_SHIP has initiated a review of the WOCE hydrographic manual to update observational methods and techniques and include a manual for observations that will be part of the observations suite of the repeat hydrography programme. Several chapters of the revised hydrography manual are now on-line and ready for open community review. The aim is to finalize the manual by September. The chapters are posted at CDIAC: http://cdiac3.ornl.gov/hydrography/. GO_SHIP has also submitted a white paper to OceanObs09.

3. Workshops and meetings

a) GSOP held its 3rd Session at the National Oceanography Centre, Southampton, on 13-14 March 2008. The meeting's main objectives were: (i) advance plans for the OceanObs'09 symposium; (ii) define GSOP participation in CMIPS decadal prediction experiments, aiming at the IPCC AR5; (iii) agree on a strategy for development of climate datasets in support of ocean synthesis and develop implementation plans; and, (iv) refine synthesis evaluation activities and foster basin-wide and global science applications of ocean syntheses.

b) GSOP has also promoted a "Workshop on Ocean Velocity Measurements and their Applications" which was held at SIO, La Jolla, USA, on 5-7 December 2007. The report can be found at http://eprints.soton.ac.uk/50803/01/129_GSOP_Workshop.pdf.

c) GSOP organised a 3rd Ocean Synthesis Intercomparison Meeting, held at JAMSTEC Office in Tokyo, on 6-8 October 2008. As done previously, one of the topics for comparison was the behaviour of the meridional overturning circulation, in addition to heat content, freshwater and sea level.

4. New activities being planned, including timeline

In addition to the ongoing activities with ocean synthesis and initialization outlined above, GSOP is planning to organize the production of an update to the 2002 WOCE Global Data Set V3. This project, in addition to the requirements from the reanalysis group, could be used to engage the CLIVAR Data Assembly Centres (DACS) in order to help with the production of a DVD set containing the datasets. These would have the best collection possible of data, with the adoption of best practices for standardization (metadata, file format, etc) across DACs. It is suggested that two updates are made, the first one in 2010 and the second one in 2012. A meeting with CLIVAR DACs is being planned as an effort to publish a DVD with ocean observations from 1990. A 4th GSOP meeting will take place at the JAMSTEC Tokyo Office from 11 - 13 November 2009.

The PAGES/CLIVAR Intersection Working Group: Summary of Activities

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The PAGES/CLIVAR Intersection Working Group is jointly sponsored by the Past Global Changes (PAGES) project of the International Geosphere-Biosphere Program (IGBP) and the Climate Variability and Predictability (CLIVAR) project of the World Climate Research Programme (WCRP). It plays an important role in developing and implementing the research programs of both CLIVAR and PAGES to improve the understanding of decadal to centennial climate variability. Studying the association between changes in potential climate forcings and reconstructed climate variability, using a combination of empirical and simulation approaches, offers real prospects for an enhanced understanding of the mechanisms and likely course of climate change. The key scientific issues being addressed by the working group are:

- Climate variability over the last few millennia
- North Atlantic circulation changes
- Hydrological changes and interactions with the land surface
- Tropical cyclones, extreme precipitation events

The Fourth Session of the working group was held in Trieste in June 2008, in conjunction with the PAGES/CLIVAR Workshop: Reducing and Representing Uncertainties in High Resolution Proxy Climate Data. The working group revisited and updated its Vision Document that was originally published in 2004. Since 2004, the working group has organised a number of workshops on the subjects of paleo-climate reconstructions and the relevance of past climate data for future predictability. The latest workshop focused on reducing uncertainties in those reconstructions and resulted in a workshop report (Cobb et al., 2008) and 6 proxy-specific White Papers (available from the PAGES website: http://www.pages-igbp.org/cgi-bin/WebObjects/products.woa/wa/product?id=331). The primary goals of this workshop were to:

- Identify the main sources of uncertainty in the different types of proxy data.
- Make recommendations for how to better represent proxy error to non-specialists.
- Develop strategies for reducing uncertainties associated with each proxy type.
- Develop an internationally coordinated strategy for re-sampling existing key proxy sites and sampling key new sites for each climate proxy.

The following recommendations were made at the workshop:

- Increase replication of high-resolution paleoclimate records so that uncertainties can be explicitly quantified.
- On-site monitoring of environmental parameters will enable more accurate estimates of proxy uncertainties, as well as facilitate forward modeling of proxy records.
- The improved integration of proxy data with modeling efforts is required to ensure that paleoclimate proxy data play a meaningful role in IPCC-related activities.
- Develop standards for the representation and archival of high-resolution proxy metadata in order to facilitate their incorporation into large-scale multi-proxy synthesis and climate modeling efforts.
- Consider additional community-wide activities that address crosscutting needs in the high-resolution paleo community, including international standards and structures for sample archival and the urgency of collecting disappearing paleoclimate archives for future work.

Over the next few years, the working group plans to continue the progress in facilitating improvements in proxy-based reconstructions and model-data comparison, with particular foci on the role of paleo-climate data in reducing the uncertainties in climate projections highlighted by the IPCC Fourth Assessment Report. The Paleoclimate Reconstruction Challenge, a NOAA funded project operating under PAGES/CLIVAR contributes towards to the assessment and improvement of climate reconstructions by means of synthetic (modelled) climate histories as reconstruction targets and pseudoproxy data (http://www.pages-igbp.org/science/prchallenge/). Some of the issues being addressed by the Reconstruction Challenge are:

- Is true climate covered by range of the reconstructions?
- What is reconstructed well, what is still missed (tropics, modes)?
- What is the influence of proxy-level uncertainty, how is it estimated and ultimately associated with reconstructions?
- What proxy network specifications are required for useful reconstructions, and what are optimal networks?

The PAGES/CLIVAR Intersection Working Group believes that the proxy record over the last two millennia provides a valuable means of evaluating coupled atmosphere-ocean general circulation models and their internal parameterisations. Through coordination with WGCM, the working group will encourage international modelling groups to undertake multi-model ensembles of integrations of the last two millennia and 6 ka BP employing a consistent set of forcings and agreed protocols. These simulation experiments should be produced using the same Earth System Models that will be used for AR5 of the IPCC. The working group will also promote mechanisms to facilitate the storage and routine distribution of the model output arising from such efforts to be made available in the same formats and data bases used for IPCC model experiments, eg. the IPCC AR4 model experiments at PCMDI or at the PMIP-servers. To this end the working group would like to open discussions with the PMIP group in the near future to encourage greater community involvement and to support a stronger integration of their efforts to coordinate with the WGCM preparations for IPCC AR5.

The working group would also like to encourage the establishment of a database of natural climate forcings of the last 2000 years and to, more generally, foster development of more active data repositories that would facilitate the work of data synthesis and will be active to encourage the development of more useful archives – either through the addition of more metadata, or the creation of new access tools.

There are a number of crosscutting themes that are specific to this working group and areas in which there is substantial room for interaction with other WCRP panels. Specifically, the panel believes that the forward modelling of proxy data whereby the proxy data is explicitly modelled directly by Earth System Models, is of fundamental importance to further improving model-paleo data comparisons. Given the diverse range of available proxies and local climatic influences upon them, it is essential that the researchers most closely involved with proxy development play a major role in the development of suitable forward models that can be either incorporated within climate models directly, or used, in conjunction with downscaling techniques, to translate climate model output.

Secondly, reducing uncertainties in proxy reconstructions (and in data synthesis in general) is very important for improving targets for climate modelling and in better understanding the intrinsic variability and forced response of the climate system.

The working group contributes more widely to the WCRP crosscutting topics and the PAGES Science Plan in the areas of atmospheric chemistry and climate, anthropogenic climate change, decadal prediction, monsoons, extreme events and sea level rise, where paleoclimate data can potentially illuminate past behaviour of these systems and provide a test bed for model predictability.

One of the main responsibilities of the panel is to organise workshops that promote the study of the issues raised above. The proposed schedule for future workshops is as follows:

Workshop 1. Forward Modelling and regional downscaling
Fall 2009 AGU (organiser: Nick Graham, Caspar Ammann)

Workshop 2. AMO: Mechanisms and Impacts
3-day workshop, which we will seek to organise jointly with the CLIVAR Atlantic Panel. Tentatively attached to the International Conference on Paleoceanography (ICP) at Scripps in 2010. (organisers Mike Mann and Eystein Jansen)

Workshop 3. ENSO: Past and future variability
Small workshop attached to a more general meeting on the Tropical Pacific – potentially in association with the CLIVAR Pacific Panel and the PAGES Global Monsoon WG (potential organisers: Julien Emile-Geay, Mike Mann, Axel Timmerman).

Workshop 4. Paleo-data/Model fusion – Data assimilation. Potential organisers Hugues Goosse, Andreas Schmittner, possibly as a special session at an EGU/AGU conference.

Workshop 5. Extreme events (Tropical cyclones, extreme precipitation events, flooding).

Evaluate status after Pages Open Science Meeting in 2009, then decide scope of possible PAGES/CLIVAR activity

The working group recommends that it is vitally important that any future CLIVAR/WCRP framework acknowledge the role that paleoclimate can play, in extending records past the instrumental period, in testing theories of climate change and in providing quantitative targets for climate model experiments. A strong focus is required for coordination of data in terms of the synthesis of existing efforts (satellite, instrumental, paleo), the development of new tools to make much better use of existing data and to encourage the adoption of open science standards.

Relevant Reference

Cobb, K., T. Kiefer, J. Lough, J. Overpeck and S. Tudhope, 2008: Representing and Reducing Uncertainties in High Resolution Proxy Climate Data. Summary report of the PAGES/CLIVAR Workshop: Reducing and Representing Uncertainties in High Resolution Proxy Climate Data, Trieste, Italy, June 2008.

CLIVAR/CCI/JCOMM Expert Team on Climate Change Detection and Indices activity

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1. ET meeting and associated workshops

The Expert Team (ET) met for a day in May 2008 at KNMI, the Netherlands, in association with a 2-day Workshop on "Extremes in a Changing Climate" jointly organized by the ET and the EU-FP6 project ENSEMBLES. This was followed the next day by a discussion meeting on "Issues of Scaling" organized by Lisa Alexander (University Of New South Wales) and aimed at how we can adequately compare observed extremes from station data with model output. At its meeting the ET surveyed JCOMM perspectives for the ET including proposals for ocean climate indices and further developments in the ET's R-software used for ET capacity building workshops.

The key question addressed at the joint workshop[1] was how best to assess the probabilities of occurrence of extremes in a changing climate. Its outcome is a WMO Guideline document on this subject which is currently being finalized. The outcome of the "Issues of scaling" meeting has been a set of guidelines and suggestions for the modelling and observational communities that will hopefully make comparison easier in future, particularly with a view to the timeline of the IPCC's Fifth Assessment Report (AR5). The guidelines are available on the ETCCDI web pages. Planning for the panels contributions to IPCC AR5 more widely is currently in hand, building on from the ET's efforts for, and significant impact on, the IPCC WG1 AR4 Report.

1 See http://www.knmi.nl/samenw/ensembles_rt5/etccdi/debiltmeeting/

2. Other workshops/meetings held since SSG-15

Since CLIVAR SSG-15 (September 2007), the ET has also held/had strong association with two regional workshops as follows:

- Exploring changes in South East Asia temperature and precipitation extreme indices, Hanoi, Viet Nam, December 3-7, 2007. This workshop had 17 participants from 11 countries across the Southeast Asian region.
- Workshop on Detection and Indices of Climate Change in Mexico, Pueblo City, March 23-27, 2009. This workshop, while not formally organized by the ETCCDI, used the ETCCDI format. Also, ET members (specifically Phil Jones) played a very active role in organizing the workshop, which was funded by the Strategic Fund Programme of the British Embassy in Mexico.

Amongst other contributions, the ETCCDI website was translated into Spanish for the workshop. This workshop had 40 participants. See http://zimbra.ine.gob.mx/tallerIndices/.

In addition:

- The International Ad-hoc Detection and Attribution Group (IDAG), which includes several ET members and has objectives related to those of the ETCCDI, met in Boulder, January 21-23, 2009. It reviewed advances on detection and attribution on extremes, amongst other topics.
- Working Groups I and II of the IPCC jointly organized a meeting to consider the possibility of an IPCC Special Report on Managing the Risks from Extremes. This meeting was held in Oslo, February 23-26, 2009. The ET co-chairs actively participated in the meeting, Francis Zwiers as a member of the Science Steering Group. A scoping paper proposing a Special Report was produced and the IPCC recently made the decision to proceed with the proposed report at its 30th Session (Antalya, Turkey, April 21-23, 2009). The report will include a chapter on observed and projected changes in extremes, and will provide an early opportunity to assess our current ability to detect and attribute changes in extremes.

3. Publications

A paper advertising the work of the ET ("Monitoring Changes in Extremes – A Tale of International Collaboration" by Thomas Peterson and Mike Manton) has appeared in the September 2008 edition of BAMS. ET members also published a paper in the April 2008 edition of the WMO Bulletin ("The adaptation imperative: is climate science ready?" by Xuebin Zhang, Francis Zwiers and Thomas Peterson) drawing attention to the fact that adaptation must be well informed by climate science.

4. Links to sponsors

The ET's main interactions with outside bodies are through its sponsors, the WMO Commission for Climatology (CCl) and the Joint WMO-IOC Technical Commission on Oceanography and Marine Meteorology (JCOMM). The work of the ET on extreme events and how they are changing is also directly relevant to the WCRP Climate Extremes Cross Cut and its work on extremes in a changing climate is a contribution to the WCRP's Anthropogenic Climate Change (ACC) Cross Cut. The ET will work with the WCRP/CLIVAR Working Group on Coupled Modelling and provide expert advice on indices that should be calculated from coupled model simulations, in particular the planned decadal and long term climate simulations.

5. New activities being planned, including timeline

The ET has a well defined work plan that was developed at its Nov 2006 meeting, and reviewed at the recent meeting at the KNMI mentioned above. Items to which the ET will attend in the current year include a review paper on climate indices and finalization of the approach that will be used to provide indices for assessment in the AR5 from the CMIP5 experiment. Several approaches are currently in discussion by the ETCCDI. It is noted that some modelling groups had difficulty implementing the calculation of indices as part of CMIP3. It is anticipated that high frequency (daily data) will be more widely available from CMIP5, which will facilitate the calculation of indices after the fact rather than at run time.

The ET will have to consider carefully how it should evolve for the next CCl cycle in consultation with CCl, CLIVAR, and JCOMM taking into consideration the WCRP Cross Cuts on Extremes and ACC. The current mode of operation of the ET, which involves indices research and development, implementation into standard supported software, application in standardized workshops, and synthesis into regional and global products is effective, and evidence is emerging that this activity is beginning to be somewhat self sustaining. Nevertheless, it is felt that a more sustainable approach is needed, and also that thought will have to be given as to how the ETCCDI can better serve developing world needs for climatic information to support adaptation. The WMO/World Bank series of workshops for Africa provide a potential model. The planned series of workshops includes an ETCCDI type workshop to develop capacity in monitoring and detecting change, a regional climate modelling workshop to similarly develop capacity to project future change, and an adaptation workshop to develop the capacity to use climatic information for adaptation.

6. Workshops/meetings planned

- Climate change data for the Indian Ocean Region; part of the Climate Change Adaptation Project for the Indian Ocean countries, which is financed by the Indian Ocean Commission, the French GEF, and the French Ministry of Foreign and European Affairs. The workshop is planned for September or October, 2009.
- WMO/World Bank Africa Workshop: The World Bank, GCOS, WCRP, WMO and the Nairobi based IGAD Climate Prediction and Applications Center (ICPAC) are collaborating to develop and implement the programme "Climate Observations and Regional Modeling in Support of Climate Risk Management and Sustainable Development." This programme will initially be implemented through three linked workshops for the ten countries of the Greater Horn of Africa (GHA), with the ultimate goal of implementing the programme in other regions under the sponsorship of the World Bank. A preparatory meeting was held in Geneva on 22-24 June 2009 for the detailed design of the workshop programme by experts in observations, modelling, and user needs. Albert Klein Tank (together with Thomas Peterson) will take the lead in organizing the first workshop in ETCCDI format.
- The International Ad Hoc Detection and Attribution Group (IDAG) will be meeting again in January, 2010.
- The next meeting in the series of International Meetings on Statistical Climatology (see overleaf) will take place July 12-16, 2010, at the University of Edinburgh. See http://cccma.seos.uvic.ca/imsc/

7. Web sites

The ET maintains websites on both the CLIVAR web pages and at http://cccma.seos.uvic.ca/ETCCDI/index.shtml which provides access to both data and indices in particular. The ETCCDI has added additional guidance[2] on data homogenization to its website in the form of a collection of classic examples of inhomogeneities that can be found in climate data sets.

2 See http://cccma.seos.uvic.ca/ETCCDI/docs/Classic_Examples.pdf

11th INTERNATIONAL MEETING OF STATISTICAL CLIMATOLOGY
UNIVERSITY OF EDINBURGH, SCOTLAND
JULY12-16, 2010

11IMSC will be the next in a series of meetings that have been held at roughly three years intervals since their commencement in late 1979, in Hachioji, Japan. That meeting, and every subsequent IMSC meeting, was designed so that statisticians and climatologists could meet to discuss issues and ideas at the interface of their two disciplines. 11IMSC will continue to promote the interaction between the two disciplines. Its program is being designed around a number of themes that will be explored in a series of thematic sessions on subjects that will include techniques for the analysis of multi-model ensembles of climate simulations; approaches for understanding recent climate change and predicting the near-term future; extreme events; predictions of climate change relevant for impacts; the adjustment and quality control of modern instrumental climate data; and the reconstruction and understanding of climate change over the Holocene from paleo climate data. In addition to these thematic areas, the meeting will also strongly encourage the submission of contributed papers in areas at the interface between statistics and climate. Pre-registration and abstract submission for the meeting will commence in October, 2009. For further information, please consult the IMSC website (http://cccma.seos.uvic.ca/imsc/imsc_home.shtml) or contact Stephanie West at the University of Edinburgh (Stephanie.West@ed.uk.ac).

Coherence between the winter Pacific Decadal Oscillation and the Surface Air Temperature trends in the continental regions adjoining the North Pacific

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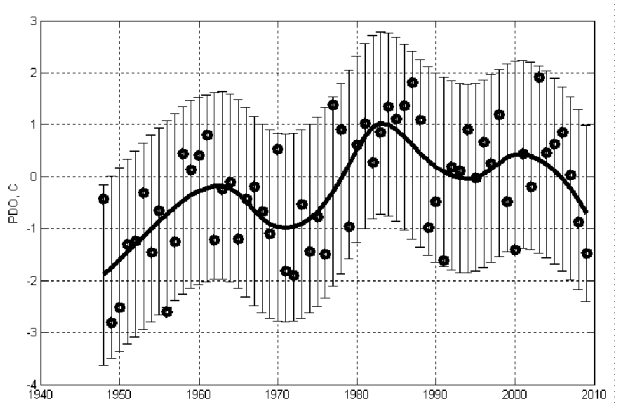
It is only in recent years that scientists are starting to recognize the impact of oceanic cycles on changing climate. The Pacific Decadal Oscillation (PDO) Index is defined as the leading principal component (the empirical orthogonal function N 1 (EOF1)) of North Pacific monthly sea surface temperature (SST) variability north of 20° N. Values of the index have been published for the period starting from 1900 (Trenberth, and Hurrell, 1994; Mantua, et al, 1997; Zhang, et al, 1997). Related investigation of the historic (1968-1990) Alaska Gyre dynamic height anomaly EOF1 was carried out by Lagerloef (1995). The PDO is a pattern of Pacific climate variability that transits from maximum to minimum on at least inter-decadal time scales typically of about 20 to 30 years (Hare and Mantua, 2000). The PDO is manifested as warm or cool surface waters in the Pacific Ocean. During a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms; during a "cool" or "negative" phase, the opposite pattern occurs. In the "warm" or "positive" phase, which appears most recently to have lasted from the middle seventies to nineties of the last century, the west Pacific Ocean became cool and a wedge in the east warmed (Hare and Mantua, 2000). The mechanism by which the pattern lasts over several years has not been identified; one suggestion is that a thin layer of warm water during summer may shield deeper cold waters (Overland, et al, 1999).

The oceanic influence on land surface atmospheric temperature occurs through hydrodynamic-radiative teleconnections, primarily by moistening and warming the air over land and increasing the downward longwave radiation at the surface (Bond and Harrison 2000). The oceans may themselves have warmed from a combination of natural and anthropogenic influences. The mechanisms giving rise to the PDO will determine whether skillful decades-long PDO climate predictions are possible. For example, if the PDO arises from air-sea interactions that

require around ten year ocean adjustment times, then aspects of the phenomenon will (in theory) be predictable at lead times of up to 10 years. Even in the absence of a theoretical understanding, PDO climate information improves season-to-season and year-to-year climate forecasts for North America because of its strong tendency for multi-season and multi-year persistence. From a societal impacts perspective, recognition of the PDO is important because it shows that "normal" climate conditions can vary over time periods comparable to the length of a human's lifetime. The primary conclusion of recent study (Compo and Sardeshmukh, 2008) based on 54 atmospheric general circulation model simulations of the last half-century with prescribed observed ocean temperature changes, but without prescribed greenhouse gas (GHG), aerosol, and solar forcing variations is that the continental warming is largely a response to the warming of the oceans rather than directly due to GHG increases over the continents.

The aim of this paper is to investigate a linkage between the PDO on one hand and the surface air temperature (SAT) on other hand over large land territories located more or less close to the North Pacific during last sixty years. To achieve this aim we seek to filter out interannual climate variability by means of technique of non-linear trend (NLT). A linear trend (LT) technique, which is the most widely used approach, permits us only to find a general tendency in climate index changes (decreasing or increasing) at long time intervals, e.g. several decades or centuries. There are two main disadvantages of LT: its dependence on base time interval selection and very wide confidence bands for estimated trend values. A confidence band is used in statistical analysis to represent the uncertainty in an estimate of a curve or function based on limited or noisy data. The latter makes the LT estimates rather uncertain in the case where the monotonous behavior of a climate index breaks down. Many authors have used a simple "moving window average" technique to smooth climate time series. In most cases the window width is a constant value. That makes such an approach rather inflexible to non-stationary behavior of climate interannual fluctuations. Our approach (Pokrovsky, 2009) seeks to implement the advantages of several sophisticated mathematical methods for climate time series analysis and, more particularly, to reveal non-linear trends or detect non-linear tendencies at interdecadal time scales, relevant to natural climate variability caused by low oscillations in SST. Background methods are: 1) a new smoothing algorithm addressed to non-stationary processes and based on Wahba's cross-validation, 2) Cleveland's local polynomial approximation to provide a best fit to the changing scale of climate variability, and 3) Tikhonov's regularization to optimize a smoothing rate; (Cleveland, 1979; Tikhonov, 1963; Wahba, 1985). The suggested technique provides on the one hand a smoothing curve with a minimal deviation from observations; on the other hand it permits detection of evident (positive, negative or transitive) tendencies at the interdecadal time intervals.

The PDO is a long-lived ENSO (El Niño / La Niña + Southern Oscillation)-like pattern of Pacific climate variability (Zhang et al., 1997). The ENSO and PDO have similar spatial and temperature patterns, but show different time scales. While ENSO events are inter-annual phenomena, the PDO covers decades (Figure 1a). The PDO series for 1900-2009 has a linear trend close to zero. An entire oscillation interval comprised of consecutive warm and cool phases, may extend over more than 60 years. The PDO demonstrated positive phases in the thirties-forties and in the seventies-eighties, and negative phase in the fifties-sixties. It had a positive LT since 1948, but has shown a negative trend since the middle of the eighties again. Thus the LT technique is not an appropriate tool to investigate such a natural slow climate oscillation. Motivation for this investigation came from a recent paper (Pielke, et al, 2007) where a role of natural climate oscillations in recent climate changes was reconsidered. We have analyzed only winter data because of the standard oceanographic assumption that the strongest



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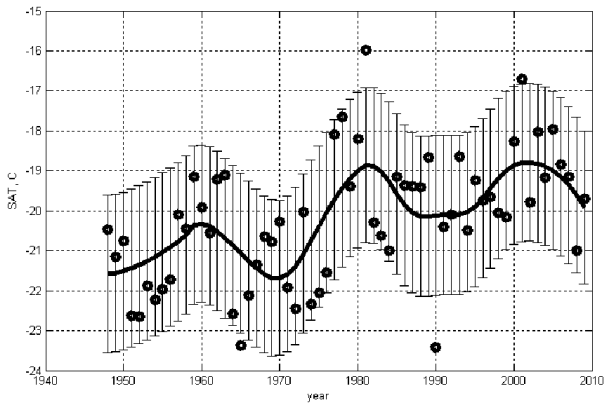

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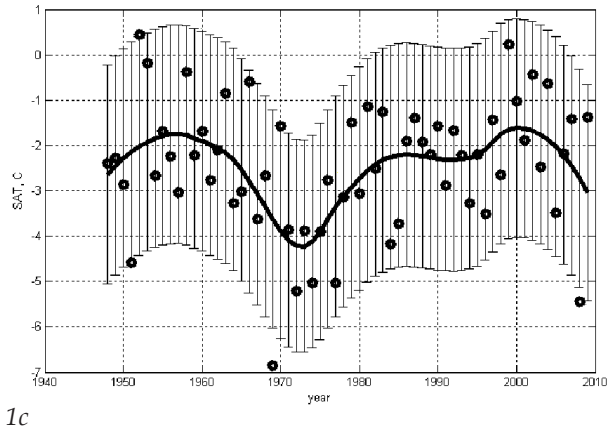

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Figure 1: Relationship between the Non-Linear trends and the confidence intervals with the 5% significance levels for winter climate series: (a) PDO values; (b) Surface Air Temperature values in the Pacific SubArctic area (Eastern Yakutya, Chukchi Peninsula in the North-East Siberia and Alaska), and (c) in Central Asia.

ocean-atmosphere interactions occur in the cold season when the solar radiation forcing is minimal. The PDO is one of the most important climate indicators. Our first assumption was related to the possible impact of the PDO on slow oscillations of the SAT in adjoining land territories. Cross-correlation and time series analysis carried out with NCEP/NCAR reanalysis monthly data permited us to find several areas in the land domain adjoining the North Pacific where winter SAT reveals negative LT since the beginning of this century. There are two large neighbouring areas of PDO impact: 1) the Pacific SubArctic including Eastern Yakutya, the Chukchi Peninsula in North-East Siberia and Alaska (55°-75° N; 160°-270° E), 2) Central and Western USA (30°-50° N; 85° -115° W). Cross-correlation analysis of the PDO and SAT in the winter seasons permits us to reveal an unknown PDO teleconnection with an area located in Central Asia (30°-50° N; 50°-80° E).

The most closely correlated pair is the winter PDO (Figure 1a) and the winter SAT in Pacific SubPolar Arctic (Figure 1b). The PDO and SAT smoothed curves we call a non-linear trend (NLT). These curves demonstrate similar extreme value configurations. Maxima are located close to 1960, 1980 and to 2000 and minima to 1970 and 1990. It is necessary to underline that the last historical maximum (close to 2000) is more pronounced in the SAT curve than in the PDO one. The cross correlation between the above smoothed climate magnitudes achieved a very high - 84% - level in this case. The next cross-correlation value was found for the pair of the PDO and the Central Asia SAT smoothed curves (Figure 1c). This SAT series follows all PDO extreme value locations with a few biases of 1-3 years. Error bars presented in Figure 1 correspond to the 5% statistical significance (95% probability) level. The mean value of the PDO NLT uncertainty (error bars) with this significance level is equal to 3.2. The corresponding uncertainty spread for the PDO LT is equal to 4.1. The difference between above spread values gives quantitative information on the efficiency of the NLT technique compared to that for the LT.

The next step in our study was concerned with finding the time scale of the slow oscillations of the above climate series. A very efficient tool to investigate this topic is wavelet analysis due to its applicability to non-stationary processes. In a previous paper (Pokrovsky, 2008) we demonstrated that the Atlantic Multidecadal Oscillation (AMO) and Arctic ice extent are mutually coherent and have an inter-decadal periodicity of 60-70 years scale. Similar wavelet analysis has been carried out for the PDO and related to the SAT for nearby land territories. The PDO wavelet spectrum (Figure 2a), computed for more than hundred years permits us to reveal two major oscillation components of 64 and 32 years, respectively. The 64-year component is much stronger. Wavelet computation for the PDO series 1948–2009 gave practically the same spectrum structure. It is interesting to note that the SAT wavelet spectra corresponded to the three mentioned PDO impact land areas (Pacific SubArctic, Central and Western part of USA and Central Asia) demonstrated similar features. The SAT wavelet spectrum for the USA (Figure 2b) computed for sixty years permits us to reveal two major oscillation components of 64 (strongest) and 32 years, respectively. The SAT spectra, besides having a very strong 64-year component, reveal a 128-year harmonic. The strongest occurrs for the Central Asia domain. The 128-year anomalies might be explained as a contribution of the LT.

In summary, our results emphasize the significant role of remote oceanic influences, rather than the eventual direct local effect of anthropogenic radiative forcings, in the recent continental warming. They suggest that the recent oceanic warming has caused the continents to warm through a different set of mechanisms than usually identified with the global impacts of SST changes. The indirect and substantial role of the oceans in causing the recent continental warming emphasizes the need to generate reliable projections of ocean temperature changes over the next century, in order to generate more reliable projections of not just the global mean temperature and precipitation changes, but also regional climate changes.

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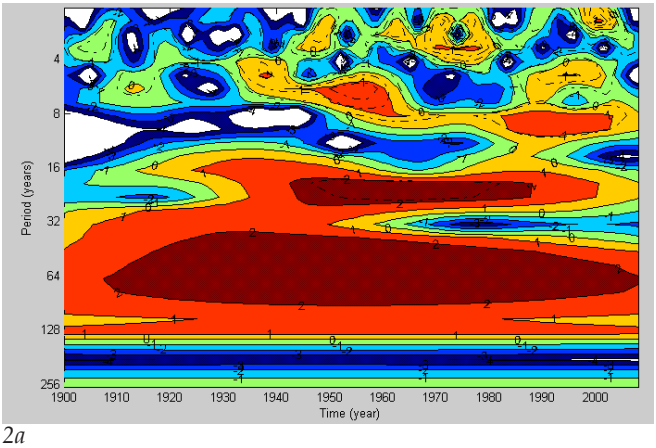

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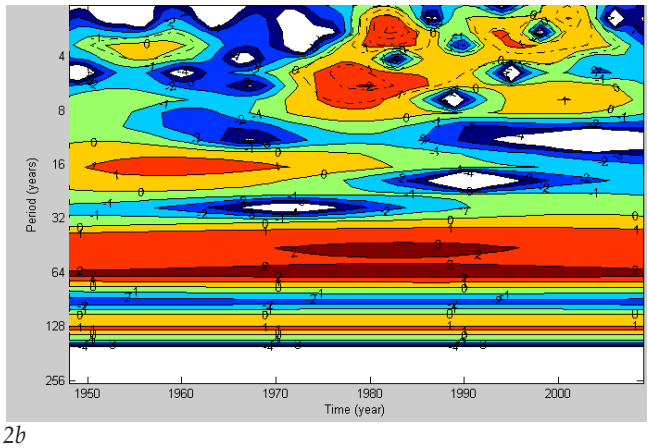

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Figure 2: Coherency in Wavelet Power Spectrum (log_2 scale) for the winter climate series of: PDO values (left panel) and Surface Air Temperature values in the Central and Western Part of the USA (right panel).

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How does El Niño Modoki affect the Australian monsoon?

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1. Introduction

Over recent decades, a different flavor of El Niño has been observed in the tropical Pacific. These events, recently-termed El Niño Modoki, are characterized by warm SST anomalies in the central Pacific straddled by colder anomalies to either side (Ashok et al., 2007). Although the mechanisms behind El Niño Modoki episodes are still elusive, it is clear that their impacts on regional climate are distinct from those related to a canonical El Niño (Wang and Hendon, 2007).

In this study we assess the impacts of El Niño Modoki events on the Australian monsoon climate, using observations and simulations with an atmospheric general circulation model (AGCM).

2. Data and Methods

The following datasets are used in this study: (1) the global SST analysis from the Hadley Centre (HadISST1); (2) rainfall from the Australian Bureau of Meteorology (BoM); (3) winds, specific humidity and vertical velocity from the NCEP/NCAR Reanalysis. We confine our analysis to the more reliable post-satellite era, namely the period from 1979 to 2005.

The NCAR Community Atmospheric Model (CAM3) is used to assess the sensitivity of Australian rainfall to different locations of SST warming in the Pacific. The AGCM is forced with climatological monthly SST values and a superimposed 1ºC positive SST anomaly along the equatorial Pacific, bounded between 10ºN and 10ºS and longitudinally located in: (1) the eastern Pacific, from 120ºW to 80ºW; (2) the central-eastern Pacific, from 160ºW to 120ºW; (3) the central-western Pacific, from 160ºE to 160ºW; and, (4) the western Pacific, from 120ºE to 160ºE.

3. Results

Observations

The Modoki SST pattern appears as the second mode of interannual variability in an Empirical Orthogonal Function analysis over the tropical Pacific, accounting for approximately 12% of the total variance (Ashok et al., 2007). Taschetto and England (2009) have shown that when a Singular Value Decomposition (SVD) analysis is performed with seasonal Pacific SST and Australian rainfall data, the Modoki pattern actually appears as the leading mode of variability during austral autumn (MAM). It is associated with dry conditions across the continent, particularly to the north, during MAM.

The robustness of the SVD result was verified by the authors via composites of SST, rainfall, vertical velocity and velocity potential anomalies for the El Niño Modoki events in 1980, 1987, 1991, 1995 and 2003. A comparison of the impacts from Modoki events with the traditional El Niños of 1982, 1987 and 1997 revealed a marked difference over Australia: while classic El Niños are associated with a significant reduction in rainfall over northeastern and southeastern Australia during SON, the Modoki events appear to drive a large-scale decrease in rainfall over northwestern and northern Australia during MAM.

Associated with the Modoki SST pattern there is an upward motion through the deep troposphere centered at 180ºW, west of the rising air in the conventional ENSO-composite circulation. As a consequence, anomalous divergence is seen in the central-west Pacific that causes convergence and thus subsidence over South America and Indonesia, forming a double Walker Cell, as described by Ashok et al. (2007).

Interestingly, when the SVD and composite analyses are carried out for the austral summer season (DJF), northern Australia does not show strong dry conditions (not shown). This raises the question of why DJF rainfall does not show negative anomalies similar to MAM for the same Modoki signature. To address this question we examine the monthly evolution of rainfall during El Niño Modoki events.

Figure 1 depicts the December through March rainfall anomalies composited for El Niño Modoki events. Strikingly, it reveals the opposite signal in January and February compared to December and March. As a result, the SVD and composite analyses for the averaged summer season did not show a strong response as the negative and positive anomalies on individual months offset each other. This gives a false impression that the Modoki anomalies do not have a strong impact on Australian climate during the summer monsoon.

The reduced rainfall in December and March and increased rainfall in January and February is a robust signal across observed Modoki events. This can be seen in Figure 2 which shows the annual rainfall cycle averaged over northern Australia (12ºS-24ºS, 120ºE-135ºE) for individual Modoki years compared to the long-term climatology. The Modoki-related anomalies lead to a shortening of the monsoon season over northern Australia, with an associated intensification of precipitation in January and February. In other words, Modoki events can be associated with a late monsoon onset and an early monsoon termination over Australia.

To investigate the mechanisms behind the shorter and more intense burst of precipitation, we calculated the vertically integrated moisture flux from the surface to 500hPa and its associated divergence field. Figure 3a (page 38) reveals that intensified rainfall in February results from a stronger convergence of moisture caused by an anomalous cyclonic circulation over northwestern Australia. On the other hand, Australia experiences a divergence of moisture in March (Figure 3b) and thus drier-than-average conditions. The rainfall decrease in March is exacerbated by the subsidence of the western branch of the anomalous Walker circulation during Modoki events. However, anomalous subsidence is not evident over northern Australia in February (figure not shown).

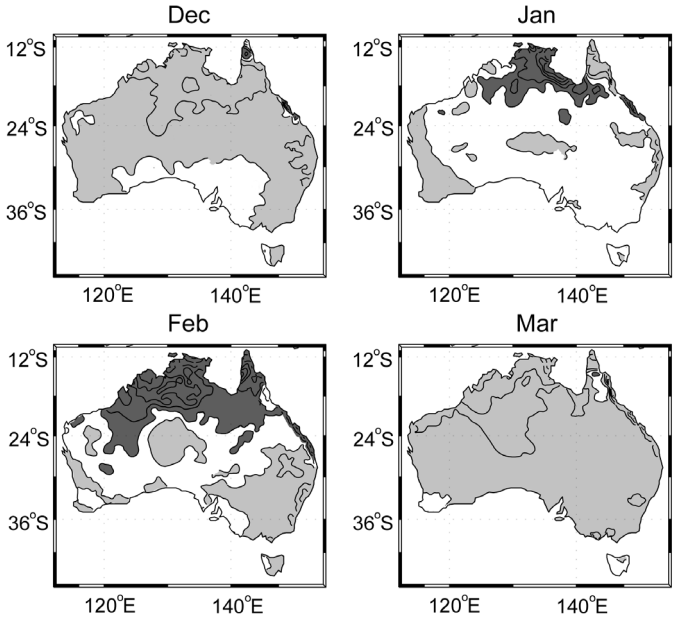

Figure 1. Rainfall anomaly composite for Modoki years from December to March (1979/1980, 1986/1987, 1990/1991, 1992/1993, 1994/1995 and 2002/2003). Positive values greater than 1mm/day are dark shaded and negative values are light shaded. Contour intervals are 1mm/day.

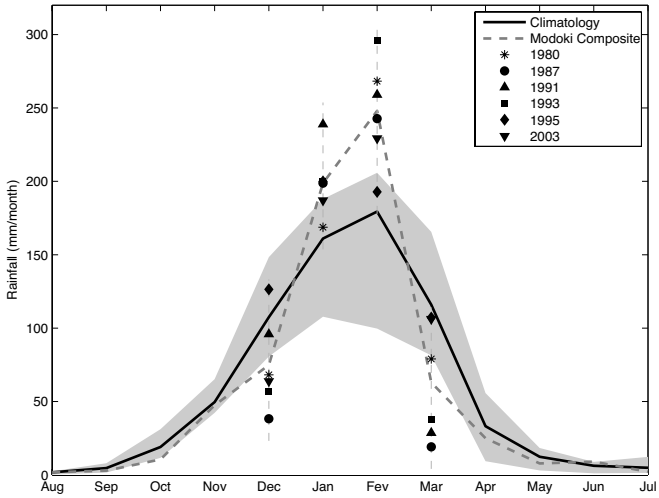

Figure 2. Annual cycle of rainfall in northwestern Australia. The black thick line represents the climatology and the dashed line indicates the mean anomalous behavior during El Niño Modoki years. Individual Modoki events from December to March are highlighted with symbols. Values outside the gray area are significant at the 95% level based on a Monte Carlo test.

The numerical experiments

The sensitivity of Australian rainfall anomalies to the location of warming along the equatorial Pacific is examined by applying warm SST anomalies at different tropical locations in numerical experiments (e.g. Fig. 3c,d). The idealized experiments show an overall rainfall increase in February and a decrease in March. The strongest rainfall response in February (wet) and March (dry) is seen when the positive SST anomaly forcing is located in the central-west Pacific (not shown). This corroborates Wang and Hendon (2007)'s finding that Australian climate is sensitive to the location of SST anomalies in the tropical Pacific. In addition, SST warming around the Dateline, typical of Modoki events, tends to impact more strongly on Australian rainfall, in the simulation, than the positive anomalies located in the east, as found during traditional El Niños.

The experiment forced with the SST warming in the central-west Pacific captures a convergence of moisture flux in February (Figure 3c) and a divergence over Australia in March (Figure 3d). This result suggests that a warming solely in the central-western Pacific may be sufficient to drive the monsoonal changes observed in Modoki years (Fig. 3a,b).

4. Conclusions

Changes in the magnitude and location of El Niño-induced-SST warming have significant implications for Australian rainfall. In this study we show for the first time that Modoki is associated with below-normal rainfall over northern Australia in December and March to May and intensified precipitation during January and February. This leads to a shorter and intensified monsoon season. This result appears very robust, occurring in almost all the Modoki events (for details, see Taschetto et al., 2009).

The increase in precipitation in January and February is caused by anomalous convergence of moisture flux onto the continent. The decreased rainfall in the other months

occurs via a divergence of moisture and the subsidence from the western branch of the altered Walker circulation during Modoki events. The reason why the subsidence is not seen in February remains unclear.

Using numerical experiments we showed that the Australian monsoon rainfall responds more strongly to a warming located in the central equatorial Pacific compared to a warming located in the east. The experiment with warming in the central-west Pacific simulated an anomalous convergence of moisture in February and an anomalous moisture divergence in March, suggesting that the Modoki–related SST warming is a key factor in modulating Australian monsoon variability.

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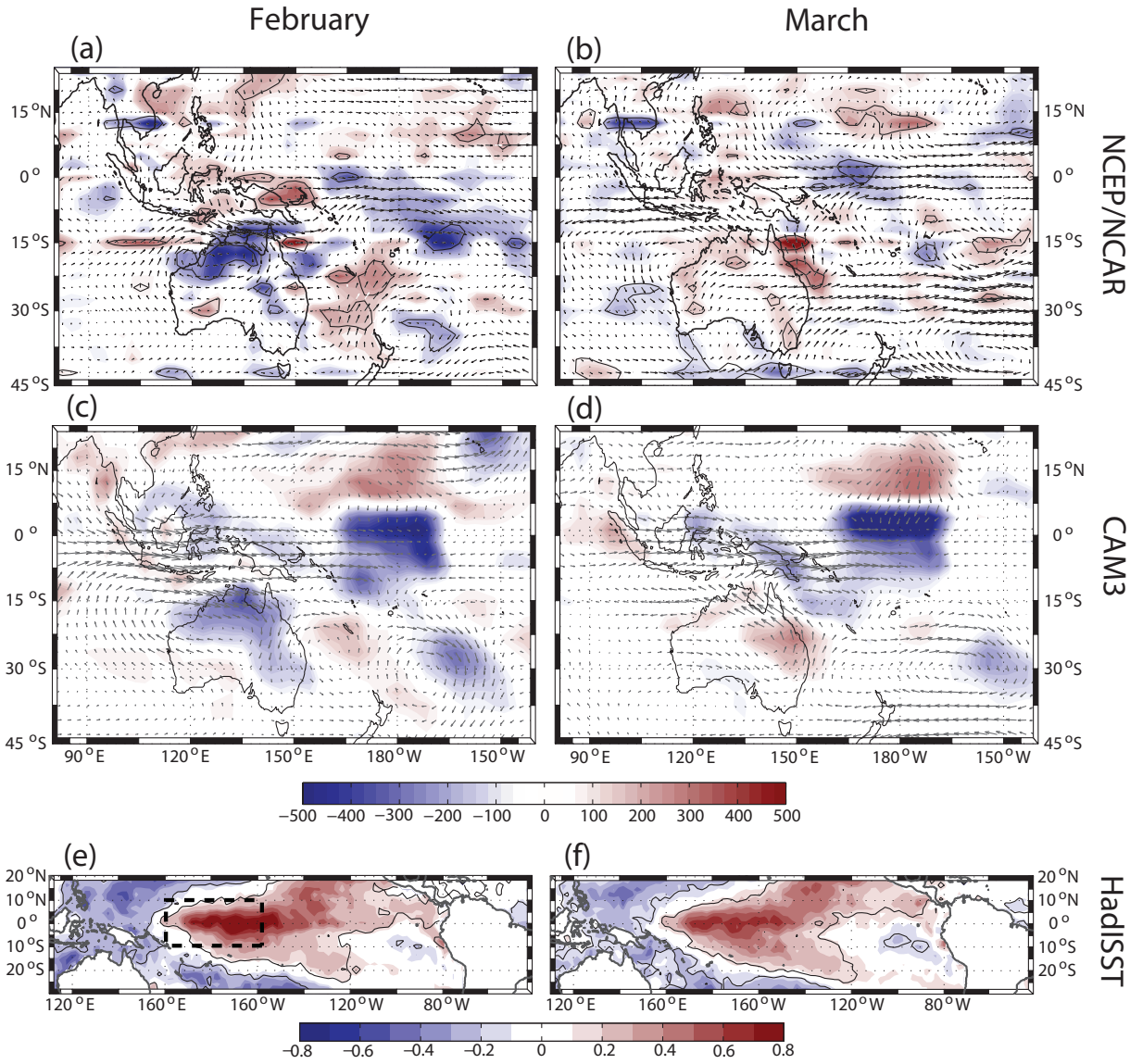

Figure 3. Composite anomalies of (a-d) moisture flux (kg m^{-1} s^{-1}), divergent moisture flux (kg s^{-1}) and (e-f) SST (Celsius) during Modoki events in February (left panels) and March (right panels). (a-b) NCEP/NCAR reanalysis, (c-d) NCAR CAM3 model and (e-f) HadISST. Areas within the thin black contours are significant at the 95% level. The solid black box in (e) represents the area where the SST anomaly was imposed to force the central-west Pacific experiment. The maximum vector length is 5 kg m^{-1} s^{-1}.

2009 US CLIVAR Summit Report

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US CLIVAR held its annual Summit during the second week of July 2009 in Annapolis, Maryland (USA). During the Summit the three US CLIVAR Panels met to review program progress as well as identify future activities. This year discussion focused on new Themes, or areas of scientific research that should become a focus of new US CLIVAR activities in the future.

The Drought and Western Boundary Current US CLIVAR Working Groups described the terrific synergy and activities stimulated. Their findings have been submitted for publication, including a Journal of Climate special issue on drought. The High-Latitude Fluxes Working Group is planning a workshop in March 2010 and a review paper. The Decadal Predictability Working Group has organized monthly teleconferences and held their first meeting in June 2009. The Atlantic Meridional Overturning Circulation (AMOC) Project (now involving nearly 2 dozen US PI's) recently organized its first international workshop (May 2009), and is coordinating activities in several areas, including prospects for additional AMOC observations, AMOC analyses, and ocean syntheses. In addition to these US efforts, reports on the new International CLIVAR Imperatives (Anna Pirani), and VAMOS (Hugo Berbery) provided valuable information on new directions and specific activities (i.e., within VAMOS) that should be considered by U.S. CLIVAR.

The Phenomena Observations and Synthesis Panel (POSP) discussed a wide range of activities and challenges, including a special focus on reanalyses and Integrated Earth System Analyses (IESA). They are considering a workshop on these issues sometime in 2010. The Process Study Model Improvement Panel (PSMIP) met and celebrated the successful issuance of a joint-agency Announcement of Opportunity for new Climate Process Teams (CPTs). They spent considerable time reviewing DYNAMO, a potential US field campaign targeting coupled ocean-atmosphere dynamics important for MJO initiation. They reviewed the state of current US-lead process studies (like CLIMODE and DIMES) and prospects for additional future studies (e.g. VAMOS IASCLIP). The Predictability, Predictions and Applications Interface Panel (PSMIP) addressed follow-on activities to the Drought Working Group; scoping of a new Tropical Biases Working Group (to be proposed later this year); and how to take advantage of upcoming Decadal Predictability / Prediction workshops. PPAI also celebrated the successful second year of its flagship activity: the Climate Prediction Applications Postdoctoral Program (CPAPP) that couples CLIVAR science with improved decision support.

Because of the effectiveness and synergy generated in response to current US CLIVAR "Themes" (i.e., "Drought" and "Decadal Predictability / Variability"), US CLIVAR wished to identify a few additional Themes, or scientific challenges for which US CLIVAR should be encouraging activities for the next 3-5 years. Two candidate themes were selected: Extremes (which will likely replace the Drought theme) and High-Latitude Climate Changes. Additionally, there was a strong push for US CLIVAR to develop Themes addressing a) climate and carbon cycle, b) ecosystems, and c) coastal interactions and feedbacks in a changing climate. Some of these new themes may already be the focus of other programs (e.g. within WCRP or IGBP); however, Summit discussions suggested that there is an opportunity and need for CLIVAR to more urgently and concretely develop partnerships with these other programs in order to address important scientific challenges that transcend disciplinary boundaries.

Over the next several months US CLIVAR will begin to scope out the scientific and programmatic landscapes associated with these new Themes in order to identify new activities (e.g., workshops, Working Groups, agency meetings) that would hasten scientific progress.

CLARIS LPB Project
A Europe–South America Network for Climate Change Assessment and Impact Studies in La Plata Basin

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The CLARIS LPB Project, funded by the European Community 7th Framework Programme, and a relevant activity associated with the GEWEX/CLIVAR La Plata Basin Regional Hydroclimate Project, aims at predicting the regional climate change impacts on La Plata Basin (LPB) in South America, and at designing adaptation strategies for land-use, agriculture, rural development, hydropower production, river transportation, water resources and ecological systems in wetlands.

CLARIS LPB is integrated by 20 Partner Institutions from South America and Europe (research institutes from France, Argentina, Brazil, Germany, Italy, Spain, Sweden, Switzerland, United Kingdom and Uruguay) and counts on the cooperation of various private institutions and NGOs. The project is coordinated with, and contributes to, the objectives of the LPB Regional Hydroclimate Project, an international project on La Plata Basin that has been endorsed by the CLIVAR and GEWEX Panels of the World Climate Research Programme (WCRP).

This multidisciplinary network is divided in four inter-related and fully complementary Subprojects (which are also divided in different work packages):

- Subproject 1: Management, dissemination and coordination activities.
- Subproject 2: Past and future hydroclimate. Its objective is to improve our description and understanding of past and future climate variability in order to better represent possible future climate scenarios and quantify their possible uncertainties.
- Subproject 3: Project interface. It aims at bridging the climate research with the socio-economic issues.
- Subproject 4: Socio-economic scenarios and adaptation/prevention strategies. It builds adaptation strategies to climate change on different issues associated with land-use, agriculture, deforestation, hydropower production, floods and ecological systems in wetlands.

The expected impacts of CLARIS LPB at the end of its four-year period are:

- Strengthening of the cooperation between European and South American multidisciplinary research communities
- Improvement of climate change impact prediction capacity for the region through the setting-up of an ensemble of multi-discipinary scenarios integrating in a coordinated way large-scale climate, regional climate, hydrological, land-use, and agriculture partners.
- Dissemination of adaptation strategies (specifically designed for land-use, agriculture production, rural development (small farmers), hydropower, flood risk, wetlands, ecological systems, river navigation, and near-river urbanization) based on ensembles of probable climate change scenarios for the period 2010-2040.

The CLARIS LPB Project was officially launched during a Kick-off Meeting held in Buenos Aires, Argentina, on November 10-13, 2008. About 70 researchers of the project were present, including members of the Executive Board, representatives from Partner Institutions, Work Package leaders, and senior and young scientists.

Map of Central South America showing the La Plata Basin outlined in red.

The Kick-off Meeting was an opportunity for the interaction of scientists within and among the work packages. They held scientific discussions around the Work Package objectives to clarify the role of each partner, the methods, the data, the interactions with other work packages, the implementation of common strategies, and the partners' needs in terms of expertise, knowledge and transference of tools.

Since the Kick-off meeting, three work packages (WP) have held new meetings, WP5, WP8, and WP9:

WP5 (Regional Climate Change assessments for La Plata Basin) met in Lund, Sweden in May 2009 to discuss regional scenarios for climate change which would be the input for the groups that work with possible impacts and adaptation strategies.

WP8 (Land use change, agriculture and socio-economic implications) and WP9 (Water resources in La Plata Basin in the context of climate change) met in Curitiba, Brazil in June 2009 to discuss methodologies to work with stakeholders and to include them in the design of adaptation strategies to climate change. There was general agreement that adaptation strategies to regional scenarios of climate change impacts require a multi-disciplinary approach where all the regional components (climate, hydrology, land use, land cover, agriculture and deforestation) are addressed in a collaborative way. Therefore, a multi-disciplinary/trans-sectorial team is crucial to successfully build adaptation strategies that politicians can apply.

The next scheduled meetings are those from the working packages dedicated to the study of past and future hydroclimate and extreme events in La Plata Basin.

CLIVAR WGOMD Workshop on Ocean Mesoscale Eddies: Representations, Parameterizations, and Observations

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1 Motivation and Goals for a Workshop on Mesoscale Eddies

The global ocean is a highly turbulent fluid, with scales of motion from the millimetre to global, on time scales from seconds to millenia. One of the most energetic scales is the mesoscale, where variability arises from the chaotic dynamics of geostrophic turbulence. The increasing power of satellite observations has confirmed that mesoscale eddies are a ubiquitous feature of the World Ocean (e.g., Chelton et al., 2007). Mesoscale eddies are critical for establishing ocean tracer properties; they affect the ventilation of heat, carbon, and other tracers; they support rich levels of biological activity; and they interact with smaller and larger scales.

A key weakness of nearly all global climate models used to study climate is the absence of an explicit representation of ocean mesoscale eddies, since their spatial scale is smaller than typical climate model grid meshes can resolve. Hence, the models rely on parameterizations. The most popular parameterizations originate from the tracer diffusion scheme of Solomon (1971) and Redi (1982) (i.e., neutral diffusion, as well as the eddy induced tracer stirring proposed by Gent and McWilliams (1990) and Gent et al. (1995). Many studies have shown that these parameterizations improve simulations relative to models run in their absence, prompting the parameterizations to be used by nearly all IPCC-class ocean climate models. Nonetheless, there remain many unresolved questions, both fundamental and practical, which support a very active research community aimed at providing more robust and flexible parameterizations of mesoscale eddies. In parallel to research aimed at understanding and parameterizing the mesoscale, the modelling community has steadily seen an increase in the numerical integrity of model codes, and the refinement of resolutions available for representing the ocean circulation. This effort has led to a few global, or near global, simulations with vigorous mesoscale eddy variability.

The intense level of research activities related to ocean mesoscale eddies prompted the CLIVAR Working Group for Ocean Model Development (WGOMD) to organize a three-day scientific workshop at the UK Met Office from 27-29 April, 2009. The main goals of the workshop were the following:

- To educate the research community regarding the importance of mesoscale eddies in theWorld Ocean, and correspondingly for establishing features of the ocean climate system;
- To identify best practices for parameterizing ocean mesoscale eddies in coarse resolution climate models, and to discuss various research avenues for improved parameterizations;
- To evaluate the ability of state-of-the-science numerical models to accurately represent the ocean mesoscale in eddying simulations.

In addition to these intellectual aims, the workshop was held to honour the seminal works of Gent and McWilliams (1990) and Greatbatch and Lamb (1990). After nearly 20 years, these works remain the touchstone for studies of mesoscale eddy parameterization and theory. Finally, the workshop represented a memorial to the tireless and intellectually penetrating work of Peter Killworth, who passed away in January 2008. Peter was a leader for more than a generation of physical oceanographers, whose work touched upon many aspects of observations, parameterizations, and modelling. He will be deeply missed.

2 The UK Met Office Workshop

The workshop consisted of six speakers per day, with each speaker presenting, in a pedagogical manner, different views on the state-of-the-science in ocean mesoscale eddies as seen through observations, simulations, and theory. The following workshop speaker list consists of a who's who in oceanography.

Participants at the Workshop at the UK Met Office, 27-29th April 2009.

Day 1: Observing and simulating the ocean mesoscale

- CarlWunsch (MIT): Observations, simulations, and assimilations
- Dudley Chelton (Oregon State University): Global mesoscale eddy variability from satellite altimeters
- Matthew Hecht (Los Alamos): POP simulations in an eddying regime
- Steve Rintoul (CSIRO): Mesoscale processes in the Southern Ocean
- Malcolm Roberts (UK Met Office Hadley Centre): Impacts of the mesoscale on coupled phenomena
- Frank Bryan (NCAR): Tracer transport in eddy resolving global ocean simulations

Day 2: Parameterizing the mesoscale

- Peter Gent (NCAR): Gent-McWilliams with 20/20 hindsight
- Richard Greatbatch (IFM-GEOMAR): Interpretation of mesoscale eddy mixing
- Carsten Eden (IFM-GEOMAR): Parameterisation of mesoscale eddy mixing
- David Marshall (Oxford University): Parameterisation of geostrophic eddies: energetics, conservation and flow stability
- Trevor McDougall (CSIRO): Thermodynamic equation of state of seawater-2010
- John Marshall (MIT): The interplay between baroclinic instability, geostrophic turbulence and Rossby waves in the ocean (and routes to parameterisation)
- Raffael Ferrari (MIT): Lateral and vertical variations in eddy mixing

Day 3: At the frontier

- Michael Bell (UK Met Office): Forecasting the ocean mesoscale
- Mike Spall (WHOI): Eddies and deep water formation
- Andreas Oschlies (IFM-GEOMAR): Eddies and ocean biogeochemistry
- Baylor Fox-Kemper (University of Colorado): Submesoscale dynamics and parameterization
- Anne-Marie Treguier (IFREMER): Anisotropy, momentum fluxes: a few remaining challenges for parameterizations
- Jim McWilliams (UCLA): Eddy roles in the general circulation

Each speaker was given 70 minutes to delve in-depth into the chosen subject, and for questions and discussion with the 140 participants. Additionally, there was time during breaks, lunch, and evening socials to view more than 40 posters from students, post-docs, and senior scientists. The presentations and most of the posters are available on the meeting webpage http://www.clivar.org/organization/wgomd/meso/meso.php.

The organizers wish to thank the UK Met Office for hosting the workshop and NOAA, NASA and NSF for generously awarding us additional funding that enabled us to provide travel support for thirteen young scientists who presented posters at the meeting.

3 Workshop Summary

It is difficult to summarize the content of a workshop such as this, where the variety of ideas discussed extend well beyond the number of speakers. Hence, to help in communicating certain of the workshop topics, the editors of Ocean Modelling, the journal founded by Peter Killworth, are planning a special edition in 2010. We have learned a tremendous amount in the 20 years since Gent and McWilliams (1990) and Greatbatch and Lamb (1990), and it is very satisfying to reflect on this deepening of understanding. It is in turn exciting to imagine how the next generation will continue to expand our knowledge of the ocean garnered from increasingly realistic global eddying simulations, the growing database of observations, and the continuing application of fundamental theoretical principles. The special edition of Ocean Modelling aims to provide a benchmark to document mesoscale eddy research of the past 20 years, and to promote many of the ideas that will be debated into the future.

We are entering an era where climate simulations with an eddying ocean will become common. Many of the assumptions and results arising from the non-eddying simulations will thus be tested. Do we need to resolve the mesoscale to obtain robust simulations of global climate, or can we rely on the parameterized coarsely resolved models? What does it mean to resolve the ocean mesoscale? Perhaps these questions will only be answered after a generation of researchers sufficiently digest eddying models to provide mechanistic interpretations of the huge amounts of information generated by the simulations. How do eddies impact climate variability, predictability, and stability? This question is of fundamental importance as the climate science community aims to realize the goals of CLIVAR by examining the potential for predicting climate phenomena at time scales extending out to the decadal, and to project climate for the 21st Century. These questions, and many more, motivate the science community to continue seeking an intellectual basis for describing the ocean and its role in climate, and to aim for realizing robust simulations of increasing realism. The discussions at this workshop indicate that the ocean mesoscale is at the heart of these goals, thus prompting an ongoing vigorous level of research forming a critical and stimulating area of climate science.

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Planning for future climate change crises: Pilot exchanges between climate scientists and humanitarian policy makers

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Critical and constructive scientific assessment of the methodologies and climate information employed within humanitarian policies and programmes;

Consideration of how humanitarian organisations could make greater use of monthly and seasonal forecasting;

Further exploration of the role of humanitarian and development organisations as gatherers and disseminators of climate information;

Consideration of the level of expertise required to effectively take on climate information within humanitarian organisations, and how best to secure sustained access to this expertise;

Greater understanding of future extreme weather events.

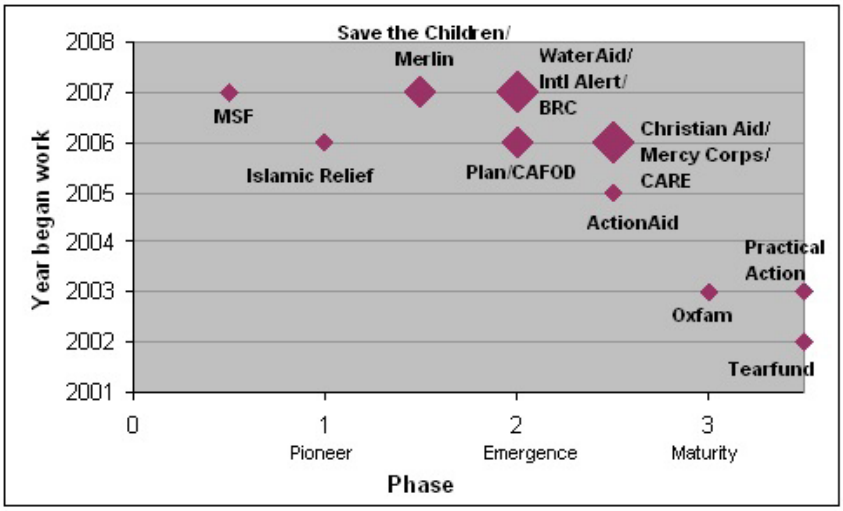
These are just some of the issues identified within a series of pilot exchanges between climate scientists and humanitarian policy makers carried out between March and June 2009. Participating scientists were drawn from the universities of Exeter, Liverpool, London and Oxford and the Met Office Hadley Centre, while the humanitarian organisations which took part included CAFOD, Christian Aid, Oxfam and Save the Children. With scientific institutions and humanitarian organisations taking turns to host discussions, participants spent one to two days in each others' organisations, learning more about ongoing and proposed climate science research and the operational contexts in which humanitarian policies and programmes are developed and supported.

The initiative was supported through the Humanitarian Futures Programme (HFP). Based at King's College, London, HFP aims to help organisations engaged in prevention, preparedness and response prepare for the changing nature, dynamics and scale of future humanitarian crises. The HFP believes that effective engagement with the natural and social sciences as well as evolving technological innovation is key to preparing for the complex threats which will increasingly characterise the future humanitarian environment.

The programme's Futures Group helps organisations prepare for such emerging future risks by strengthening the dialogue and links between a wide range of scientists and humanitarian policy makers. Between 2006 and 2008 the Futures Group employed a number of different forms of dialogue – including a scenario development exercise, a science-policy fair and a series of seminars on specific issues of future vulnerability – to explore which channels might be most effective in strengthening effective communication between the two communities.

There remained a need to develop understanding of how humanitarian organisations deal with scientific uncertainty and build the organisational capacity to integrate evolving scientific learning within humanitarian planning processes. In HFP's engagement with partner organisations, climate change has been consistently identified as one of the most important drivers of future crises. Yet recent research, as well as discussions which HFP carried out between October-December 2008, made clear that the capacity to engage with climate science varies greatly across international non-governmental organisations (NGOs)[1]. While many

1 HFP, 2009, Planning for future climate change crises: A draft note from discussions preparing for the Futures Group seminar, available at www.humanitarianfutures.org . Brooks, N and Grist, N, 2008, Development Futures in the light of climate change: creating new insights into the past, the present and global futures, and Rowling, M, April 2008, Integrating climate change adaptation into relief and development; strategic approaches among international NGOs.



Plot of the year INGOs began working on climate change against the point they were judged to have reached, as of the first quarter of 2008, on the 'climate smart' transition process outlined by Tanner and Mitchell. The pioneer phase focuses on building a case for organisational response, drawing on external knowledge, together with internal awareness-raising and external networking. In the emergence phase, champions draw in human resources, establish vision and strategy for mainstreaming and start to focus on knowledge management and messaging. In the maturity phase, climate change is internalised and mainstreamed through mandate, strategy and operational plans. Top-level political will drives funding and activities, including risk-screening of programmes. Knowledge is communicated to empower supporters, enable adaptation and make the case for political action. (Source: Rowling, M, Integrating climate change adaptation into relief and development; strategic approaches among international NGOs, April 2008, pages14-16.)

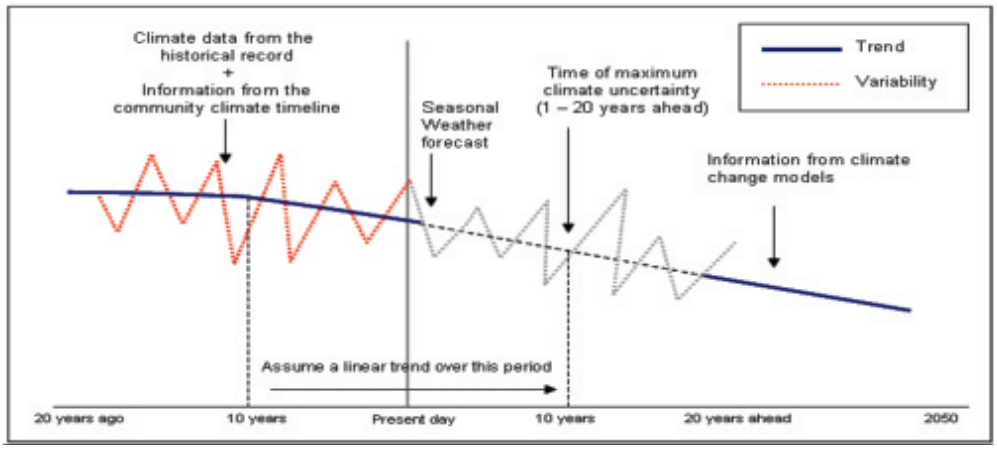


Diagram showing levels of certainty around climate information (Source: Richard Ewbank, Christian Aid, 2008)

humanitarian and development organisations have produced reviews, policies or guidelines on how climate change affects the groups with whom they work, the HFP review was able to identify much less published material indicating how international organisations were enabling climate science to directly inform their humanitarian planning[2]. This led HFP to hold a seminar in January 2009 which sought to promote dialogue between climate scientists and humanitarian policy makers about the types of climate information required for effective humanitarian planning and ways to strengthen an effective dialogue between the two communities.

The January seminar[3] highlighted concerns about the misleading use of climate information by user communities and that effective and systematic dialogue has yet to be created between climate scientists and humanitarian organisations. To enable such a dialogue, scientists need to know what knowledge humanitarian groups have of existing sources of climate information, what humanitarian organisations want to know, and how they need it to be conveyed to them. However, if humanitarian organisations are to be able to ask the right questions of scientists, they also require a more informed understanding of the range of existing sources of climate information and how these may be used.

HFP has found that humanitarian planning timeframes generally range from three to ten years. Seminar discussions made clear that these timeframes lie beyond verifiable seasonal forecasting systems and ahead of existing climate projections. This 'gap' in climate information requires that humanitarian organisations source climate information from both the climate variability and climate change communities.

To inform humanitarian planning, humanitarian organisations also need to be able to gauge how important the impacts of climate change are compared to other hazards. While some humanitarian policy makers see climate change as yet one more 'layer' of vulnerability, alongside such issues as HIV, age and gender, others recognize that it demands that humanitarian organisations extend their planning horizons to take account of the future vulnerabilities which climate change will bring.

HFP held an initial workshop in June 2009 to bring together learning from across the pilot exchanges. There was much enthusiasm for exploring how the dialogue could best be further extended and enable climate scientists to most effectively collaborate with the extensive networks of humanitarian and development organisations. HFP will be outlining the principal findings of these pilot exchanges and producing a briefing note reviewing the usefulness of this type of exchange for strengthening the science-humanitarian policy dialogue. It is hoped that learning from this initiative will also form the basis of a longer contribution to the next CLIVAR Exchange.

The HFP is keen to explore the extension of this exchange to an international context, to bring international, regional and national climate expertise to work with communities directly affected by climate change, and their humanitarian and development partners. Alongside this, the programme is seeking to develop a Scientific Advisory Group, to increase understanding about the range of drivers of future vulnerability and develop tools to assist humanitarian policy makers to consider climate change alongside a range of risks identified from across diverse scientific disciplines. The programme also intends to develop training workshops, to enhance understanding within the humanitarian community of a range of relevant scientific disciplines. The proposed course will showcase climate information tools which the pilot exchanges have identified as useful, providing an opportunity for humanitarian policy makers to try these out in a supported 'hands-on workshop ' and gain greater understanding of how climate information generated by these tools can most usefully inform their work.

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2 One clear exception being the International Federation of the Red Cross and Red Crescent's 2008 Early warning>Early Action handbook.

3 HFP, 2009, Planning for future climate change crises, seminar report, available at: www.humanitarianfutures.org

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