CLIVAR Climate Variability & Predictability World Climate Research Programme

Exchanges

No 54 (Volume 15 No 4) July 2010

Participants at the 17th Session of the CLIVAR Scientific Steering Group meeting held at the National Center for Atmospheric Research (NCAR), Boulder, Colorado, USA from 17-20 May 2010.

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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

First and foremost I would like to extend a hearty welcome to Bob Molinari who will take over from me as Director of the International CLIVAR Project Office with effect from 1 September 2010. As you will see from Bob's own account of his past career below, he comes to CLIVAR with a wealth of experience that will strongly benefit the programme over the coming years. For me, it has been a wonderful opportunity to work over the past 8 years with a wide variety of climate scientists and I thank you all for your cooperation, collaboration and support in helping to take CLIVAR forward over changing times. In particular I would like to thank the wonderful CLIVAR co-chairs I have worked with – Tony Busalacchi, Jim Hurrell, Tim Palmer, Martin Visbeck and Jurgen Willebrand – as well as the Directors and members of the Joint Planning Staff for WCRP, especially Valery Detemmerman who has been a tower of strength throughout. I have also been privileged to work with great and supportive staff members namely (and in no particular order) Katherine Bouton, Andreas Villwock, Mike Sparrow, Katy Hill, Carlos Ereño, Roberta Boscolo, Anna Pirani, Nico Caltabiano, Kate Stansfield and of course, Sandy Grapes who has always been there to pick up the pieces. I am also most grateful to the funding agencies supporting the ICPO, especially the UK Natural Environment Research Council and NASA, NOAA and NSF for their support through US CLIVAR. Funding for the Office from Australia, Canada, France, Germany and Japan is also acknowledged with sincere thanks.

I am grateful indeed to David Legler, Director of US CLIVAR, both for his insightful engagement with the ICPO and CLIVAR more widely and for his always sage advice. In addition the we have benefited strongly from being hosted centrally here at the National Oceanography Centre, Southampton (formally Southampton Oceanography Centre) and from the Institutes hosting individual staff working outside of Southampton, namely the University of Buenos Aires, Argentina; the Consejo Superior de Investigacion Cientifica Instituto de Investigations Marinas in Vigo, Spain; GFDL, Princeton, USA and, more recently, the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy.

So my thanks to all, and apologies to any I might have inadvertently forgotten. It has been a privilege to work for WCRP and CLIVAR. My very best wishes to Bob in taking CLIVAR forward. I will certainly look forward to watching the future evolution of CLIVAR and WCRP. There are undoubted challenges ahead, some of which are set out in the WCRP JSC-31 and CLIVAR SSG-17 reports that will be found in this edition, but I am sure that under Bob's Directorship of the ICPO and the continued support of the community through the Panels and Working Groups and more widely, that CLIVAR science will continue to develop and flourish in the years ahead.

Howard Cattle

Introducing Dr Robert "Bob" Molinari

Dr. Robert 'Bob' Molinari was born and raised in Brooklyn, New York. Thus he hopes his time in Southampton will improve his English curtailing the dese, dems and dose used by those of Brooklyn descent. He attended the City College of New York (CCNY) and received a Bachelor of Science in 1965. His major was meteorology, as CCNY did not offer a major in oceanography (his preference) at the time. He then moved on to Texas A&M University, College Station, Texas (where Brooklyn's is a foreign language) and received a Masters of Science degree in 1968 and Doctor of Philosophy in 1970, both in physical oceanography. He notes that he was very fortunate to have the late Professor Bob Reid as his PhD advisor. Bob and his wife of several years, Pat, then moved on to Miami where he had obtained a National Research Council Postdoctoral position at the Atlantic Oceanographic and Meteorological Laboratory (AOML) of the National Oceanic and Atmospheric Administration. This was a one-year extended to two-year position. However, the co-workers, work, beach, ocean and sun (similar, he expects, to Southampton) led him to apply for a NOAA appointment as a research oceanographer, which he received in 1972. He remained at AOML until December, 2006 with a one-year (1981-1982) leave of absence spent in Paris working on tropical Atlantic data with French partners. During the 34-year period at AOML Bob performed both management and research activities. He served as a Supervisory Oceanographer, Director of AOML's Physical Oceanography Division and AOML's Global Ocean Observing System (GOOS) Center. However, his main interest was observational oceanography. He served as Chief Scientist on more than 35 cruises to the Atlantic, Indian and Pacific Oceans. His main research interests in his early years at AOML were using the data collected during these cruises to study the subtropical western boundary and tropical currents of the three basins (perhaps he preferred these latitudes because of his susceptibility to seasickness). After starting the GOOS Center at AOML, his work on sustained ocean observations increased. The GOOS Center managed NOAA's contributions to the global surface drifter program, the Argo program and the expendable bathythermograph ship of opportunity program. Center activities included data collection and management. Throughout his career he served on the national and international research (e.g., WOCE) and sustained observation (e.g., GOOS) committees that provided the coordination for major programs. Ironically, Bob was on the first CLIVAR Scientific Working Group (1993-1995), which established the original foundation for CLIVAR and now finds himself returning to the program. Bob retired from NOAA in December 2006 and took a research position at the University of Miami's Rosenstiel School of Marine and Atmospheric Science joint institute with NOAA, the Cooperative Institute of Marine and Atmospheric Studies (CIMAS). Throughout his career in NOAA and CIMAS Bob was written over 75 articles that have appeared in referred journals and books and numerous grey literature publications.

Dr Molinari and his wife Pat, on a recent visit to ICPO in Southampton with Jacky Wood, Head of the National Marine Coordination Office, NOC [left]; Kate Stansfield, ICPO [bottom centre]; and Sandy Grapes, ICPO [right].

He acknowledges one major problem in accepting the position of Director of the International CLIVAR Project Office (ICPO), that is, following in the footsteps of Dr. Howard Cattle. Howard has established a level of professionalism that will be difficult (more likely impossible) to achieve as he has witnessed in attendance at several meetings and through interactions during the Director transition. In the short period of time since Bob accepted the Director's position, Howard has been a wealth of information providing him with invaluable insight into the intricacies of the position and CLIVAR. This continued involvement in CLIVAR extended beyond Howard's original retirement date of 31 March 2010 and is a measure of his dedication to the program. Bob looks forward to (more likely is desperate for) Howard's continued advice.

Report on the 31st Session of the Joint Scientific Committee of the World Climate Research Programme. 15-19 February 2010, Antalya, Turkey

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The 31st Session of the WCRP Joint Scientific Committee (JSC) was held on 15-19 February 2010 in Antalya, Turkey, supported by the Turkish State Meteorological Service (TSMS). The WMO Permanent Representative of Turkey and Director-General of TSMS, Mehmet Çağlar, welcomed the participants to Turkey and Antalya. Attending on behalf of CLIVAR were Martin Visbeck (SSG co-chair) and Howard Cattle (ICPO Director). The JSC Chair, Tony Busalacchi, opened the session and noted that the meeting would focus on two major items, the WCRP visioning and the role of climate research in support of climate services. A joint session of JSC with the WMO Commission for Climatology (CCl) took place on Thursday, 18 February 2010.

Tony Busalacchi acknowledged the important contributions of WCRP scientists to the World Climate Conference-3 and OceanObs'09, as well as major activities in the past year with respect to regional climate downscaling, modeling coordination and climate research in general. The vision for WCRP post-2013 would be strongly influenced by the evolution of climate science in the past decades, he said, but the future would demand more flexibility and agility to respond to stakeholder demands and the needs of society. Tony Busalacchi shared his personal perspective on topics that would demand research advances from WCRP in the future. These included, among others, decadal predictability and variability, projections of future precipitation, probability of extreme events, sea ice and ice-sheet modeling, seasonal forecasting of the Arctic, aerosols and climate services.

Ghassem Asrar, Director of the WCRP, reviewed major events supported by the WCRP since the previous JSC session, including the joint GEWEX/IGBP iLEAPS Conference hosted by Australia. Cross-cutting activities have made significant progress in the last year and also the World Bank sponsored project for the Greater Horn of Africa countries will hold its first workshop in April 2010. Two important publications were the WCRP Achievements Report and its Intermediate Implementation Plan, which are currently being translated into French, Chinese, Spanish and Russian through the greatly appreciated initiatives of JSC members. Ghassem Asrar finally presented an overview of the income and expenditures for the programme, noting that there had been a significant improvement in its financial status and hence in its ability to support activities. He thanked the sponsors for their continuing confidence in WCRP.

WCRP Visioning

David Griggs gave a brief introduction to the WCRP visioning process, recalling the agreement at last year's JSC session that the way in which WCRP could most effectively carry out its activities would be if the structure was constructed along interdisciplinary scientific lines. It was proposed that the general structure of four Core Projects be retained but with revised responsibilities to facilitate climate system research at the interface of the physical Earth system components, i.e., the WCRP overall activities would be based on four fundamental interactions of the physical climate system: ocean-atmosphere, land-atmosphere, cryosphere, and stratosphere-troposphere. Core Projects or similar structural elements would continue to be the main bodies through which WCRP would carry out its work program. In order to achieve this, each Core Project would be supported by an international coordination Project Office. It was agreed that within each of the four Core Projects there exist a common set of basic themes, namely: observations and analysis; model development, evaluation and experiments; process understanding; and applications and services. Members of the JSC and the community had been identified to write white papers on each of these themes, with an additional paper on capacity building, and these were presented next.

Process studies

Jochem Marotzke spoke about "processes". Understanding of processes underlies most of WCRP research and hence in discussing how to proceed, it was useful to classify these processes into three categories, namely:

1. processes underlying phenomena (e.g. East Asian monsoon),
2. ubiquitous processes (e.g. ocean diapycnal mixing), and
3. processes studied for testing parameterizations (e.g. cumulus convection).

The first category is usually regional in focus and its governance should therefore lie within the Core Projects. The second category would be well served within the Core Projects, too, but the challenge in both categories is how to organize studies of processes spanning several earth system domains. The third category requires engagement of and coordination amongst two very different communities, namely the observations and small-scale modeling communities, to develop and improve models. It was remarked that there exists a disconnect between small-scale process studies and global modeling, and that it was not clear how best to organize WCRP to make these interactions occur.

Observations, reanalysis

A key issue noted by Kevin Trenberth, is that most of the observations needed for climate research are not done by WCRP. He elaborated on three categories of observations, namely those from process studies, sustained observations, and enhanced monitoring, each with their own stewardship issues.

The role of WCRP vis-à-vis observations could be summarized as follows:

- Advocate improved observations and analysis
- Data set development
- Data assimilation and analysis
- Advice on best data sets
- Data sets for use in evaluating climate models
- Promote sound data stewardship
- Help to make data accessible and available.

Kevin Trenberth also advocated providing "operational attribution" through numerical experimentation in real time (e.g. to allow reliable statements on why the climate is the way it is and mechanisms involved). All of these activities necessitated a "climate information system". There was a call for WCRP to coordinate the distribution of in situ and satellite observations to the modeling community and it was suggested that the WCRP Observations and Assimilation

Panel (WOAP) might play this role. A reflection was made that there does not exist a climate observations community that parallels the modeling community and hence this is a challenging undertaking. It was pointed out that successful WCRP projects do bring together process studies, observations and models, such as the Cloud Forcing Model Intercom parison Project (CFMIP), and hence there are precedents on which to build. It was remarked that a lot of WCRP research involves designing and building prototypes of next generation observing systems and/or identifying the necessary improvements of the existing networks. Thus every effort should be made to maintain such activities.

A breakout group analyzed the WCRP roles vis-à-vis observations and noted that there was a need to communicate to the Global Climate Observing System (GCOS), the World Meterological Organisation (WMO), institutions making observations and others, the observational requirements for climate research. There was also a need to advocate and advise on data standards, ensure data availability, work to sustain existing systems and identify new data needs. Data analysis and validation and data availability for applications were also issues. The group recommended that existing structures be maintained to supervise disciplinary data stewardship (Ocean Observations Panel for Climate [OOPC], Atmospheric Observations Panel for Climate [AOPC], etc.), and that a pan-WCRP working group be formed to manage interdisciplinary data issues and to oversee broader data management issues.

There are many ongoing reanalysis activities but coordination amongst them is insufficient. Too few people are evaluating the reanalysis products. There is also a problem with continuity since most of the reanalyses are done in the research domain, and key personnel are lost when a particular effort is terminated. A reanalysis conference will be held in 2012 in USA, cosponsored by NOAA and NASA. A grand science challenge could be coupled reanalysis. A task force could be required to make plans, for instance for a reanalysis intercomparison that would bring together the various communities working on reanalyses to evaluate the current state of reanalysis and to take into account land, ocean, troposphere, stratosphere, chemistry, ecosystems, etc.

In the near term, there is a need to catalyze interactions between the observations and modeling communities, including interactions with external organizations such as the Group on Earth Observations (GEO) and GCOS. It was also decided that an Observations and Analysis Council should be formed to make recommendations to JSC and that this Council would supersede WOAP.

Modeling

The authors of the white paper on modeling suggested that the key role for WCRP is to develop an integrating strategy for climate modeling that also connects models with observations and process studies. Gregory Flato outlined four major activities in this area:

- Promoting the confrontation of models with observations and results of process studies;
- Promoting collaboration amongst various climate science communities (includes numerical weather prediction (NWP), seasonal to interannual prediction and climate projection communities as well as those dealing with biogeochemistry, air quality, terrestrial ecology, etc.);
- Promoting application of models to problems of societal relevance, quantifying uncertainties and making sure they are well communicated and understood;
- Promoting the development of model improvements.

There was considerable discussion both about the function and form of the WCRP modeling efforts. In terms of organization, the authors recommended that well established panels and working groups should be maintained. It was emphasized that the WCRP modeling infrastructure should be flexible to allow focusing of efforts where they were most needed, for instance for applications. There was a need to include in the framework a means to exchange learning at fine scales to determine if parameterization was the correct approach or whether these fine-scale processes needed to be resolved in climate models. The sense was that the time was right for a systematic study of the role of horizontal and vertical resolution in climate models. Model evaluation and quality assessment were also important roles for WCRP. The next Coupled Model Intercomparison Project (CMIP5) would provide an ideal opportunity to assess how to best combine and evaluate these models. It was noted that confronting models with observations would be a first step in this direction.

The main recommendation from the discussion and a breakout session was the formation of a Modeling Council that would be a coordination mechanism for various WCRP modeling groups, with strong participation of the JSC. The Council could meet at JSC sessions, and would make recommendations to the JSC.

Applications

Carolina Vera presented some major themes for WCRP in support of applications. These included:

- Addressing science needs for delivering more reliable predictions on all timescales,
- Provision of timely and reliable forecasts of the likelihood of hazardous weather and climate, requiring interaction between the weather and climate communities,
- Promoting more research and investment into higher resolution models,
- Exploring new forecast variables and providing more flexible formats,
- Improving communication, for instance of uncertainties, by putting information in context, and in clear language, and
- Promoting partnerships to develop meaningful two-way and sustained communication with user communities.

The WCRP should also address the need for a new generation of researchers that can conceptualize, develop and implement research that bridges the gap between science and applications. Carolina Vera noted that this theme depends on all other themes, involves the Core Projects, and that the scope of applications that WCRP research must support should be defined in parallel with the conceptual development of the Global Framework for Climate Services (GFCS).

Capacity building

Hasan Virji, Director of START (System for Analysis, Research and Training), remarked that there seemed to be a clear consensus that WCRP should be involved in capacity building and that this was an underlying theme for all the other themes. However, most of the workshops/trainings that WCRP had co-sponsored in the past, for instance with START, had been "one-off'. H. Virji proposed that JSC reflect on how to address all capacity building requirements and include consideration of other strategic partnerships in addition to START.

A breakout group on capacity building felt that the WCRP role was to identify needs and advocate the importance of raising the capacity/capability to continue to undertake climate research, prediction and services. Two different categories of requirements existed: qualified people in the developed world, and institutional capacity in countries that cannot develop it themselves. WCRP should build on existing entities within WMO/IOC/ICSU and networks such as START and focus on creating the scientific community we need for the future. Model development and computational science were critical areas. Capacity building was the key to the success of climate services and the GFCS should take this into account. The JSC decided to develop a long-term plan of sustained WCRP capacity building activities.

Grand Challenges

Two parallel break-out groups were formed to discuss how the concept of grand challenges would fit within the proposed overall structure of WCRP, what would be their nature and how they would be selected. It was generally agreed that a grand challenge (GC) would be defined as a burning issue or barrier to progress in climate research. Implementation would involve multiple projects and/or other programmes, but an outstanding issue is the extent to which the projects would take the lead in corresponding implementation activities or whether a separate dedicated steering committee would be formed.

Initial discussions had suggested a limited lifetime for GCs of three to five years, but issues were raised as to whether this was realistic, both in terms of being able to accomplish something concrete and in terms of what would attract funding agencies to commit significant resources. Some expressed the view that climate science was moving so fast that we shouldn't create very large long-term projects as in the past (e.g. TOGA or WOCE), but rather focus on shorter timescale efforts that target more specific problems of scientific, but also societal, interest.

The issue of how to select grand challenges was discussed in detail. The JSC could define the issue itself, or consider suggestions submitted via white papers from the community. Once a GC had been adopted by the JSC, town hall meetings and workshops should be held to build community support, develop plans and seek funding. The WCRP Open Science Conference in 2011 could be a platform for identifying GCs. Rapid sea-ice loss could be seen as an example of a GC, based on the white paper that had been presented to and endorsed by this JSC session.

WCRP future function and structure

David Griggs summarized the discussions on WCRP future function and form as follows. There would be four Core Projects working at the interfaces between the physical climate system components as agreed in Maryland. Modelling and Observations Councils would be formed to provide leadership and coordination and would report to the JSC. These Councils would not carry out activities of their own but would include representatives from the Core Projects and relevant external organizations to enable activities to be co-ordinated across the Core Projects. Councils would generally work electronically with the potential to meet for one day immediately preceding JSC meetings. While it was agreed that the idea of WCRP bringing the international scientific community together to carry out a scientific push to address a major or grand challenge of climate science was very attractive, no decision was made pending further discussion on how these could be implemented in practice. The role of crosscuts would need to be revisited. The JSC requested the current Core Projects to consider the implications of the decisions made on future structure and come back to the next JSC with views on the implications of these decisions on the sub-structure of the Core Projects within the new structure.

WCRP Open Science Conference

Ghassem Asrar reported that the WCRP Open Science Conference (OSC) is scheduled for 24-28 October 2011 at the Sheraton Hotel in Denver, Colorado, USA. A web site is operational (www.wcrp-climate.org/conference2011) and a first announcement has been published. The aim is to assemble most of the WCRP research community and also to engage other key international programmes. The OSC would provide an exclusive opportunity for exchange and collaboration across diverse research communities (e.g. WCRP, WWRP, IGBP, and IHDP). At least 1500 participants are anticipated. The main motivations for the Conference include appraising the current state of science, identifying the most urgent scientific issues, ascertaining how WCRP can best facilitate this research, developing partnerships critical to progress in the context of the fast-emerging GFCS, and facilitating growth of the diverse workforce needed for the future.

Partner Presentations

Representatives of several agencies and programmes made presentations to the JSC and elaborated on how WCRP could support partner programme goals. These included the IPCC Working Groups I and II, IGBP, Earth System Science Partnership, WMO Commission for Atmospheric Sciences (CAS), GCOS, European Space Agency speaking on behalf of the Committee on Earth Observation Satellites, Group on Earth Observations, and the Integrated Research on Disaster Risk (IRDR) project. In particular, speaking on behalf of IPCC WG I Dr Stocker noted that WCRP was the most important group contributing to WG I in the past and that a lot was expected of WCRP for the next assessment. Specific areas of research that would make invaluable contributions might include:

- clouds and aerosols – processes and sensitivities,
- decadal prediction – evaluation and verification,
- multi-model ensembles using earth system models,
- regional climate change – detection and attribution and projections,
- sea level rise and ice sheet instabilities, and
- geoengineering – assessment of physical basis.

During discussion of the WMO CAS report, the great importance of seasonal and sub-seasonal forecasting to WMO Members and the Global Framework for Climate Services was emphasized. Hence every effort should be made to make progress in this area. It was suggested that cooperation between the WCRP CLIVAR, Climate System Historical Forecast Project (CHFP) and the THORPEX Interactive Grand Global Ensemble (TIGGE) should be discussed in detail so that results can be compared and in order that cross-fertilization can take place.

Sponsor highlights

Kari Raivio of ICSU reviewed the decision of the 29th ICSU General Assembly that led the way for the ICSU visioning exercise with the goal to engage the scientific community in exploring options and proposing implementation steps for a holistic strategy of Earth system research. Luis Valdes of IOC reviewed the very successful OceanObs'09 conference, which was supported by WCRP, and identified several aspects of WCRP research that were of particular interest to IOC Members. There was a question as to whether the link between IOC and the WCRP community was in need of enhancement and if so, how this should occur. Louis Valdes noted that in some countries, like Germany, the link was strong, but that in others it was much weaker, As an outcome of the discussion, CLIVAR was asked to to compile a list of nations engaged in oceanographic activities affiliated with the Project.

Avinash Tyagi, Director of the WMO Climate and Water Department, focused on the outcomes of the World Climate Conference – 3 (WCC3) held in Geneva on 31 August – 4 September 2009. He lauded the very high level of participation of WCRP scientists in the WCC3 Expert Segment that had recommended, inter alia, a strengthening of both GCOS and the WCRP in support of a Global Framework for Climate Services (GFCS). The High Level segment agreed to establish a GFCS to strengthen production, availability, delivery and application of science-based climate prediction and services and called for the formation of an independent High Level Task Force (HLTF) that would, after consultation with governments, partner organizations and relevant stakeholders, prepare a report, including recommendations on proposed elements of the Framework. In the discussion, a concern was expressed as to the mechanism for technical/scientific input to the GFCS HLTF. Despite the fact that the Conference declaration implies that the HLTF should deal with technical issues, there was limited climate science representation on the HLTF. A panel discussion on GFCS and the need for a mechanism, by which science requirements could be effectively fed into the process of defining the "Framework", ensued.

National Climate Services

The Chair introduced this topic, noting that many nations were in the early stages of formulating plans for climate services, but that it was important for JSC to hear their current or anticipated requirements from WCRP. JSC Members and meeting participants summarized in their presentations the status and development of climate services in Germany, USA, France, UK, Japan, and Canada. Adrian Simmons also made a brief presentation on the European Global Monitoring for Environment and Security (GMES) atmospheric environmental services. The approaches to climate services varied significantly from country to country. Common themes were partnerships between government, business and universities and an emphasis on providing useful climate information for a wide range of applications. Some countries, such as Germany and the USA, were spinning up new "climate service" entities, while others, such as Japan and Canada, were operating within existing structures, usually the meteorological services. In Germany funding for the new climate services effort was being provided by the research ministry and hence there was an emphasis on understanding climate change and supporting research. The UK's plan was to "operationalize" climate prediction in a "seamless" manner, i.e. on all timescales. Both the USA and the UK were aiming for an "end-to-end" system which would include everything from climate monitoring to attribution. France was focusing on the transition of climate research results into the operational realm. In Japan, the Japanese Meteorological Agency's climate prediction division was providing climate information, but it was noted that the Ministry of Environment also had a major project concerning extreme events in the future climate. Canada had no formal climate service entity, but was providing climate services including operational climate monitoring, seasonal predictions and future climate projections.

A breakout group on climate information and services suggested that the WCRP should partner with institutions and projects such as IRDR, environmental agencies and START to achieve an effective dialogue with users to help drive the research priorities. WCRP should promote multi-model ensembles (MMEs) and research into how to use them. WCRP could act as coordinator across national climate services with respect to this topic. A key issue would be to manage expectations. In this respect it was important to remember that climate services are now where numerical weather prediction was 20-30 years ago. WCRP had a responsibility to communicate the credibility and skill of predictions that underpin services and promote research needed to do this better. It was noted that the best way for WCRP to engage was through national programmes and defining good measures of credibility and skill. There was also a need to recognize the diversity of delivery mechanisms. As an outcome, the JSC decided to establish a working group on science underpinning climate services.

Core Project and Working Groups Reports

A full day of the Session was devoted to reports of and discussion on activities by the WCRP Core Projects and other working bodies: CliC CLIVAR, GEWEX, SPARC, the Anthropogenic Climate Change Crosscutting Activity, the Task Force on Regional Climate Downscaling (TFRCD), the Working Group on Coupled Modeling (WGCM), the Working Group on Numerical Experimentation (WGNE) and the WCRP Observations and Assimilation Panel. Only issues of high relevance for CLIVAR are briefly summarized below.

CLIVAR report and discussion

Martin Visbeck outlined the "CLIVAR imperatives" developed at the most recent SSG meeting

- Anthropogenic Climate Change
- Decadal Variability, Predictability, and Prediction
- Intraseasonal and Seasonal Predictability and Prediction
- Improved Atmosphere and Ocean Components of ESMs
- Data Synthesis and Analysis
- Ocean Observing System
- Capacity Building

and noted that a major priority over the next 5+ years would be to strengthen interaction with the ocean biogeochemistry community.

He reviewed some recent CLIVAR activities, many of them related to decadal variability and predictability. He noted that knowing natural decadal variability was as important as being able to predict on these time scales and emphasised the importance of the ocean synthesis activity for both predicting and understanding decadal variability. He also lauded the CLIVAR/GOOS Indian Ocean Panel for great progress in establishing sustained observations in that basin. There were still many areas for improvement of seasonal to interannual prediction. The Climate Historical Forecast Project (CHFP) was the flagship element in this effort with potential for links to the THORPEX TIGGE project. He noted that the Tropical Atlantic Climate Experiment (TACE) contributed to many of the "imperatives" and that several important field activities were spinning up in the Pacific, including the Chinese-led North Pacific Ocean Climate Experiment (NPOCE). VAMOS was very active in education and capacity building activities, often in partnership with IAI.

Martin Visbeck raised several issues for consideration by the JSC. He asked the JSC whether CLIVAR should continue to develop its current list of "imperatives". He noted that CLIVAR did not have a strong connection to the Arctic and suggested that they might join efforts with CliC and GEWEX. CHFP was looking to strengthen participation by the other WCRP projects and CliC in particular. There was concern over how CLIVAR efforts in Africa, other than AMMA, should best advance and that there was a need for improved integration of observational and modelling efforts with regards to monsoons. Martin Visbeck also remarked that data sharing and access worked best when there was a formal oversight structure and encouraged JSC to support such international agreements.

Overall the JSC were supportive of list of CLIVAR imperatives though it was noted that they were very broad in scope and looked much like WCRP imperatives. The JSC encouraged the CLIVAR SSG to further refine the ocean/atmosphere relevance of its imperatives and include coupled ocean/atmosphere observations. CLIVAR was encouraged by the JSC to produce review articles in time to provide input to the IPCC process. Martin Visbeck noted that the imperatives provide a framework for producing such articles and that they would likely be produced for the WCRP OSC in 2011. It was noted that there was a lot of interest in the Arctic and that the time was ripe for a cooperative effort; a workshop on short-range prediction in the Arctic currently being organized by WWRP could provide an opportunity for initial discussions. It was remarked that the atmosphere seemed to be missing in the CLIVAR presentation and that integrated projects such as the one proposed for the Arctic could provide a good opportunity for this. CLIVAR should indeed also encourage interaction with WWRP/THORPEX in the area of sub-seasonal and seasonal prediction, and particularly the interactions of CHFP and TIGGE.

A question was raised as to what CLIVAR was doing to prepare for the Aquarious salinity mission; Martin Visbeck saw the CLIVAR Global Synthesis and Observation Panel as the appropriate avenue for this, but noted that the Atlantic Panel was discussing this and that US CLIVAR was considering a process study, as well. In response to the mention of how best to move forward activity by the CLIVAR Africa Panel, Fred Semazzi, a member of the Panel, noted that climate services could be a rallying point for future activity.

Arising from the presentation by CliC of a white paper on "Rapid Loss of Sea Ice in the Arctic", CliC, with CLIVAR, were asked to proceed with scoping a CMIP5 diagnostic project analyzing historical Arctic sea-ice loss as simulated by current climate models and evaluating the range of future projections.

Joint CCl-WCRP Session

Thursday 18 February 2010 was devoted to a session jointly organized by the WMO Commission for Climatology (CCl) and the WCRP. Presentations focused on observational and modeling research needs to improve seasonal to interannual predictions and research requirements for enhancing the use of climate information in impact, adaptation and mitigation studies. A joint statement on enhancing the use of climate information was agreed at the end of the session (http://wcrp.wmo.int/documents/Resolution_CCl_WCRP_2010.pdf).

JSC closure and the next meeting

The next JSC session will be held at the UK Met Office in Exeter, UK from April 4-8, 2011. The Chair closed the 31st session with expressions of appreciation to participants and special thanks to outgoing JSC members Guoxiong Wu and Venkatachalam Ramaswamy and retiring ICPO director, Howard Cattle

Summary of CLIVAR SSG-17

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Introduction

The 17th session of the CLIVAR Scientific Steering Group (SSG-17) was held at the National Center for Atmospheric Research (NCAR), Boulder, Colorado, USA from 17-20 May 2010. The delegates were warmly welcomed to Boulder in an opening address by Dr. Greg Holland, Director, NCAR Earth System Laboratory (NESL). Dr. Holland identified and discussed a number of scientific challenges being tackled by NESL, including regional climate prediction, closer ties between the weather and climate modelling communities, and the promotion of science and its communication to society. The SSG co-chairs (Dr. Jim Hurrell and Prof. Martin Visbeck) led the meeting of 33 participants comprised of SSG members, chairs or representatives of CLIVAR Panels and Working Groups, representatives of other core WCRP projects and other invitees, including Dr Bob Molinari as prospective new ICPO Director. The meeting focused on: the anticipated future structure for WCRP and its implications for CLIVAR; review of the "imperatives" for CLIVAR research (developed at CLIVAR SSG-16; see Exchanges edition 49/50); review of progress and plans by CLIVAR Panels and Working Groups; consideration of number of specific regional issues (in particular Arctic climate, CLIVAR's Africa programme, and the Indonesian Seas). Summaries of progress in Panel and Working Group activities are also published in this edition of Exchanges and serve to supplement this report.

The SSG is most grateful to Lisa Butler (NCAR) for acting as the local organizer of the meeting and for all her efforts to ensure that the meeting was an extremely successful and sociable event.

WCRP strategy, outcomes of JSC-31 and other WCRP core project and wider programme inputs

To help set the context of the meeting, Dr. Ghassem Asrar, Director of WCRP, reviewed the major events of the past year since CLIVAR SSG-16. This included publication of the WCRP Achievements and Implementation Plan documents; the outcomes of World Climate Conference-3 (Geneva, Switzerland, September 2009) and the resulting development of a Global Framework for Climate Services; the OceanObs'09 Symposium (Venice, Italy, September 2009) and its follow-on limited lifetime working group to recommend a framework for moving sustained ocean observations ahead over the next decade; the ongoing ICSU visioning process , and the WCRP's own visioning process aimed at developing a new longer-term structure for the programme (see below). A major future event will be the WCRP Open Science Conference (Denver, USA, October 2011), plans for which were the subject of a separate presentation by Jim Hurrell (as chair of the International Scientific Organizing Committee) later in the meeting.

In a follow-on presentation, Valery Detemmerman (Joint Planning Staff for WCRP) identified a number of challenges and opportunities for coordinated research among both the WCRP projects and with other programmes. Activities under the WCRP's Global Energy and Water Experiment (GEWEX) were provided by its new chair, Dr. Kevin Trenberth, who summarized the GEWEX SSG's research imperatives and where it saw the "frontiers" of GEWEX activity to lie. These will be further discussed at a pan-GEWEX meeting in Seattle, Washington USA (August 2010). A presentation on behalf of the WCRP's Climate and Cryosphere (CliC) project by Dr. David Bromwich summarized the current status of CliC and, in particular, its lead in the WCRP's cross-cutting activity on sea level rise. Later in the meeting Dr. Bromwich also addressed the issue of Arctic Climate and the CliC lead in the development of a working group to address this issue across WCRP. The SSG were also briefed by Prof. Ken Drinkwater on the IGBP's programme on Integrated Marine Biogeochemistry and Ecosystem Research (IMBER). IMBER's Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) project links strongly with the CLIVAR/GOOS Indian Ocean Panel whilst there are further potential areas for collaboration, for example in synthesis and modelling and in IMBER's activity on "Integrating Climate and Ecosystem Dynamics in the Southern Ocean".

Development of the Ocean Observing System

Prof. Detlef Stammer reviewed the outcomes both of the last meeting of the Ocean Observation Panel for Climate (OOPC) on behalf of its Chair, Dr. Eric Lindstrom, and of OceanObs'09. He emphasized the role of OOPC as a component of the integrated framework for sustained ocean observations post OceanObs'09, including biogeochemical and ecosystem observing. OOPC is also looking to improve the societal relevance of its activity on ocean climate indices. A particular call to research programmes, including CLIVAR, is to articulate the need for sustained legacy observations in a systematic way. OOPC is encouraging data sharing, by promoting regular tracking of adherence to data sharing policies. Prof. Stammer also briefly outlined the current status of the remotely-sensed and in situ observing system. The latter was assessed as being 62% complete in 2009 resulting in a call from OceanObs'09 for nations to strive to complete the initial system by 2015. A task force is currently working on a set of recommendations for a new framework for integrated sustained observations and will report back to its sponsors later in 2010.

US CLIVAR presentation

The meeting was pleased to have an update on US CLIVAR science initiatives from Dr. Marty Hoerling, its outgoing chair. In particular, US CLIVAR is moving ahead on the themes of decadal variability and climate extremes. The climate of polar regions is an emerging third core theme, further explored at the recent (July 2010) US CLIVAR Summit. In addition carbon cycle and ecosystem opportunities are being assessed within US CLIVAR. US CLIVAR has pioneered the concept of Climate Process Teams (CPTs) and four new teams covering ocean boundary mixing, cloud parameterizations and sea ice/ocean mixing will begin in 2010. A call is also being coordinated for CMIP5 analysis proposals, including those addressing decadal diagnostics (see Working Group on Coupled Modelling report, this issue). In addition, the Atlantic Meridional Circulation activity has now grown significantly to 38 projects.

CLIVAR strategy, its research imperatives and future evolution towards the ocean-atmosphere project of a restructured WCRP

During its meeting the SSG extensively discussed the proposals for a new structure for WCRP via breakout groups and plenary discussion. Present thinking on this by the Joint Scientific Committee (JSC) for WCRP is for a transition in the 2013-15 timeframe from the present projects to four core areas covering ocean-atmosphere interactions, land-atmosphere interactions, cryosphere-climate interactions and troposphere-stratosphere interactions. In addition observation and analysis and modelling councils will provide overall coordination in their respective areas. Some attention was also given to the prospect of identifying overall "grand challenges" across WCRP (for more detail, see the report of JSC-31 (Antalya, Turkey, February 2010) in this issue of Exchanges). The JSC is requesting feedback from all its projects and activities on these ideas, and CLIVAR views were developed via breakout sessions during the meeting. The overall view which emerged was that

CLIVAR could indeed adapt to the new structure (recognising that this is still in an early form) with attention to issues such as scope (in particular of the ocean-atmosphere interactions component), structure (including the SSG), partnerships, interfaces, especially to the regions and applications, and the nature of the deliverables (data, models, information services etc). A summary of the discussion at SSG-17 and feedback to the JSC will be provided.

At its last meeting, the SSG developed the basic structure for its imperatives for research over the coming 5 years and set up tiger teams to develop this further. The outcomes of this activity were reviewed and a mechanism to publish these in a common format identified. The imperatives will provide the basic platform to guide the programme over the timescale of the next 5 years or so and will provide a basis for future reporting on progress with CLIVAR activities.

Reports from CLIVAR Panels and Working Groups

The third day of the meeting was primarily taken up with presentations on progress by CLIVAR's panels and working groups and discussions of these. Each was encouraged to bring to the table any issues that they had for the SSG. As noted above, 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 (in preparation). Two particular issues discussed by the SSG were the steps to set up of a Task Team to develop a programme for the Indonesian Through Flow Region, and how to best further CLIVAR's activities in Africa and the future programme of its Variability of African Climate Panel. The latter discussion was led by Prof. Richard Washington.

Wrapping up

The final morning of the meeting then focused around a review of the CLIVAR procedure for endorsement of activities developed separately from the CLIVAR programme itself, along with a review of the actions and outcomes of the meeting. The next SSG will be hosted by the International Oceanographic Commission at the UNESCO building in Paris during the week of 2-6 May 2011.

The full set of meeting papers is at: www.clivar.org/organization/ssg/ssg17/ssg17.php

Presentations are at: www.clivar.org/organization/ssg/ssg17/SSG17-presentations.php

Working Group on Coupled Modelling Activity Report

Sandrine Bony, Gerry Meehl, Anna Pirani and members of the Working Group
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WGCM's overall goal is to promote a balance between prediction and the evaluation of models using observations and understanding. The Coupled Model Intercomparison Project Phase 5 (CMIP5) is a major activity that was approved by WGCM in 2008 in collaboration with AIMES (IGBP) and the wider climate science community. It is a 5-year experimental design (2008-2013) for climate change experiments encompassing many elements of WCRP and IGBP. The CMIP5 coordinated experiments were not dictated by IPCC but were formulated by the climate science community to address relevant science questions. It will also be assessed as part of the IPCC AR5.

CMIP5 reflects a new paradigm for climate change science with the emerging field of prediction at decadal timescales for the next 30 years, as well as the more familiar long-term projections that are being run with new generation Earth System Models (ESMs) to study longer-term feedbacks past the mid-21st century. The Representative Concentration Pathway (RCP) mitigation scenarios imply policy decisions and options for targeted climate change stabilization at different levels. They are the product of a bottom-up collaboration of WGCM, the Integrated Assessment Modeling (IAM) Consortium and IGBP AIMES. Climate change science is now focused on mitigation/adaptation and what difference mitigation can make for adaptation. As an example, mitigation would lead to more Arctic sea ice being retained, particularly in summer (Washington et al., 2009, Geophys. Res. Lett., 36). New tangible links are forming throughout the climate science community (WCRP, IGBP, IPCC Working Groups 2 (impacts/adaptation/vulnerability) and 3 (integrated assessment modeling and scenarios)). The challenge for climate science will be to determine what is the regional, time-evolving climate change will be to which society will have to adapt.

The near-term experiments consist of two tiers. The core decadal experiments are all hindcasts, with one 'prediction' experiment into the future. The experimental design reflects the community's inexperience with the decadal prediction problem and will assess initialization methodologies and prediction skill. Some centers will run very high-resolution (10-20km atmosphere) time slice experiments to study changes in tropical cyclones and regional climate change. The difference in the CMIP5 long-term simulations as compared to CMIP3, is that in addition to the climate change projections, there are now an extensive number of runs looking at model sensitivity, model development, and climate feedbacks. All this has been possible due to the buy in from numerous communities (e.g. IDAG, PMIP, CFMIP, C4MIP, CCMval).

At least 21 global modeling groups will participate in CMIP5. It is likely that about 5 groups will have 50 km class AOGCMs for decadal prediction, at least 10 groups will have ESMs, and several groups will have high-resolution time slice AGCMs (<50 km). The full sets of forcings (20th and 21st century) and the list of model outputs have been finalized and simulations have now started in most modeling groups. Model output will be accessed via the Earth System Grid (distributed grid technology). An extensive documentation of the models and of model experiments will be available for CMIP5 following the EU Metafor (standardized vocabulary and documentation), and US Earth System Curator projects (web-based tools for ingesting metadata). Many model runs will be completed by the end of 2010, but will continue into 2011. Analyses of model data will begin early 2011, and will continue through mid-2012 for assessment in the IPCC AR5. The final deadline for papers to be assessed in the AR5 is July 31, 2012, though CMIP5 model simulations and analyses will continue well beyond AR5 deadlines. There will be a session on CMIP5 analysis at the WCRP Open Science Conference in 2011 and a dedicated workshop is being planned for 2012.

Evaluating model reliability continues to be an outstanding issue and the WGCM Metrics Panel has been assessing multiple ways to rank models. It remains impossible to find a universal way of ranking models. The multi-model average always outperforms single models. If models simulate present climate, their credibility in simulating future remains unknown, as does whether feedbacks in present-day climate are representative of feedbacks in the future. CMIP5 process study experiments, such as CFMIP simulations (idealized, aquaplanet) that address uncertainties in how clouds are represented and their feedbacks, and paleoclimate simulations provide a test bed for gaining insights into these issues. More specifically process-orientated experiments, such as the DRICOMP-type of experiments for drought, can be envisaged as part of a future CMIP6.

Over the next year, WGCM will encourage and coordinate the analysis of the CMIP5 multi-model dataset and also encourage community groups to write synthesis papers regarding aspects of the CMIP5 dataset (e.g., CliC for snow/ice (ARCHIMEDES), CFMIP for cloud forcing/response, PMIP for paleoclimate etc.) so as to contribute to and facilitate the IPCC AR5. WGCM has also endorsed a Coordinated Experiment (CMIP) on Geoengineering. WGCM will contribute to the synthesis and follow-up of the WCRP-WWRP model improvement survey. In the next year or so, WGCM will also be working closely with IGBP AIMES to develop a strategy for the development of the next generation Earth System Models.

Working Group on Seasonal to Interannual Prediction Activity Report

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The Climate-system Historical Forecast Project (CHFP) hindcast framework is reaching maturation with several centers providing open access data to the project archive in accordance with the CMIP5 data protocol. The Centro de Investigaciones del Mar y la Atmósfera (CIMA), Argentina, has agreed to support the whole dataset. The CHFP is a test bed to evaluate how different components of the physical system (land, cryosphere, stratosphere) impact seasonal prediction and has been successful in expanding the seasonal forecast problem out of the traditional ocean-atmosphere domain. Run with the best models and the best initialization possible, it will provide the control dataset for seasonal prediction, that will make possible the assessment of where we stand on seasonal prediction today.

A strong representation from other WCRP projects within WGSIP membership has been important for its ability to reach out and entrain participation in the CHFP, as well as initiating additional suites of experiments. As the modeling centers submit their runs to the archive, WGSIP wishes to increase the visibility of the CHFP to encourage the wider community, particularly the regional panels to join the analysis effort. This could be achieved with a dedicated session at the 2011 WCRP Open Science Conference and a Second WCRP Workshop on Seasonal Prediction focused on the CHFP outcomes.

The 2nd phase of the GEWEX Global Land Atmosphere Coupling Experiment (GLACE-2) is an integral component of the CHFP. GLACE-2, which follows on from the successful pilot study GLACE, is aimed at quantifying the forecast skill associated with the initialization of land surface state variables.

A WGSIP-SPARC collaboration has launched the Stratosphere resolving Historical Forecast Project (Strat-HFP), another component of the CHFP. The purpose of the Strat-HFP is to:

- Quantify improvements in actual predictability by initializing and resolving the stratosphere in seasonal forecast systems
- Compare with existing seasonal to interannual forecast skill and to provide a hindcast data set that may be used to:
  - demonstrate improvements in currently achievable season forecast skill for a range of variables and lead times
  - understand improvements under particular scenarios such as El Nino and years with an active stratosphere
  - justify changes in operational seasonal forecast approaches and methods as a subproject of the CHFP

The development of the Strat-HFP protocol and enlisting the participation of seven leading centers has been a major achievement this year and the data will also be hosted on the CHFP server at CIMA.

WGSIP continues to work to identify the best links to CliC to develop a component of the CHFP that addresses predictability on seasonal to interannual timescales and the role of the cryosphere. B. Kirtman, WGSIP co-Chair, will participate in the WCRP Polar Predictability Workshop being held later this year, whilst a CliC representative is attending the next WGSIP meeting in July 2010.

WGSIP will be discussing the World Weather Research Programme THORPEX Interactive Grand Global Ensemble (TIGGE) development of operational 1-90 day prediction capability at its next meeting. Making the link with the weather community is not straight forward since the seasonal prediction and weather prediction communities speak different languages in terms of how prediction skill is evaluated, what models are used, etc. and it would help to entrain those working at the interface, to address the problem of how to merge weather and seasonal prediction. WGSIP also wishes to strengthen its links to WGNE.

WGSIP has contributed to the design of the CMIP5 near-term experiments through its collaboration with WGCM and will be evaluating the results in terms of seasonal prediction skill. The CMIP5 near-term experiments will be a test bed for initialization techniques, understanding multi-model combinations and a starting point to launch additional experiments proposed at the workshop Decadal Forecasts and Initialization (Utrecht, The Netherlands, November 2009). With much of the community's focus shifting to the emerging decadal problem, there is concern that work on the seasonal timescale will lose attention. However, it is clear that progress on decadal work will also give progress on the seasonal timescale.

How WGSIP links to applications has evolved to having members that work on the interface between the seasonal prediction and applications communities. While not being 'users' themselves, these members can provide examples and case studies of how information can be used by users, particularly in areas of health and agronomy. WGSIP would enthusiastically broaden its links, for example to the forestry and hydrological modeling communities. To do that, it needs to identify which are the right communities to get good interaction with and that also can provide feedback to the global modeling centers. WGSIP seeks guidance on the possibilities to collaborate with the WMO's regional structures, such as the Regional Climate Outlook Fora (RCOFs) and the regional implementation of the standard verification system.

Working Group on Ocean Model Development Activity Report

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The Working Group follows two parallel approaches – one focused on ocean model development and the other on ocean-ice simulations and analysis.

Model development	Model simulations and analysis
Level, layer, and hybrid models	Atmospheric forcing
Resolution & parameterizations (US CLIVAR CPTs)	Spin-up procedure
Numerics (accuracy, efficiency, consistency, etc.)	Model evaluation against observations
Test-bed for development of the ocean component in the new generation of ESMs	Model comparison (but no MIP)
Biogeochemistry (particularly CO_2 and ocean acidification) and passive tracers	Analysis of interannual to decadal variability
Ice shelves	Analysis of possible mechanisms
Regional (nested) modeling	Sensitivity experiments

The success of the Climate Process Teams (CPTs) coordinated by US CLIVAR cannot be stressed enough and US members of WGOMD wish to continue to be involved in future CPTs, where appropriate. The last two CPTs have had direct implications for making progress in ocean modeling and model bias issues.

The Coordinated Ocean-ice Reference Experiments (CORE - www.clivar.org/organization/wgomd/core/core.php) is a framework for benchmark simulations for global ocean-ice models with detailed protocols, facilitating solution comparisons from different models. The key goals of CORE are to provide a workable and agreeable experimental design for global ocean-ice models to be run for long-term climate studies and to establish a framework where the experimental design is flexible and subject to refinement as the community gains experience and provides feedback. Associated with this experimental framework is the distribution of the CORE surface forcing dataset (Large and Yeager, 2008), which WGOMD views as the current best estimate of forcing for ocean-ice models that is available today. The CORE-II hindcast simulations are arguably more reliable than reanlyses, particularly for the pre-Argo period, and hence of significant value as an alternative for the initialization of decadal prediction systems.

In particular, CORE-II directly contributes to the:

- evaluation, understanding, and improvement of the ocean component in ESMs;
- investigation of mechanisms for inter-annual to decadal variability, e.g., AMOC;
- evaluation of robustness of mechanisms across models; and to
- provide initial conditions for decadal predictability studies.

NCAR has initiated the open distribution of simulations forced by the CORE-II atmospheric data sets by means of the Earth System Grid and within three weeks of it being made available, 20 users had registered. WGOMD invites the CLIVAR basin panels to analyze the runs and give feedback on how different processes are simulated. NCAR can provide additional data if needed and more modeling groups are expected to contribute data in the next few months. WGOMD will collaborate with the CLIVAR Basin Panels to analyze these simulations and publish the results in the peer-reviewed literature.

As part of its future directions, WGOMD will start work on coordinating CORE-III, which is an idealized experimental protocol for studying the ocean impacts of freshwater input from Greenland ice sheet.

WGOMD contributes to capacity building by organizing workshops for the ocean model development and climate modeling communities. These routinely take place in conjunction with WGOMD meetings. The next workshop, that will precede the 9th WGOMD meeting will be held in Boulder, USA inSeptember 2010, is the WGOMD-GSOP Workshop on Decadal Variability, Predictability and Predictions: Understanding the Role of the Ocean. This meeting, which is joint with GSOP, will seek community consensus for a framework tp coordinate efforts to address the decadal prediction problem. Various topics are being discussed as ideas for a workshop for 2012, as well as a proposal for a summer school on the fundamentals of ocean modeling. WGOMD also contributes to community white papers and it continues to develop the Repository for Evaluating Ocean Simulations (REOS), which is a web based community tool (www.clivar.org/organization/wgomd/reos/reos.php).

WGOMD is seeking to expand its expertise by inviting new members to join in the areas of land ice, ocean biogeochemistry and regional ocean modeling. Bringing land ice modeling expertise to the working group will strengthen its contribution to the understanding of the sea level problem. Issues related to eddy resolving models are also being addressed, including the comparison of eddy and non-eddy resolving models. WGOMD will continue to provide recommendations for evaluating ocean simulations (see REOS), including those for eddy resolving models.

Global Synthesis and Observations Panel Activity Report

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1. Contributions to CLIVAR science

GSOP has several charges, including CLIVAR data and ocean synthesis issues, both with global emphasis, and integrating the regional basin panel's science activities to provide the global context. GSOP has been particularly active in the ocean observations and synthesis model communities. GSOP is working towards the initialization of coupled models and towards coupled assimilation. With respect to the former aspect, GSOP co-sponsored a workshop on Decadal Forecasts and Initialization held in Utrecht, The Netherlands in November 2009, and jointly with WGOMD, is organizing the Workshop on Decadal Variability, Predictability, and Prediction: Understanding the Role of the Ocean, to be held in Boulder, USA, in September 2010. GSOP was one of the organizers (together with OOPC and IMBER) of the highly successful OceanObs'09 Symposium (Venice, Italy, September 2009). GSOP members were co-authors of a number of the Community White Papers presented at the conference.

GSOP contribution to CLIVAR science goals includes the ongoing evaluation of ocean synthesis/reanalysis products and organising/encouraging community usage of these to increase our knowledge of the role of the ocean circulation on the global climate. This work has resulted in several peer-reviewed papers comparing a range of ocean synthesis products and the 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 and a detailed list of existing syntheses is maintained on the GSOP web page. Both these actions will make it easier for groups to gain access to multiple synthesis products for the purpose of further comparison and scientific study. The KlimaCampus in Hamburg is now gearing up to provide available ocean syntheses in a common format to all interested researchers. This is in response to the request of the coupled modelling community for gridded reanalysis products for decadal coupled climate model initialization (http://www.clisap.de/Easy-INIT.easyinit.0.html)

GSOP, particularly through its ocean observation and synthesis project, is also engaging in decadal forecast experiments and is in the process of providing available ocean syntheses as initial conditions for these . First such experiments are ongoing and show some success. One key element is to encourage ocean synthesis groups to provide updated datasets to be used for decadal prediction experiments. However, it is necessary that the requirements for ocean synthesis products for this purpose be better defined in order to encourage this. GSOP has also begun to investigate possibilities of coupled data assimilation. Respective efforts are spinning up and will grow over the next few years.

GSOP is providing leadership in articulating the societal benefit of a sustained ocean observation system and in encouraging growth in key observations areas, as shown by its involvement in OceanObs'09. A two-page document to policy makers has been prepared by GSOP and the Ocean Observation Panel for Climate (OOPC). GSOP has begun discussion with OOPC and the WMO/IOC Joint Commission for Oceanography and Maritime Meteorology (JCOMM) regarding an assessment of the coordination of the ocean climate data sets and the need to develop implementation plans to produce data sets in support of ocean synthesis and reanalysis projects. GSOP also engages with ocean observation activities of CLIVAR's basin panels and with data providers in order to highlight the need for timely availability of quality-controlled observations.

2. Cooperation with other projects

Together with the International Ocean Carbon Coordination Project (IOCCP), and in collaboration with the IGBP SOLAS-IMBER Carbon Coordination Group, GSOP is a co-sponsor of the Global Ocean Ship-based Hydrographic Investigations Program (GO_SHIP). The programme brings together scientists with interests in physical oceanography, the carbon cycle, marine biogeochemistry and ecosystems, and other users and collectors of ocean interior data to develop a sustained global network of hydrographic sections as part of the global ocean climate observing system.

GO-SHIP held an all-day international planning meeting in February 2010 in Portland, Oregon in conjunction with the 2010 Ocean Sciences meeting. Approximately 50 participants from 12 countries discussed on-going and planned cruises and the way forward for the development of the international program. Participants reviewed reference sections and made modifications to the strategy based on feasibility of occupation and occupation frequency. It was also agreed that an oversight committee on data management was needed to develop strategies for global coordination of data assembly for hydrography variables. The GO-SHIP strategy was presented as an Information Document to the 43rd Session of the IOC Executive Council, June 2010.

Another GO-SHIP activity is the revision of the hydrography manual. This is final stages and the revised manual is planned to be published by mid-summer 2010.

3. New activities being planned

GSOP is planning to organize a Data Management meeting with the objective of supporting science and data requirements for decadal prediction and reanalysis projects and which would bring together activities of WCRP core projects involved with data quality control, archiving and distribution. This workshop would try to organize best practices for standardization (metadata, file format, etc) across functioning CLIVAR Data Assembly Centres and other interested groups,. The meeting is in its planning stages but it is likely to happen at the end of 2010.

Through GSOP endorsement, WCRP is providing funding for an XBT workshop to be held in Hamburg in August 2010. The workshop is the second international XBT workshop and is supported to provide best practise guidelines for fall rate correction of existing XBT data sets and standardized metadata format for XBT data.

Following a request from the WCRP Observations and Assimilation Panel (WOAP), the CLIVAR SSG, has tasked GSOP with development of a strategy for coordinating current activities on surface fluxes across GCOS and WCRP projects enabling assessment of the current observational program and to ensure that significant gaps in the observational programs are identified. This activity is currently being scoped, including the need to organise, jointly with WOAP, a dataset assessment workshop on global surface fluxes, to include both physical and biogeochemical properties.

Activity Report for the Expert Team for Climate Change Detection and Indices

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The ETCCDI approach for monitoring changes in extremes is based on an internationally coordinated set of climate indices (see http://cccma.seos.uvic.ca/ETCCDMI). The indices are simple, straight forward, reliable, and consistent descriptions of extremes, which include frequency, amplitude and persistence. They can be used for both observations and models, globally as well as regionally (supported software is available in R and Fortran) and they can be coupled with simple trend analysis techniques, standard detection and attribution methods and more advanced methods specifically developed for extremes. ETCCDI's work on the detection and attribution of extremes (indices, risk of rare events), indices properties and the impact of large-scale climate variations on extremes contributes directly to the CLIVAR imperative on anthropogenic climate change. A review paper on indices and the reassessment of the current set of ETCCDI indices is underway as well as guidelines for calculating and assessing extremes in CMIP5.

ETCCDI continues to develop standardized supported software and apply it in standardized regional workshops that have been taking place for over a decade to promote the monitoring and analysis of extreme climate events (see Peterson and Manton, 2009 BAMS, 89,1266-1271). The Asia-Pacific Network has co-sponsored this activity for areas of Asia that do not have much data to assess changes in extremes and this has been extended to rest of world by the ET. The goals of the workshops are to build capacity to analyze observed changes in extremes, improve information services on extremes, publish peer-reviewed papers from each workshop and contribute to worldwide database of derived indices. This is a leading activity for the CLIVAR imperative on capacity building. The CLIVAR ETCCDI website has been updated to keep a record of all past workshops, participants lists and peer-reviewed publications. Results from past workshops should be regularly updated and this remains problematic from often having lack of continuity in the local contacts.

A guidelines document has been published, in support of emerging operational climate services, which will help more groups make similar analyses:

Klein Tank, A. M. G., F. W. Zwiers and X. Zhang, 2009: Guidelines on Analysis of Extremes in a Changing Climate in Support of Informed Decisions for Adaptation. Climate Data and Monitoring WCDMP-No. 72, WMO-TD No. 1500, 56pp.

The ET is the international counterpart of the US-funded International Detection and Attribution Group (IDAG, see Stott et al., 2010, Detection and attribution of climate change: a regional perspective, Wiley Interdisciplinary Reviews: Climate Change, 1(2), 192-211). The status of detection and attribution work is that now there are many sub continental/ regional results in the literature and there are also some early detection results available for anthropogenic signal in observed changes in surface temperature extremes and precipitation extremes using indices. Future challenges in detection and attribution include how to assess external influences on extremes and 'event' attribution, in other words, what has the anthropogenic influence been on the odds of an event itself.

The future activities of the ET include reviewing the indices and addressing how to improve on how indices are applied, improving the global dataset of indices and continuing to organize regional workshops. This is dependent on funding so the ET is currently collaborating with the WCRP/GCOS/ World Book project on Climate Observations and Regional Modeling in Support of Climate Risk Management and Sustainable Development. This project involves a series of three workshops on data, regional modeling, and adaptation. The ET will continue to maintain its standardized software, which is being made available for larger datasets so that it can be used for the post processing of CMIP5 results. Diagnostic studies related to indices will be carried out using CMIP5 data. The ET is evaluating how the list of indices could be expanded, for example, with indices relevant for regions where monsoons are important, as well as introducing more application-relevant indices. The ET also plans to collaborate with the WCRP Drought Interest Group (DIG).

The ETCCDI membership has been reviewed this year. It currently has four members from each sponsor and an additional member has been added to represent GEWEX. However, the future of the ET and its membership needs to be considered strategically beyond the next few years to maintain its success while reacting to an increasing demand from a widening range of users. The ET will likely meet in 2011 to articulate how it can grow in capability while retaining its focus and efficacy, maintaining its current successful link between the science of detection and attribution and regional operational activities related to indices. In turn, the ET seeks guidance from its sponsors in what their expectations are for the team's continued and future activities. From the CLIVAR perspective, the ET acts as a vehicle to climate services as well providing training for the CLIVAR community in the assessment of extremes and the treatment of uncertainties

CLIVAR / PAGES Working Group Activity Report

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Paleo-climate studies, though lower in resolution, can contribute to understanding the externally forced and unforced components of modern and future climate variability.

The intersection panel acts as interface between WCRP CLIVAR and IGBP PAGES in activities related with modeling, data, and comparisons to identify patterns of climate variability and what is potentially predictable as determined from the geologic record. The intersection panel has contributed to the inclusion of the Paleo-climate modelling framework (PMIP3) in CMIP5 (Last millennium - tier 1, Mid Holocene and LGM - tier 2 experiments) that will be run with the same model versions as the modern and future simulations.

The CLIVAR-PAGES Intersection Vision Document (2009) outlines the focus and plans of the panel for the coming years and the main areas of research where the paleo-climate community can directly help with uncertainties in modern and future climate:

- Internal and forced variability over the last few millennia
- Sensitivity of the North Atlantic circulation
- Hydrological changes and interactions with the land surface
- Tropical Cyclones, Extreme Precipitation Events

This will be accompanied by an increased rigor in the production of paleo-climate datasets and new advanced analysis techniques for climate variability of the last few millennia by coupling proxy data to model simulations. The Paleoclimate Reconstruction (PR) Challenge gives an objective, independent evaluation of state-of-the-art reconstruction methods by means of double blind tests of pseudo-proxy networks and simulations of climate change during the last few millennia. Climate model simulations are effectively used as a test bed for evaluating paleo-climate reconstruction methods. PR Challenge data can be accessed from the World Data Center for Paleoclimatology..

The intersection panel is active in organizing workshops that bring different communities together and stimulate community review papers. Various process-orientated workshops are being planned that will be relevant for various groups within CLIVAR (Forward Modeling and regional downscaling, AMO: Mechanisms and Impacts, ENSO: Past and future variability, Paleo-data/Model fusion - Data assimilation, and Extreme events). CLIVAR participation in the organizing committees of these workshops should be enhanced.

The last formal meeting of the panel was held in Trieste, Italy in May 2008. About half the panel met informally in 2009 as part of the PAGES Open Science Meeting. The panel has been successful in generating a new community, particularly in last few years with progress accelerating dramatically as a result of the advent of better climate models and proxy records. The efficacy of the CLIVAR link in the intersection is being re-evaluated by the CLIVAR SSG.

A multi-author review of late-Holocene palaeoclimatology has been published, resulting from a PAGES/CLIVAR meeting that took place in June 2006 (P.D. Jones et al., 2009: High-resolution palaeoclimatology of the last millennium: a review of current status and future prospects, The Holocene, 19, 3-49.). The paper describes the scientific and methodological basis for the climate reconstructions for the last millennia, which provide baselines for anthropogenic warming and for natural variability. The discussion resulted in a number of recommendations for improving reconstructions, some of which may tap expertise elsewhere in IGBP. Recommendations include improvement of the coverage, quality and diversity of proxy data, to conduct process studies to improve the understanding of what individual proxies respond to, to apply reconstruction techniques that allow reliable quantification of the uncertainties, and to use climate model simulations to guide the choice of reconstruction techniques and future sampling.

Activity Report for the Atlantic Implementation 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 predictability on seasonal to decadal timescales. The ongoing Atlantic programs, which AIP promotes and facilitates, are clustered around three central themes:

1. Tropical Atlantic studies
The observational network presently includes 3 major field campaigns -- PIRATA, TACE, AMMA -- which link tropical Atlantic and West African monsoon research quite effectively:
http://tace.ifm-geomar.de/index.html
http://www.pmel.noaa.gov/pirata
http://amma-international.org/index

AIP members attended the 2010 "Tropical Atlantic and PIRATA-15 meeting" held at AOML, Miami, USA in March, (http://www.aoml.noaa.gov/phod/pne/meeting2010.html) which took place in association with the last AIP meeting. One of the issues discussed there, and that was brought to the participants' attention by AIP, was the always present need to better understand and reduce the tropical Atlantic model biases. The panel will work closely with VAMOS and VOCALS in order to promote a workshop on Atlantic model biases. This workshop is being planned for late winter/early spring 2011. Seasonal to interannual predictions and improved dynamical characterizations of the African and South American monsoon systems are fundamental elements of these programs. Significant effort is also directed toward evaluating decadal predictability through the regional contribution to Atlantic multi-decadal variability (AMV). Issues pertaining to model biases are considered a primary hurdle to assessing predictability levels and developing and validating predictive models. At AIP's urging, this was made a particular focus of the 2009 PIRATA meeting (Toulouse, France in February). AIP members Terray and Chang are working closely with WGSIP on tropical Atlantic model issues.

2. Atlantic Meridional Overturning Circulation (AMOC) studies
AIP plays an active role in the coordination of programs to measure and monitor the Atlantic MOC (UK-RAPID, EU-THOR, US-AMOC). One issue still be resolved is how to achieve a global AMOC observing system. There is need for a clear roadmap towards improving the coordination between the various existing programs and identifying the missing parts. Panel members are attending several AMOC related meetings during this year: SAMOC (Rio de Janeiro, May 2010), US AMOC (Miami, June 2010) and one on the sub-polar region (Woods Hole).

A number of AMOC-related and other larger projects are currently addressing the emerging science of decadal predictions (e.g. US AMOC, EU-ENSEMBLES, EU-THOR, EU-COMBINE). A practical consideration and current effort is the development of the CMIP5 protocol, which will lead to a large effort to perform decadal prediction simulations in 2010/2011. A workshop to set standards for initialization and perturbation techniques was held in Utrecht, The Netherlands in Nov 2009, co-sponsored by the Panel.

3. General
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. It also continues to promote and receive progress reports on process studies such as CLIMODE (Subtropical Mode Water experiment) which is now in its data synthesis phase.

Some community white papers prepared for OceanObs'09 were promoted by AIP:

- The present and future system for measuring the Atlantic meridional overturning circulation and heat transport (lead author S. Cunningham)
- Moving towards the future of a global array of deep ocean observations (S. Garzoli)
- Cyclical and secular shifts in the freshwater balance of the North Atlantic Ocean (R. Curry)
- Ocean observations in the Intra-Americas Sea (D. Enfield)
- Salinity and the Global Water Cycle (R. Schmitt)

One critical issue identified by AIP is data management for observations and models. It is felt that WCRP/CLIVAR has to engage quickly as modelling groups have a real need for good quality data, with standard agreed format, easy access and a detailed and informed user guide on the appropriate use of observed datasets. This will play a central role in the CMIP5 exercise validation).

AIP has also recommended to CLIVAR, the setting up of a new Arctic Panel. This panel should focus on the exchanges between Arctic and adjacent ocean basins (mainly the Atlantic) and the coupling with the polar atmosphere and not only on the pure cryosphere questions. It would also set up the stage for stronger coordination and development of the various existing prediction systems.

4. New activities being planned
The panel has discussed the need for a deep ocean observing system and encourages new observations on deep circulation as it can control climate changes on long term timescales (decadal to millennia). Questions include how to achieve a system able to measure the evolution of the full ocean heat content in order to close the Earth system energy budget including how to complete Argo and achieve a global coverage? One of the missing parts is the deep ocean so measurements in this region are also essential for ocean heat content as most of the estimates are limited to the upper km of the ocean. Measurements will also be essential for fresh water balance because of indications of increased freshwater input at the high latitudes of the oceans.

Analysis of CHFP and CMIP5 data regarding the Atlantic is also encouraged, including, but not restricted to, AMOC variability, Tropical Atlantic biases (cold tongue, Atlantic warm pool, Benguela SSTs) and the African Monsoon. High-resolution simulations (both forced and coupled) are also necessary to address the possible influence of small temporal (diurnal cycle) and spatial scale processes upon air-sea interaction.

Strong links with other CLIVAR panels is also a critical issue, particularly with WGOMD on the need for joint analysis of CORE-II oceanic simulations to infer possible oceanic causes or mechanisms (mixing, upwelling processes) involved in forced and coupled model biases, and with GSOP on the need for joint analysis and evaluation of existing ocean synthesis products (with focus on their AMOC and deep ocean mean state and variability representation)

Activity Report for the Pacific Implementation Panel

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The Pacific Panel (PP) has engaged in several activities and has been proactive in coordinating the integration of process studies in the region, all contributing to the development of CLIVAR science.

1. Seasonal to Decadal Prediction:
For the OceanObs'09 Conference (Venice, Italy, September 2010.) two relevant white papers accepted had PP member participation: "Decadal Climate Prediction: Challenges and Opportunities" (http://www.oceanobs09.net/cwp/proposals/062_Hurrell_DecadalClimatePredictions_CWPprop.doc) and "Ocean Initialization for Seasonal Forecasts" (http://www.oceanobs09.net/cwp/proposals/007_Balmaseda_InitializationSeasonalForecasts_CWPprop.doc). PP members have also developed the idea of concerted decadal prediction experiments via various workshops, national and international planning meetings, taking the lead on a project focusing on the Interdecadal Pacific Oscillation and its impacts on regional rainfall, and drought.

The panel maintains a website (http://www.clivar.org/organization/pacific/pacific_ENSOforecasts.php) that allows easy access to recent ENSO forecasts issued by several Climate Prediction Centers around the world using both dynamical and statistical models. It has also supported the ENSO metrics project, which has compiled an extensive list of useful metrics and diagnostics to evaluate seasonal climate prediction models (http://www.clivar.org/organization/pacific/Pacific_Metrics.pdf). The panel has also helped with the development of a review paper on ENSO simulation in IPCC models that has now been published (Guilyardi et al, 2009)

2. Sea level:
A recent study on the decadal predictability of sea-level anomalies in the North Pacific was led by a PP member. A reasonable skill can be obtained for lead times of up to 8 years in the Kuroshio Extension region. The PP helped to disseminate these results, which have potential relevance for Pacific Island nations, during conferences and workshops on climate predictability. The panel is also leading a program to provide projection of sea level rise and extremes for the Pacific Island nations. This is conducted through the Australia's Pacific Climate Change Program (PSSCP).

3. Anthropogenic Climate Change:
In March 2009 the PP organized the WCRP/CLIVAR workshop "ENSO and climate change" in conjunction with the Greenhouse 2009 conference in Perth Australia. A study on ENSO and climate change on behalf of the PP entitled "The impact of global warming on the tropical Pacific Ocean and El Niño" was published in Nature Geoscience (Collins et al., 2010).

4. Monsoons:
As contribution on studies of the role of the ocean in the Asian-Australian monsoon system, the PP is providing an international platform for the scientific and logistical coordination of the Northwestern Pacific Ocean Circulation and Climate Experiment (NPOCE) and the Southwest Pacific Ocean Circulation and Climate Experiment (SPICE), both endorsed by CLIVAR.

SPICE has started major field experiments with French agency-funded repeat XBT/Argo seeding in the Coral Sea, besides gliders, mooring deployments and an exploratory cruise in the Solomon Sea. US agencies have additionally funded glider exploration and high resolution modeling of the region. The Australian Integrated Marine Observing System (IMOS) program has funded current meter arrays in the Western Boundary Current system along the Australian coast, and is launching repeat glider deployments.

NPOCE has had its successful inauguration meeting (see the separate article, this edition), which was a milestone for the development of NPOCE. The NPOCE international joint program will open a new chapter on the Northwestern Pacific Ocean circulation and air-sea interaction research.

In addition to those two main projects, others are also networked into the panel's coordination efforts including the Topical Western Pacific Climate Experiment (GAIA), the Origin of the Kuroshio and Mindanao Current (OKMC) and PCCSP. This network of projects was promoted through a side event organized during the OceanObs'09 Conference, which had presentations on all of them. The panel also helped in the organization of the "International workshop on North Pacific West Boundary Current dynamics", which took place in June 2010, in Qingdao, China.

PP members are also heavily involved in the planning of the PCCSP initiative. The PCCSP 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 is tracking recent and current climate trends, investigating regional climate drivers (such as the SPCZ), providing regional climate projections, and improving understanding of ocean processes including acidification and sea level rise. The PP is also spearheading new activities to improve our understanding of the South Pacific Convergence Zone (SPCZ). Among these activities is a planned international workshop on the SPCZ for August 2010 in the Samoa Islands. Discussions during that workshop will include the scoping of a coordinated SPCZ analysis of observations, AMIP, CMIP3, CMIP5 runs and high resolution AGCMs.

5. New activities and future meetings
Through a task team set up by the CLIVAR SSG and in conjunction with the Indian Ocean Panel, the PP is also scoping the need for an Indonesian Throughflow study as a follow on from the very successful INSTANT program. Arrangements are also being finalized for:

- A Workshop on "The South Pacific Convergence Zone: dynamics, impacts and future changes" (23-26 August 2010), Apia, Samoa
- An International Workshop on "ENSO, Decadal variability and Climate Change in South America" (12-14 October 2010) – Guayaquil, Ecuador, in association with the 6th session of the Pacific Panel
- A Workshop on 'New strategies for evaluating ENSO processes in climate models" (17-19 November 2010), Paris, France

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CLIVAR / GOOS Indian Ocean Panel Activity Report

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The Indian Ocean Panel (IOP) was established in 2004 and has met on six occasions. The most recent meeting was held in La Reunion in May 2009. 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 are supported jointly by IOC-Perth Regional 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.

IOP mainly contributes to CLIVAR imperatives through building the ocean observing capability in the tropical Indian Ocean and stimulating the data and model based studies. It has developed the Implementation Plan for IndOOS and is coordinating its development. IndOOS has developed in response to the urgent data requirements by the science and social communities. 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 for monitoring sea surface conditions. Its critical component, the Research moored Array for African-Asian-Australian Monsoon Analysis and prediction (RAMA), which is the Indian Ocean counterpart of the TAO/TRITON array in the Pacific and PIRATA in the Atlantic, consists of 46 planned moorings. As of May 2010, 26 (56%) of the RAMA mooring sites are already occupied, with the equipment and/or ship time contributions from the US, Japan, India, China, Indonesia, and France, as well as from regional programs such as the Agulhas and Somali Current Large Marine Ecosystems (ASCLME) project. Several additional moorings are expected to be deployed in 2010 and the implementation rate will be close to 70% of the full array by the end of 2010.

Because of the rapid progress in the implementation of IndOOS, new data obtained has=ve already helped to improve our understanding of various phenomena of climate importance, such as i) the ocean dynamics associated with Indian Ocean Dipole, ii) dynamics of the equatorial currents at intra-seasonal, semi-annual and annual time scales, and iii) upper ocean response (SST and mixed layer depth) to MJO and cyclone forcing and its potential feedbacks. The data stream from IndOOS will be vital for advancing monsoon research, particularly from the point of view of monsoon-ocean interaction. IndOOS data will certainly help to advance our understanding of the monsoon dynamics, and lead to improvements in seasonal prediction skill in the African-Asian-Australian monsoon region.

IOP has been developing strong links with the Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER) project, which is a regional program under IGBP/IMBER. SIBER and IOP will cooperate to implement both physical and biogeochemical instruments on the IndOOS infrastructure. IOP, in collaboration with SIBER, has developed a plan for deployment of biogeochemical sensors on RAMA moorings. This plan includes guidance for site selection, potential sensors, installation options and priorities, and a summary of key questions that can/should be addressed. A prototype biogeochemical sensor package has been constructed and is slated for deployment in the western Indian Ocean this year.

IOP is also working as a sub-panel under IO-GOOS. During the IO-GOOS meeting in Hyderabad in December, 2009, a business plan of IndOOS Resources Forum (IRF) was adopted. IRF is a critical activity to secure the ship-time and other resources for IndOOS. The IRF members will be executive-level managers from agencies and national or international programs that are currently supporting the development of IndOOS. During July 2010 in Perth, Australia, meetings of IO-GOOS-VII, the SIBER SSC, and IOP-7 will be held jointly, in order to enhance links and mutual collaborations among the projects. The first IRF meeting will immediately follow, with inputs from the IO-GOOS/SIBER/IOP meetings. This series of meetings will contribute to further development of IndOOS, regional/coastal observing systems in the Indian Ocean, and related research activities.

IOP has been engaging in cross-panel activities within CLIVAR, in particular, interacting with CLIVAR GSOP in assessing the performance of a list of global ocean (model-data) synthesis products (i.e., state estimation or assimilation products) using IndOOS observations. IOP has developed metrics to evaluate these products in the Indian Ocean and performed related analysis of the synthesis products. IOP has provided feedback to the ocean data assimilation community both through reports to GSOP and through joint publications among IOP members, GSOP members, and developers of the ocean data assimilation systems.

IOP has also developed collaborative projects among panel members and the external (modeling and assimilation) community to use synthesis products and IndOOS observations for various Indian-Ocean researches. Examples include the study of mixed-layer temperature and salinity budgets in the southwest Indian Ocean thermocline ridge region and the study of intraseasonal variability in the equatorial Indian Ocean.

CLIVAR / CliC / SCAR Southern Ocean Region Implementation Panel Activity Report

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The goal of the Southern Ocean Panel, which is co-sponsored by CLIVAR, the WCRP Climate and Cryosphere Project and the Scientific Committee for Antarctic Research (SCAR), is to understand the role of the Southern Ocean region in the global climate system. To aid it in its work, the panel has produced a vision document for climate variability research in the Southern Ocean-ice-atmosphere system (available from the panel's web page at www.clivar.org/organization/southern/southern.php). The document summarizes significant progress in research in this area achieved over the past few years and identifies a number of imperatives and frontiers for CLIVAR research, expanding on the most pressing research issues and questions for the coming 3-5 years. Particular areas of progress in Southern Ocean region research include the following:

- Documentation of the variability of the Southern Ocean at various time scales from observations of hydrography, sea-surface height, and direct measurements of currents. The Argo network 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.

- The linking of ocean-ice shelf interaction to ice shelf collapse and faster-than-expected dynamical response of the ice sheet, with significant implications for sea-level rise. Recent results suggest that ocean heat input, from upwelling warmer deep waters, will play a significant role in determining the future of the Antarctic ice sheet and therefore future sea-level rise.
- Evidence of changes in sea ice. This suggests that the sea-ice coverage is retreating near the Antarctic Peninsula, but is marginally increasing in the Amundsen Basin. However, in order to link sea-ice with evolving freshwater fluxes under climate change, it is crucial to determine ice thickness changes. Recently, first estimates of large-scale Antarctic sea ice thickness have been made. Cryospheric satellites are making measurements of circumpolar sea-ice properties for the first time, but there is a critical need for further in situ validation. First estimates of sea ice formation rates in the open pack, derived from winter salinity changes measured by elephant seals with CTD sensors show promise for future observational needs.
- New insights into the structure, dynamics and variability of the Antarctic Circumpolar Current (ACC) showing the ACC to consist of multiple frontal jets, which can be tracked using altimetric SSH. The fact that the detailed structure of the ACC can be tracked in altimetry allows the variability of the ACC, and its relationship to SSH changes, to be determined.
- A variety of models, observations and theory suggest that the ACC may be "eddy-saturated", with implications for the response of the ACC, overturning and carbon uptake to changes in the winds. New work has begun to expose the key time scales for the interaction between eddies and wind forcing. There are suggestions that, while a significant net poleward shift in the ACC has occurred, this is not accompanied by stronger isopycnal slopes, consistent with the eddy saturation regime.
- A much better understanding of the formation, subduction, circulation, and variability of Subantarctic Mode Water and Antarctic Intermediate Water over recent years. 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 "fingerprint" of anthropogenic climate change. IPCC models suggest mode and intermediate water migrate to lighter densities with climate change, but the range between models is very large.
- Trends in the Southern Annular Mode (SAM) have been associated with ozone depletion (and eventual recovery) at high latitudes and tropical ocean surface warming. In the southeast Pacific these trends interact with ENSO and give rise to the dominant low frequency variability. The impact is different in summer and winter and the resulting seasonal climate signal is important to distinguish. Regional processes control the local impact of atmospheric forcing and determine the nature of the ocean-ice response to changes in forcing, including feedbacks. Significant differences exist in current SAM reconstructions and any conclusions on the significance or otherwise of recent trends set in the context of these datasets needs to be treated with caution.
- The Southern Ocean has been shown to contain large amounts of anthropogenic CO_2 and the question of the future of this carbon sink for the atmosphere is being debated. Air-sea CO_2 fluxes may decrease in years to come if the SAM trends continue and more natural carbon upwells. 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 from ocean acidification.
- The first high-resolution state estimates for the Southern Ocean (e.g. the Southern Ocean State Estimate or SOSE) have produced ocean reanalysis fields gaining wider use for the determination of key processes and the role of eddies. Further advances incorporating the role of sea-ice and the interaction with the Antarctic continental shelf are needed.

Key topics for Southern Ocean region climate research that emerge include:

- The dynamics of atmospheric modes and their impact on the ocean-ice system, the influence of the ocean and ice on these modes, the dynamics of the ACC, and the stability of the Southern Ocean overturning, or upwelling circulation. In this overall framework, a better estimation of heat, moisture fluxes and wind stresses at the ocean surface is of great importance. Better model representations of deep-water formation in the ocean, of ocean-ice shelf interactions, and of fast ice streams should be priorities. These goals could in part be achieved through regional reanalyzes, eventually using coupled atmosphere-ocean-sea-ice models.
- One of the main difficulties when addressing the behaviour of the Southern Ocean system is the paucity of long time series compared to other oceans. There is an absolute need to maintain the current observations system together with expansion into under-sampled locations in order to permit the analysis of long-term trends: water masses and the signals of CO_2 fluxes and ice melt, sea-ice concentration and thickness, sea surface elevation, and the grounding line of ice sheets. To this end the panel have been engaging with SCAR in the development of plans for the post-IPY development of the Southern Ocean Observing System (SOOS).
- 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 are needed to combine observations and model results to be able to estimate the magnitude and variability of the changes over the 20th century and understand their causes.

On the longer time-frame, evaluation of the quality of Earth system models in the high latitudes of the Southern Hemisphere and work to improve these is needed in order to provide better projections of future Southern Ocean carbon uptake, water-mass trends, changes in Antarctic sea ice, and the response of the ecosystem to acidification. In IPCC AR4 a major source of uncertainty in sea-level rise prediction is dynamic change to ice sheets. The stability of the Antarctic ice sheet is a looming question yet ice sheet models within climate models are rudimentary at present, and as a result, projections of future sea-level rise are very uncertain. Earth system models should be designed to incorporate these components of the climate system as well as the ocean and atmosphere in order to predict such changes.

The vision document and progress in many of these areas of research were reviewed at the Southern Ocean Panel (SOP-6) meeting following SSG-17 held in Southampton, UK, from 14-17 June 2010. The outcomes of that meeting will be reviewed in a subsequent article in Exchanges.

Asian-Australian Monsoon Panel (AAMP)Activity Report

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The 10th Session of the CLIVAR's Asian-Australian Monsoon Panel (AMMP10) was held at the APEC (Asia-Pacific Economic Cooperation) Climate Center, Busan, Republic of Korea from 15-19 June 2010. AAMP10 was held jointly with the first meeting of the WCRP/WWRP THORPEX Year of Tropical Convection (YOTC) Task Force on the Madden Julian Oscillation and the AAMP/MJOTF Workshop on Modelling Monsoon Intraseasonal Variability. AAMP has strong representation on the YOTC MJO Task Force (follow-on to US CLIVAR MJO Working Group), which is a WCRP/WWRP-THORPEX Cross-cut Activity.

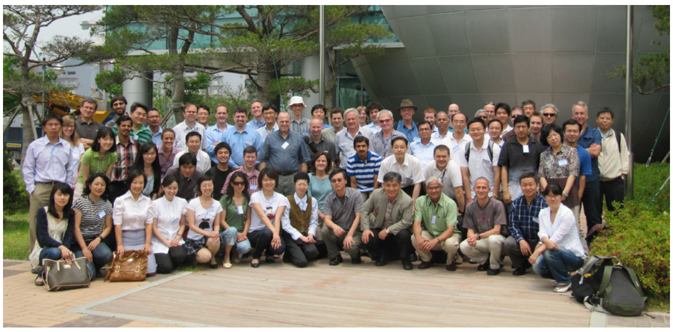
The Workshop provided a framework for assessing the predictability of the MJO and other monsoon ISV from hindcast experiments, assessing skill of real-time forecasts for monsoon ISV, reported on recent advancements and highlighted ongoing shortcomings in the simulation of monsoon ISV and the MJO, including results from simple models, global climate models and high resolution global models. The design of diagnostics, especially focusing on convective processes was also discussed. The Workshop sought to provide necessary insight into model representation of physical processes, thereby providing pathways for model improvement. The 66 attendees included 15 graduate and early career researchers.

Key focus areas for the AAMP10 were:

1. Modelling of the MJO
The Madden-Julian Oscillation (MJO) plays a key role in monsoon variability but is not well simulated or predicted. The AAMP is helping to formulate and refine the development of a simulation and prediction experiment for the Monsoon Intra-Seasonal Oscillation (MISO). The MJO/MISO hindcast experimentation protocol was revised to extend the hindcast period through October 2009 to partially cover the YOTC period. Modellling Groups are participating and Centres will be requested to contribute enhanced model output during the YOTC period to better understand the role of the diabatic heating components in the MJO.

The AAMP has participated in the development of MJO diagnostics and metrics for model evaluation, resulting in two publications in Journal of Climate (CLIVAR MJOWG ,2009, and Kim et al. 2009). The panel has also been involved in the development of a procedure and implementation of a real-time MJO forecast system (in conjunction with the WGNE) to which 9 operational NWP centers are contributing data. The details are reported in Gottschalck et al., (2010).

2. MJO Task Force
The AAMP has a strong representation on the YOTC MJO Task Force. The Task Force is a follow-up of the US CLIVAR MJO Working Group, and is a WCRP/WWRP-THORPEX Cross-cut activity whose goal is to facilitate improvements in the representation of the MJO in weather and climate models in order increase the predictive skill of the MJO and related weather and climate phenomena.



Participants at the recent AAMP meeting held at Asia-Pacific Economic Cooperation (APEC), Busan, Republic of Korea

3. MJO field studies
The panel has reviewed and facilitated coordination of Indian Ocean observational campaigns (e.g., CINDY/DYNAMO, TRIO) that will acquire observations relevant to mechanisms of MJO/ocean-atmosphere interaction. AAMP recommended that the proponents:

(1) Seek to obtain high spatial resolution, high temporal sampling numerical weather prediction analyses for the duration of the experiment with enhanced output to study MJO processes

(2) Enlist a wider scope of modellers in numerical experiments to understand the acquired observations

4. The Asian Monsoon Years (AMY 2007-2012)
AAMP will continue to play a leading role in the coordination of the AMY modelling activity. B. Wang is currently the co-chair of the AMY Science Steering Group. As such, he has co-convened two AMY workshops

(1) Yokohama, January 2009: The major topic at Yokohama was obtaining reanalyses for the AMY period. JMA has agreed to launch such an effort. The big challenge is to collect AMY observations. J. Matsumoto is coordinating with each participating team to get data ready for initialisation of the AMY reanalysis.

(2) Kun Ming China December 3-4 2009: On behalf of AAMP, B. Wang proposed (a) a coordinated analysis of future change of the AAM using AR5 outputs which will be available October 2010, (b) an AAMP/AMY joint workshop in February-March 2011 to exchange the analysis results of AR5, and (c) that AAMP/AMY should consider special issues for publishing the results on the assessment of future change of AAM in the second part of 2011, so that accepted papers can contribute to AR5 report.

5. Wider interactions
AAMP co-chair, Harry Hendon, attended the WGSIP meeting (Miami, USA; January 2009) and promoted the ISV prediction experiment as part of the Climate System Historical Forecast Project. He also attended the Pacific Panel Meeting (Perth, Australia; March 2009), and promoted the ISV prediction experiment, evaluation of El Niño hindcasts and was briefed on NPOCE, for which AAMP provides input to the Implementation Plan. Some AAMP members attended the YOTC Implementation Planning Meeting (Honolulu, USA; July 2009), successfully promoting case study periods of interest relevant to analysing MJO predictability, and promoted the extension of the MJO/MISO experimentation to cover part of the YOTC period. Finally some AAMP members attended the 13th Session of the Working Group on Coupled Modelling (San Francisco, USA; September 2009), finding the opportunity to foster AAMP interaction with the regional climate modelling community for improved understanding of regional monsoon variability.

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

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The 12th Session of the CLIVAR VAMOS Panel (VPM12) was held on 3-5 June 2009, in San Juan, Puerto Rico, USA, and hosted by the Department of Physics of the University of Puerto Rico and the PR Space Grant Consortium from NASA with joint support from WCRP, NOAA/CPPA and US CLIVAR. The VAMOS panel meeting was preceded by an Intra-American Seas CLImate Program (IASCLIP) workshop which was held on 2-3 June at the same venue. The VAMOS meeting focused on the progress of the VAMOS projects, particularly the VOCALS Regional Experiment, the La Plata Basin (LPB), the Monsoon Experiment South America (MESA), and IASCLIP. The panel also addressed the contribution to the CLIVAR Imperatives, cross-cutting themes and other WCRP programs, such as GEWEX as well as IGBP programs and activities.

The VAMOS panel is now organizing its 13th Session to be held on 29-31 July 2010 in Buenos Aires, Argentina. The event includes a one day joint session with WGSIP. In addition, members of the panel are convening several VAMOS-related sessions at the AGU Meeting of the Americas, Foz do Iguassu, Brazil, 08-13 August 2010. Special symposia will be held with focus on LPB, VOCALS, MESA and IASCLIP. Presentations on SAMS will be made at the PAGES Second Global Monsoon Symposium in Shanghai, from September 13th to 15th, 2010.

1. Seasonal prediction

Under the Monsoon Experiment in South America (MESA) a number of studies on the onset and end of the South American monsoon and comparisons of metrics have been made, including studies of the intra-seasonal variability of the monsoon using global models, and on land surface processes and impacts on the monsoon characteristics and variability.

The overarching goal of IASCLIP is to estimate and exploit the potential predictability of warm-season weather and climate in the Western Hemisphere warm pool (WHWP) region, mainly on intraseasonal to interannual timescales, based on improved understanding and modeling of relevant physical and dynamical processes. Most IPCC AR4 models fail to simulate the Atlantic Warm Pool (AWP) in their runs for the 20th century. In many of these models evaporative flux over the AWP is largely dictated by the air-sea humidity difference contrary to observations which indicate that surface evaporative flux is equally influenced by the air-sea humidity difference and surface winds.

The VAMOS panel has endorsed and promoted the establishment of the YOTC MJO Task Force (see AAMP report, this issue) and will strengthen the links with it. MESA is contributing to a YOTC MJO publication led by D. Waliser, that should be published in BAMS 2010.

2. Monsoon processes

A final version of the MESA Science and Implementation Plan has been developed, and a review paper on "New developments on the functioning, characteristics and variability of the South American Monsoon System" has been submitted to International Journal of Climatology (accepted with revisions). There were also MESA contributions to the development of data assimilation in regional models using South American Low Level Jet Experiment (SALLJEX) data.

IASCLIP is contributing to an inventory of all available daily, monthly and surface synoptic observations, as well as, all rawinsonde observations available for the IASCLIP domain (30N to 5S and 50W to 110W). The inventory will be used to determine weaknesses in the climatology for the region and to help assess the current status of the observing system in the region

3. Anthropogenic Climate Change

The GEWEX/CLIVAR La Plata Basin Regional Hydroclimate Project, through CLARIS LPB (A Europe South America Network for Climate Change assessment and Impact Studies in La Plata Basin), is contributing to a number of WCRP CORDEX (Coordinated Regional Climate Down Scaling Experiment) objectives and products. The studies will provide an ensemble of regional hydroclimate scenarios and their uncertainties for climate impact studies.

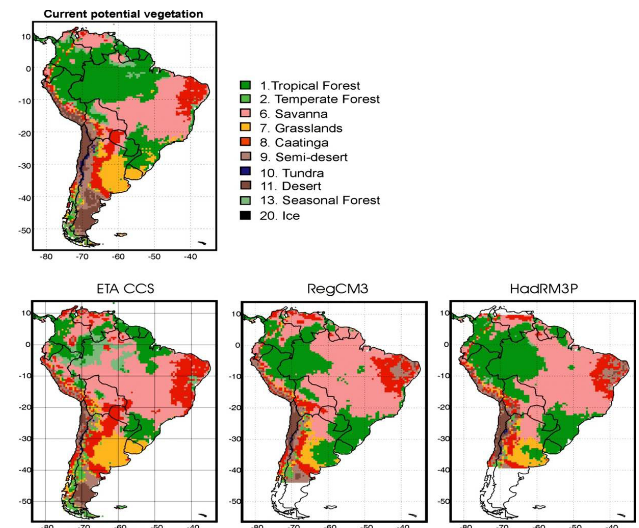
The new studies in MESA on the South American Monsoon System (SAMS) characteristics and variability are focusing on the future using regional models forced by the CMIP 3 models, and also derived form the analyses of CMIP3, which are also relevant to CORDEX. These include studies on changes in potential vegetation in Amazonia and "savannization" of Amazonia.

4. Extremes, including drought

In the 12th Session of the VAMOS Panel, after receiving the report from the Task Force on Extremes, the panel recommended the creation of a VAMOS Extremes WG (co-chairs Siegfried Schubert and Iracema F.A. Cavalcanti) to start working on some of the recommendations of the task force (see http://www.clivar.org/organization/vamos/Publications/vamos_extremes_21jul08.pdf)

The panel encouraged the working group to focus on the physical-dynamic forcing of extremes in the Americas, and following a recommendation from CLIVAR SSG16, to consider the use of indices and indicators of climate variability and change as defined by the CLIVAR/CCl/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI). The VAMOS Extremes working group is not only a cross cut between the VAMOS scientific components but is also intended to coordinate with GEWEX and other working groups within CLIVAR. Various MESA and North American Monsoon Experiment (NAME) papers using the ETCCDI extreme indices have been produced, and are used in the elaboration of the IPCC SREX to be published in 2011.

The IASCLIP team discussed the extension of drought monitoring efforts into the Caribbean at the North America Drought Monitor and World Drought Monitor Conference in Asheville, North Carolina in April 2010. Contacts were established with the Dominican Republic to plan an IASCLIP team visit to this country in order to launch joint drought monitoring activities which will be based on approximately 60 long term stations.



Projected changes in potential vegetation 2071-2100 (A2 scenario) relative to 1961-90, derived from 3 RCMs (Salazar et al 2010).

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

Contributions have been made to a Special Issue of Atmospheric Chemistry and Physics (a journal of the EGU) on VOCALS (The VAMOS Ocean Cloud Atmosphere Land Study). Collaborative papers were prepared on PreVOCA model assessment, VOCALS operations overview, marine boundary layer and clouds, aerosol composition and size distribution among others.

Contributions were also made to US CLIVAR Variations with papers on (a) Confronting VOCALS hypotheses with data, and (b) constraining the southeastern tropical Pacific heat budget with observations (Available: http://www.usclivar.org/Newsletter/V7N3.pdf).

Finally, the April 2010 special issue of CLIVAR Exchanges was dedicated to VOCALS, with 12 short papers on various VOCALS research projects. (http://eprints.soton.ac.uk/148765/1/Exch_53.pdf)

A list of VOCALS publications is available at

http://www.eol.ucar.edu/projects/vocals/publications/publications.html

Variability of the African Climate System (VACS) Activity Report

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VACS aims to promote CLIVAR activities to diagnose the variability and predictability of African climate and to develop related databases and associated analysis activities. In doing so it seeks to include the involvement of African scientists wherever possible and to develop links with relevant programmes and organizations interested in the application of VACS research. Through CLIVAR it acts in particular as a co-sponsor of the African Multidisciplinary Monsoon Analysis (AMMA) programme. The first phase of AMMA which ran from 2002-2010 has left a substantial legacy in terms of the climate observing system in the region of the west African monsoon. This has come about through Long-term (2001-2009), Extended (2005-2007) and Special (2006) Observing Periods and related modeling and prediction and analysis activities. Links have been developed in particular between AMMA and the Tropical Atlantic Climate Experiment (TACE) under CLIVAR's Atlantic Implementation Panel (AIP - see the AIP report, this volume). However the achievements of AMMA do not only lie in its scientific outputs - the human legacy of AMMA is just as strong. Thus there are 158 doctoral students in the AMMA programme, including 79 Africans, whilst AMMA-Africa has a network of 250 African scientists from different disciplines, representing the research institutes, universities and national or regional operational services involved in this international programme. In additional three capacity building schools have been held over the period of the programme. AMMA is now moving to its second phase. This will last until 2020 and will focus more on the science relevant to social impacts. However to enable this, there is still a clear need to improve models used for climate prediction (from intraseasonal to decadal timescales as well as for climate change prediction) providing opportunities for VACS engagement through its links to CLIVAR's Working Group on Interannual to Seasonal Prediction and the JSC/CLIVAR Working Group on Coupled Modelling.

Work at the University of Oxford on development of the VACS African Climate Atlas has continued. There are currently 5 parts on line:

Part I Observed Climatologies
Part II Observed Climate Anomalies
Part III Aerosols
Part IV ERA-40
Part V CMIP-3
with a further 3 being tested:
Part VI Thresholds and Extremes in CMIP-3
Part VII Regional models
Part VIII FAQs on African Climate

The Atlas can be accessed via http://www.geog.ox.ac.uk/%7eclivar/ClimateAtlas/.

With regard to regional modeling, the Greater Horn of Africa Regional Climate Model Intercomparison Project (AFRMIP) being spearheaded by Richard Anyah (University of Connecticut, USA) continues to progress. The project started in March 2008, and is being undertaken within the framework of VACS implementation. Its primary goal is to investigate uncertainties in regional model simulations of the Greater Horn of Africa (GHA) climate. It is expected that at the end of this project a more objective way of addressing the inadequacies in the parameterizations of various physical processes in RCMs that may hinder accurate simulation and understanding of the primary processes associated with regional climate variability and change will be identified, if not addressed. Another important aspect of the project is to generate high-resolution climate change scenarios for the GHA based on several RCMs nested in a few IPCC (AR4) AOGCMs with a view to using the information for impact assessment and application in formulating adaptation strategies. The project covers the whole eastern Africa and Horn of Africa domain, with model spatial resolution of 30km. The PI of the project is also collaborating with the other modelling groups participating in the WCRP COordinated Regional climate Downscaling EXperiment (CORDEX) which has Africa as its priority domain.

Although most of the participating modelling groups are on volunteer basis, AFRMIP has made several strides since its inception. Some of the milestones achieved so far, include:

(i) At least three model runs have been completed for the baseline climate (1981-2000)
(ii) Two models (WRF and RegCM3) have also been used so far to simulate the CORDEX- Africa domain at both 30km and 50km resolutions
(iii) The AFRMIP website (http://public.homepages.uconn.edu/~ria08001/afrmip) and data portal is currently being developed to enable data sharing among the participating groups as well as with any other interested scientific community.
(iv) The climate change simulations based on A2 and A1B scenarios, for the period 2046-2065 have been completed using forcing from ECHAM5 and FvGCM GCMs to derive RegCM3. WRF simulations driven by NCAR CCSM model are also in progress.

A new programme with UK (PI Richard Washington), French and German participation in collaboration with scientists in Algeria, Mauritania and Mali focuses on the Saharan climate system. The programme, called "Fennec", after the name of the Saharan fox, is aimed at quantifying and modeling boundary layer and aerosol processes over the Saharan heat low region. This is an pivotal area for the west African monsoon and is the location of numerous extremes in the Earth System as well as the source region of Saharan dust which itself is of global importance. Indeed the region has the deepest boundary layers and (during the boreal summer) the largest mineral aerosol loadings of anywhere on Earth. Model systematic errors in radiation are also greatest for that region which itself is data sparse. Overall "Fennec" aims to deliver:

- A definitive data set for central Sahara from aircraft, ground, model and satellite observations
- Description of the thermodynamic, dynamic and

compositional structure of central Saharan troposphere
- Assessment of model errors and how these can be reduced
- The mechanisms of dust emission, transport and radiative forcing from the planet's largest summer source.

Other activities in which VACS has had influence include:
- Leadership of the African Climate Report of ClimDev, an African development programme to integrate Climate Risk Management into pertinent policy and decision processes throughout the continent
- Membership of the 8-member Steering Committee for coordination of the development of the Earth System Science Partnership (ESSP)/Consultative Group on International Agricultural Research (CGIAR) Challenge Programme on Climate Change, Agriculture and Food Security. This is a $40M programme covering 3 regions (East Africa, West Africa, both under development, and the Indo-Gangetic Plain).

There are various challenges for VACS both from its position within WCRP/CLIVAR and more widely and the vision for how VACS moves forward in the future is currently being scoped. This was a subject of discussion at CLIVAR SSG-17 and progress in this respect will be reported on later. Altogether VACS, to date, has had most success as a springboard for activity and in spawning and facilitating major programmes. In developing VACS for the future it must be borne in mind that most climate programmes are now "applications oriented" an important factor for Africa in particular.

Temperature Variability Over Africa

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Introduction

Climate change over Africa has been difficult to study largely due to the sparse data coverage of freely available station data. Of the few studies which are available on climate change in Africa, many focus on rainfall. There have been few studies about climate change focusing on temperature which consider the whole of Africa. This work investigates how the near surface air temperature at 0.995 sigma above the Earth's surface in Africa between 1948 and 2009 varies in the National Centers for Environmental Research/National Center for Atmospheric Research (NCEP/NCAR) Reanalysis (Kalnay et al., 1996). Hulme et al. (2001) note that El Niño Southern Oscillation (ENSO) is a potentially important driver on future African climate. Therefore, in this paper ENSO is also considered to examine whether it significantly affects temperature variability over Africa.

Methodology

The temperature variability at 0.995 sigma above the Earth's surface over Africa between 1948 and 2009 is investigated using the NCEP/NCAR Reanalysis. Hereafter, air temperature at 0.995 sigma above the surface will be referred to only as "temperature". Other studies such as Collins et al. (2009) for South America have utilized the Climate Research Unit's (CRU) dataset called CRUTEM3 which consists of land air temperature anomalies available on a 5 by 5 degree grid-box basis (Brohan et al., 2006). While the use of this dataset may be appropriate for other areas of the world, it did not have good spatial coverage over Africa, particularly the Sahara.

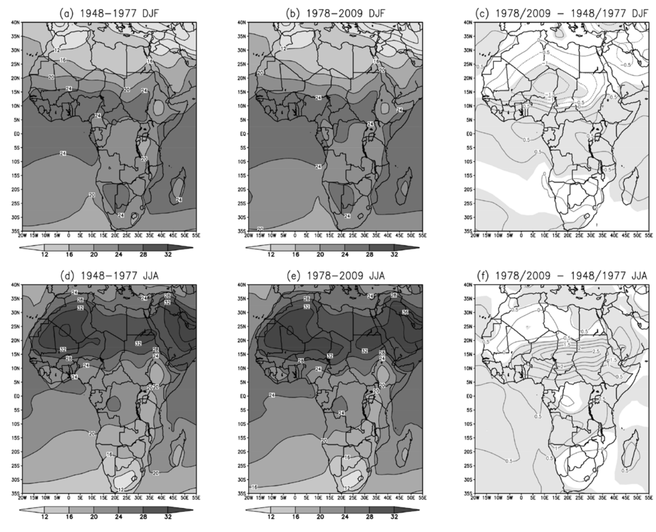

Figure 1 - Mean near-surface air temperatures (°C) in DJF and JJA during (a, d) 1948-1977, and (b, e) 1978-2009 and (c, f) the difference of the mean between these two periods. In Fig. 1c and 1f shaded areas represent statistical significance at the 5% level.

The temperature means are determined for the periods 1948-1977 and 1978-2009, as well as the most recent ten years (2000-2009), and the results presented in this paper are the average of December-January-February (DJF) and June-July-August (JJA). This division into the periods 1948-1977 and 1978-2009 is based on observations by Hulme et al. (2001) who note that the most rapid warming for Africa (not dissimilar to that experienced globally) is in the 1910's to 1930's and the post 1970's. An examination of their data reveals the temperature anomalies begin to become positive around 1978 (compared to their long term average based on the years 1961-1990). This is consistent with a climate shift noted in other parts of the world. For example Obregon and Nobre (2003) verified the occurrence of a climate shift in the mid 1970's from station precipitation data in South America. We also consider the temperature of the last ten years (2000-2009) since in the recent period there is a marked temperature increase starting at the beginning of this century in Africa and globally. The statistical significance of the difference between the composites, for the different periods considered in this work, is calculated from the ordinary least squares regression applying the Student's t-test, assuming that the population variances are not equal. The results shown in this paper could be associated with natural and anthropogenic variability, thus the occurrence of all ENSO events are verified based on the current NOAA operational index, the Oceanic Niño Index (ONI), by considering the three month seasonal values. To examine the ENSO effect, in addition to examining the periods 1948-1977 and 1978-2009, we next examine the differences in temperature between these periods after the El Niño and La Niña seasons have been removed (i.e. just considering the neutral years). In addition, the periods were then also investigated solely analyzing El Niño and La Niña years separately in each period.

Results

When considering the temperature change in the DJF season between the earlier period 1948-1977 with the most recent period 1978-2009 besides the Arctic and Antarctic, two continents show significant temperature increases across much of the continent: Africa and South America. When considering the JJA season considering continents within the low and middle latitudes, only Africa shows significant temperature increases over the majority of the continent (figures not shown). This highlights the need to study temperature change in Africa in more detail.

The spatial patterns of the temperature during DJF in Africa are strikingly similar in both periods, 1948-1977 and 1978-2009 (Fig. 1a, 1b). However, there are some notable differences,

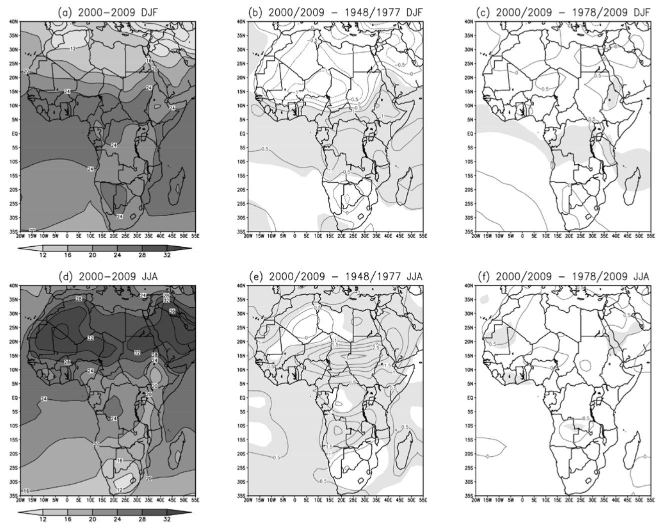

Figure 2 - Mean near-surface air temperatures (°C) in (a) DJF and (b) JJA for 2000-2009, and difference between this period and (b, e) 1948-1977 and (c, f) 1978-2009. In Fig. 2b, 2c, 2e and 2f shaded areas represent statistical significance at the 5% level.

for example, in the period 1978-2009, a change in the temperature pattern in Africa is observed, with enlargement of the area enclosed by the 24°C isotherm around 20°E and the equator (Fig. 1b). The temperature differences between the two periods are shown in Figure 1c (with significant results to the 5% level shaded in gray). It can be seen that significant warming occurs over much of the continent between the period 1948-1977 and the period 1978-2009. The observed warming in South Africa occurs largely on parts of the southern and eastern coast. This is in agreement with Muhlenbruch-Tagen (1992) studying the period 1940-1989 using station data who noted that only the coastal stations of South Africa had significant increasing temperature trends. Despite most of Africa showing a warming trend, an area emerges as showing a cooling trend in the DJF months. This cooling trend in some regions is consistent with the results of Hulme et al. (2001), although they note that specifically Nigeria/Cameroon and Senegal/Mauritania cooled. However, in the present study, a larger region of cooling extends from north of 10° N to almost 30° N and across most of the continent (although not closer to the coasts). This area of cooling encompasses the Sahara Desert.

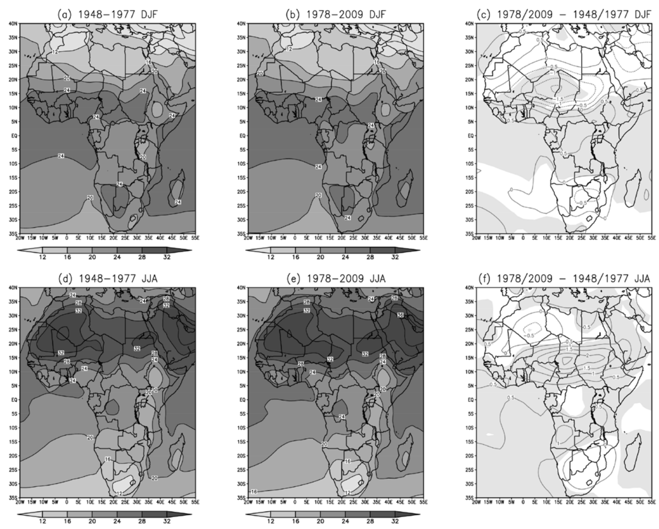

Figure 3 - Mean near-surface air temperatures (°C) in DJF and JJA during (a, d) 1948-1977, and (b, e) 1978-2009 and (c, f) the difference of the mean between these two periods. Note in each period ENSOs greater than the absolute value of 0.5°C have been removed. In Fig. 3c and 3f shaded areas represent statistical significance at the 5% level.

The JJA temperature patterns in Africa are similar for the period 1948-1977 and 1978-2009 (Fig. 1d, 1e). However, an examination of the temperature differences between the two periods (Fig. 1f) shows that, unlike what was observed in DJF, significant warming not only occurs throughout much of the continent but this also includes the Sahara region where temperature differences here are up to 3° C in the most recent period than in the period 1948-1977. This is particularly the case for the large desert expanse of the Sahara where the influence of continentality is notable. This value is higher than the increase in the total global temperatures (0.76°C increase) from 1850-1899 to 2001-2005 estimated by the IPCC AR4 (2007). This result also supports literature which states that winters in some parts of the world are getting cooler and summers are getting warmer causing extremes in climate (IPCC AR3, 2001). This result is also consistent with Hulme et al. (2001) who examined the period 1901-1995 and notes that a slightly larger warming in Africa occurs in the months JJA (and SON) than in the months DJF (and MAM). Although based on the result above, for this study particularly in the Sahara region, the temperatures are significantly warmer than the months DJF. Considering JJA, there are no areas of significant cooling.

The mean temperature patterns for DJF for the period 2000-2009 (Fig. 2a) looks similar to earlier periods shown in Figure 1a, 1b. The temperature differences in DJF between 2000-2009 and 1948-1977 are shown in Figure 2b and the temperature differences in DJF between 2000-2009 and 1978-2009 are shown in Figure 2c. Considering the majority of Africa where warming is observed, these temperature differences are greater when 2000-2009 is compared with the 1948-1977 period (rather than when 2000-2009 is compared to 1978-2009), with difference values above 1°C covering most of Ethiopia (Fig. 2b). We observed that when comparing the JJA season in 2000-2009 (Fig. 2d) with the period 1948-1977 (Fig. 2e) almost all of Africa exhibits a significant warming. However, when comparing the most recent 10 years with the recent period 1978-2009 (Fig. 2f), although we still observe warming over large parts of Africa, most of this is not significant.

Figure 3 (a-c) shows the analysis of DJF for the period 1948-1977 compared to 1978-2009 like in Figure 1 (a-c), but now with El Niño and La Niña events removed so that only neutral ENSO years are considered. It can be seen when comparing Figure 3 and Figure 1 that similar results emerge, i.e. there is a significant increase in temperatures for the majority of Africa in the more recent period with a large area of cooling over the Sahara. This suggests that ENSO does not account for the noted warming in most of Africa. Similar to the analysis of the DJF season, Figure 3 (d-f) shows the analysis of the period 1948-1977 compared to 1978-2009 like in Figure 1 (d-f), but now with significant ENSO events removed leaving just the neutral years for the JJA season. It can be seen when comparing Figure 1 and Figure 3 that again similar results emerge, i.e. there is a significant increase in temperatures for the majority of Africa in the more recent period. Thus again supporting the suggestion that ENSO does not account for the noted warming considering most of Africa. In fact, an examination of the El Niño and La Niña years for both seasons (Figures not shown) also shows similar results to Figure 1c. Overall, similar results are found when considering the neutral years, La Niña years, and El Niño years separately.

Conclusions

This work shows how the near surface mean air temperature in Africa varies in NCEP/NCAR Reanalysis between 1948 and 2009. Considering the DJF season, significant warming was observed over most of Africa comparing the period 1978-2009 with 1948-1977, with the exception of the Sahara where significant cooling was observed. An examination of the more recent period shows less cooling occurring in the most recent 10 years than the other periods examined. The difference between the time periods (1978-2009 with 1948-1977) in the JJA season is that significant warming extends across almost the entire continent, with larger temperature increases observed in the Sahara than anywhere else on the continent. The analysis from the NCEP/NCAR Reanalysis also suggested that the warming in the most recent period (1978-2009) compared to the earlier period (1948-1977) is not a result of ENSO since an examination of the differences within these periods were similar when examining neutral years, La Niña years and El Niño years separately. When considering each of these phases, and the temperature difference between the two periods, again one can see in DJF a significant increase in temperatures for the majority of Africa in the more recent period with a large area of cooling over the Sahara. Likewise in each of these three phases, in JJA one can observe warming throughout the whole continent. Due to these similarities between phases, this suggests that the temperature increases in Africa may not be due to ENSO but some other component of natural variability of the climate and/or may be a result of human activity.

Acknowledgments:
The author would like to acknowledge Rosane Rodrigues and David Roache for their advice with GRADS.

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The Pacific-Japan pattern: A meridional teleconnection over the summertime western North Pacific

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Introduction

The Pacific-Japan (PJ) teleconnection pattern is one of the dominant low-frequency anomaly patterns that influence the summertime East Asian climate. Since first identified by Nitta (1987; hereafter N87), it has been regarded as a barotropic Rossby wave response to anomalous diabatic heating associated with anomalous cumulus convection around the Philippines and to the east. However, recent analyses by the authors (e.g., Kosaka and Nakamura 2006, 2008, 2010a; hereafter KN06, KN08 and KN10a, respectively) have revealed its distinct characteristics that apparently contradict the nature of free Rossby waves. They are related to the predominance of the climatological mean meridional flow with notable vertical shear over the western North Pacific (WNP) in summer. In this paper, the recent findings on the dynamics of the PJ pattern are summarized to propose a new conceptual model of the pattern.

Observational data

Monthly data of the Japanese 25-year reanalysis (JRA-25) of the global atmosphere (Onogi et al. 2007) are used. KN08 found more coherent structure of the PJ pattern in JRA-25 than in other reanalysis datasets. Monthly data of the U.S. Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP; Xie and Arkin 1997) are also utilized. As a proxy of the atmospheric convective activity in the tropics and subtropics, $I_{\phi\lambda}$ is defined as the strongest monthly anomaly of the U.S. National Oceanic and Atmospheric Administration (NOAA) interpolated outgoing longwave radiation (OLR), either positive or negative, over a 10º×10º domain centered at (latitude ϕ, longitude λ) for each month. All the datasets are available over a 29-year period from 1979 to 2007. In order to focus on large-scale features, horizontal smoothing has been applied to vorticity through a spectral expansion with T47 truncation, multiplying a spherical harmonic component of the total wavenumber n by exp $[-K\{n(n+1)^2\}]$, where the factor K is such that amplitudes of the harmonic components with n=24 are reduced by 50%.

Structure of the PJ pattern

Figures 1a-c show precipitation and vorticity anomalies composited for 38 monthly events with negative $I_{15^\circ N,\,125^\circ E}$ that exceeds half the standard deviation in magnitude for June, July and August (JJA). Enhanced precipitation over the northern portion of the South China Sea (SCS) and the tropical WNP accompanies significant cyclonic and anticyclonic anomalies centered near the enhanced convection center in the tropics and to the southeast of Japan, respectively, in the lower troposphere (Figs. 1a-b). This meridional dipole in anomalous circulation is a characteristic feature of the PJ pattern (N87). In the upper troposphere (Figure 1c), the dipolar vorticity anomalies are displaced poleward relative to their lower-tropospheric counterpart. Thus the anomalous circulation is in neither barotropic nor the first baroclinic structure, but tilted poleward with height (KN06; KN10a; Hsu and Lin 2007). The anomalies transport heat eastward from the warmer Asian continent to the cooler North Pacific. Embedded in the northerly-sheared mean flow, the anomalies accompany poleward and equatorward wave-activity flux in the lower and upper troposphere, respectively, indicating that poleward Rossby wave propagation occurs mainly through the lower-tropospheric southerlies. These features indicate that the PJ pattern cannot be regarded as a barotropic Rossby wavetrain propagating in the upper troposphere or in the zonally-uniform westerlies, on the contrary to early studies on the PJ pattern (e.g., N87; Kurihara and Tsuyuki 1987; Huang and Li 1989; Tsuyuki and Kurihara 1989; Lau and Peng 1992; Grimm and Silva Dias 1995; Lu 2004). The importance of the zonally-varying mean state is also suggested by a vorticity budget analysis, which reveals a primary balance in the (sub-) tropical WNP among the anomalous meridional advection, β effect and Rossby wave source (KN06).

Modal characteristics of the PJ pattern

Barotropic and baroclinic energy conversions (CK and CP, respectively) and diabatic energy generation (CQ) are evaluated based on the composited anomalies shown in Figs. 1a-c. Zonally-elongated cyclonic anomalies embedded in the exits of the monsoon westerlies and the Trades gain kinetic energy (KE) through CK in the lower troposphere (Figure 1e; Kawamura et al. 1996; Fukutomi and Yasunari 2002). In midlatitudes, the westward-tilted anticyclonic anomalies embedded in the vertically-sheared Asian jet gain available potential energy (APE) efficiently through CP (Figure 1f; Fukutomi and Yasunari 2002). Efficiency of the conversions can be evaluated as time scales on which the area-integrated energy could be replenished by the conversions integrated over a given domain. The efficiency of the combined conversions $\tau_{dry} = [KE+APE]_{NH}/[CK+CP]_{WNP}$ is 28.9 days, where $[\ ]_{NH}$ and $[\ ]_{WNP}$ represent integrals over the entire Northern Hemisphere and WNP (Eq.-60ºN, 100º-150ºE), respectively, both after integrated vertically from the surface to the 100-hPa level. It

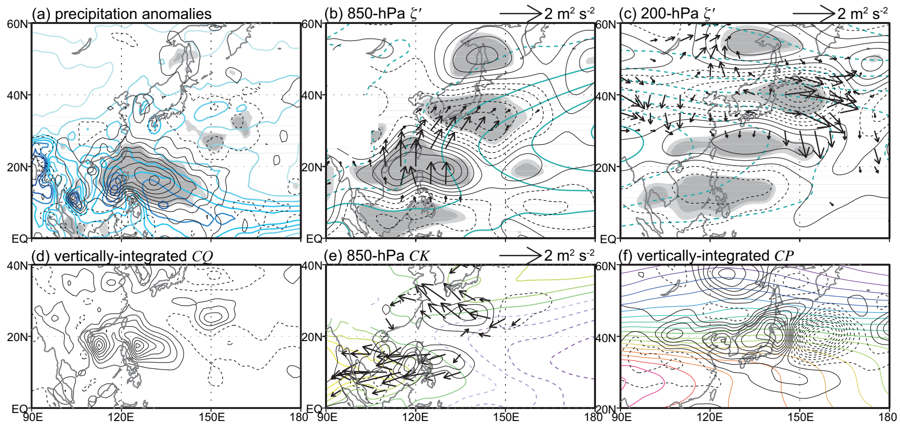

Figure 1 (Black contours in a-c) Anomalies of (a) precipitation (mm day^{-1}) and (b-c) vorticity (× 10^{-6} s^{-1}) at the (b) 850-hPa and (c) 200-hPa levels composited for the 38 strongest monthly events of PJ pattern observed with enhanced tropical convection. Light and heavy shading represent the 90 and 95 % confidence levels, respectively, based on the t-statistic. Arrows in (b-c) indicate a wave-activity flux formulated by Takaya and Nakamura (2001). (Black contours in d-f) Distributions of (d) diabatic energy generation CQ (× 10^{-2} W m^{-2}), (e) barotropic energy conversion CK at the 850-hPa level (× 10^{-5} m2 s^{-3}) and (f) baroclinic energy conversion CP (× 10^{-2} W m^{-2}). CQ and CP are integrated vertically from the surface to the 100-hPa level. Arrows in (e) represent the extended Eliassen-Palm flux. Contour intervals are (a, b, f) 0.5 (±0.25, ±0.75, ±1.25, …), (c) 1 (±0.5, ±1.5, ±2.5, …), (d, e) 2 (±1, ±3, ±5, …). Solid and dashed contours represent (a-c) positive and negative anomalies, respectively, and (d-f) energy gain and loss, respectively, for the anomalies. Colored contours show climatological-mean (a) precipitation (2, 4, 6, … mm day^{-1}), (b-c) stream function (× 10^6 m^2 s^{-1}) at the (b) 850-hPa (±2, ±6, ±10, …) and (c) 200-hPa (±5, ±15, ±25, …) levels, (e) 850-hPa zonal wind (±1, ±3, ±5, … m s^{-1}) and (f) 400-hPa temperature (every 1 K), in JJA.

is comparable with the efficiency of the diabatic generation $\tau_{moist} = [KE+APE]_{NH}/[CQ]_{WNP}$ of 42.9 days (KN08) and shorter than a month, indicating the effectiveness of the conversions in maintaining the *monthly* PJ pattern (KN06; KN10a). This result suggests that the PJ pattern can be regarded as *a dynamical mode inherent in the zonally asymmetric climatological mean flow characterized by the Asian summer monsoon to the west, the North Pacific subtropical anticyclone to the east and the vertically-sheared Asian jet.*

The same compositing as in Figs. 1a-c has been repeated for each of the 55 OLR indices $I_{\phi,\lambda}$ with ϕ = [10°N, 15°N, ⋯, 30°N] and λ = [105°E, 110°E, ⋯, 155°E]. The dry energy conversion $CK+CP$ is found particularly efficient with τ_{dry} < 30 (days) if the anomalous convection occurs near the northern Philippines (15º-20ºN, 115º-125ºE) or around the Bonin Islands and to their east (20º-30ºN, 140º-155ºE). This sensitivity to the location of enhanced convection supports the notion that the PJ pattern is a dynamical mode over the summertime WNP (KN10a).

The PJ pattern in a simple model

The critical importance of the particular climatological mean state over the WNP for the modal characteristics of the PJ pattern can be confirmed by using a steady, linear, quasi-geostrophic two-layer model on a β plane centered at 45ºN (KN10a). A hypothetical basic field is prescribed in the model that consists only of a pair of a monsoonal low and a subtropical high as a low-level manifestation of the first baroclinic structure of the mean planetary wave (Figure 2b). In the upper-level basic state, this pair, after its sign has been reversed, is added to a zonally uniform subtropical westerly jet at 40ºN (Figure 2c).

As a response to a localized diabatic heating prescribed between the model monsoon and subtropical anticyclone (Figure 2a), a lower-level vorticity dipole and an upper-level tripole are generated, with an apparent poleward phase displacement of the latter relative to the former (Figs. 2b-c). The structure of the response, including poleward and equatorward wave-activity flux at the lower and upper levels, respectively, is consistent with the observations (Figs. 1b-c). In contrast, the PJ-like response could not be obtained if the model basic state consisted only of the zonally-uniform component or of the zonally-varying component alone, indicating the critical importance for the PJ pattern of the combination of those two components as actually observed in the summertime climatological mean state over the WNP (KN10a).

To further explore the possibility of the PJ pattern as a dry dynamical mode, a singular value decomposition (SVD; Navarra 1993) is applied to the linear model system (KN10a).

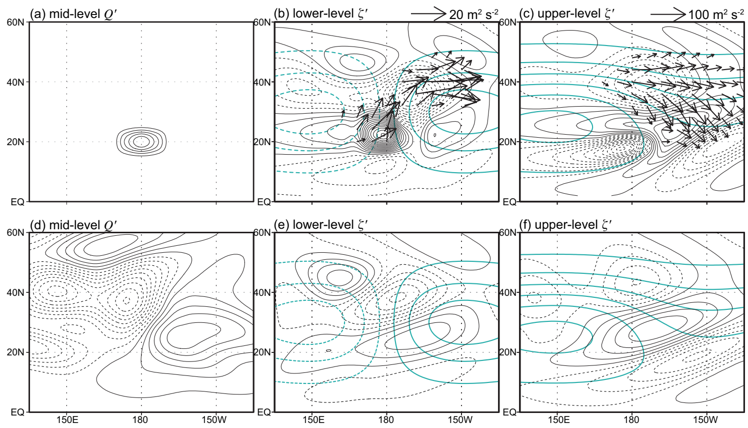

Figure 2 (a) Distribution of prescribed diabatic heating (K day^{-1}) and (black contours in b-c) vorticity response (× 10^{-6} s^{-1}) to this diabatic heating at the (b) lower and (c) upper levels. Arrows in (b-c) indicate the wave-activity flux associated with the response. (d) Diabatic heating (K day-1) in the forcing vector and (e-f) vorticity perturbation (× 10^{-6} s^{-1}) at the (e) and (f) upper level in the response vector of SVD2. Contours are drawn with intervals of (a) 0.5 (0.5, 1, 1.5, …), (b-c, e-f) 1 (±0.5, ±1.5, ±2.5, …) and (d) 0.5 (±0.25, ±0.75, ±1.25, …). Green contours in (b-c, e-f) show basic stream function (× 10^6 m^2 s^{-1}) at the (b, e) lower (with contours of ±2, ±6, ±10, …) and (c, f) upper (with contours of ±5, ±15, ±25, …) levels.

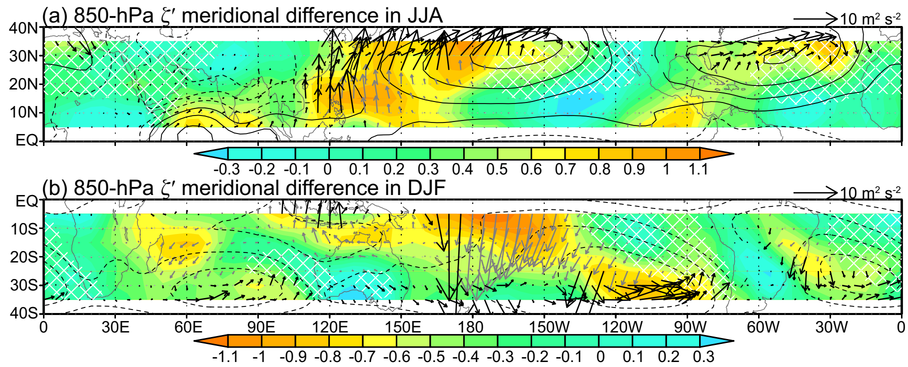

Figure 3 Maps of "meridional teleconnectivity" for (a) JJA in Northern Hemisphere and (b) DJF in Southern Hemisphere. Plotted at a given location (latitude ϕ, longitude λ) are those based on a composites with the OLR index $I_{\phi,\lambda}$. Shading represent meridional vorticity difference calculated as composited 850-hPa vorticity anomalies averaged over (a) [ϕ~(ϕ+10º), (λ-10º)~(λ+10º)] and (b) [(ϕ-10º)~ ϕ, (λ-10º)~(λ +10º)], subtracted from those averaged over (a) [(ϕ +20º)~(ϕ +30º), (λ-10º)~(λ +10º)] and (b) [(ϕ-30º)~(ϕ-20º), (λ-10º)~(λ +10º)], then normalized with its climatological standard deviation. The wave-activity flux averaged over (a) [ϕ ~(ϕ+10º), (λ-10º)~(λ +10º)] and (b) [(ϕ-10º)~ ϕ, (λ-10º)~(λ +10º)] is plotted with black and grey colors over the climatological-mean westerly and easterly regions, respectively. Contours show climatological-mean stream function at the 850-hPa level, with an interval of 4 (±2, ±6, ±10, …) × 10^6 m^2 s^{-1}. Crosshatched areas represent those in which the composited OLR (climatological-mean plus anomalies) is greater than 250 W m^{-2}, indicating that the anomalies are not associated with enhanced convection.

While the leading SVD mode represents vorticity perturbations confined to the subtropical westerly jet, the second singular mode (SVD2) is characterized by cyclonic and anticyclonic perturbations around 20°N and in midlatitudes, respectively, at the lower level (Figure 2e). At the upper level, it is characterized by anticyclonic perturbations in both midlatitudes and the tropics and a cyclonic perturbation in between (Figure 2f). These perturbations are tilted poleward with height, with their centers in good correspondence to their counterpart in the heat-induced model response (Figs. 2b-c). The diabatic heating to excite SVD2 (Figure 2d) with the particular polarity as in Figs. 2(e-f) is positive around the prescribed diabatic heating in Figure 2a. These features, as well as the second smallest singular value, indicate that SVD2 is the leading mode of variability that shapes the PJ-like heat-induced model response, confirming the characteristic of the PJ pattern as a dynamical mode.

A recent study by Lu and Lin (2009), who used a more sophisticated linear baroclinic model, indicates an important contribution from midlatitude anomalous diabatic heating along the Meiyu-Baiu frontal system, in forcing the PJ-associated circulation anomalies. This result indicates an importance of climatologically heavy precipitation in midlatitudes, in addition to tropical precipitation, in triggering the PJ pattern.

PJ-like meridional teleconnections over the globe

The analysis thus far has stressed the importance for the PJ pattern of the climatological mean field over the summertime WNP characterized by the Asian summer monsoon to the west and the North Pacific subtropical anticyclone to the east. It in turn suggests a possibility that similar meridional teleconnection patterns may be observed in other regions where the climatological mean field is similar to that over the summertime WNP.

In Kosaka and Nakamura (2010b), composite maps have been constructed for each of the 1008 OLR indices $I_{\phi\lambda}$ that altogether cover the entire tropics and subtropics, namely, ϕ = [5°N, 10°N, 15°N, ···, 30°N and 35°N] for boreal summer and [5°S, 10°S, 15°S, ···, 30°S and 35°S] for austral summer, with λ = [0°, 5°E, 10°E, ···, 10°W and 5°W] for each of the hemispheres. Here the difference compositing (i.e., "positive" minus "negative") has been adopted where the "positive" ("negative") events are those months when the negative (positive) $I_{\phi\lambda}$ at a given location exceed half the standard deviation in magnitude for a particular calendar month. Figure 3 shows geographical distributions of local meridional difference in the composited lower-tropospheric vorticity anomalies associated with locally enhanced convection, as a measure of a PJ-like meridional dipole. The meridional dipoles are prominent over the tropical WNP east of the Philippines, corresponding to the PJ pattern. In addition, PJ-like dipoles are observed over a tropical region over the eastern North Pacific and Mexico (Figure 3a). Likewise, vorticity dipoles are found also in austral summer over the western South Indian Ocean, central South Pacific and western South Atlantic/Amazon (Figure 3b). These regions correspond to the western peripheries of basin-scale surface subtropical anticyclones (Figure 3). Except for the central South Pacific, they also lie around eastern fringes of upper-tropospheric anticyclones associated with the continental monsoons. For the central South Pacific, climatologically active convection

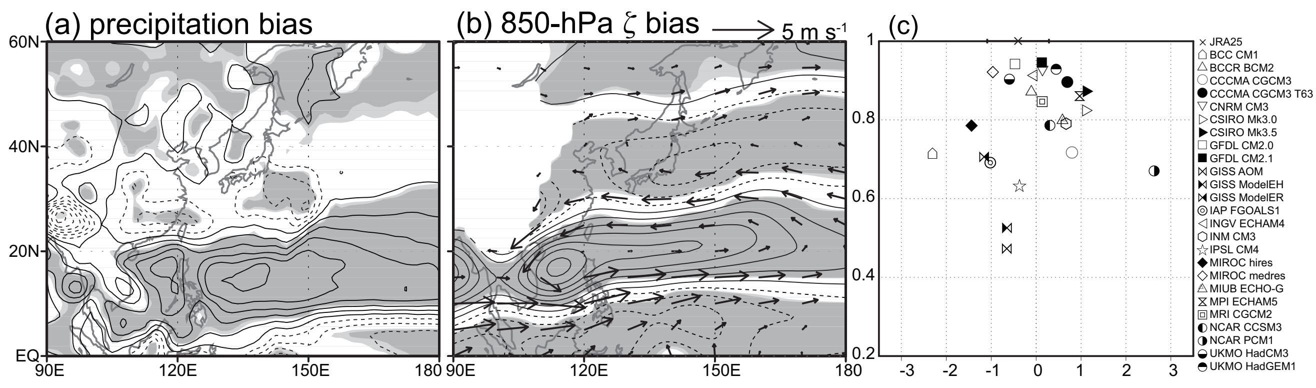

Figure 4 (a-b) Horizontal maps of JJA climatological-mean biases regressed onto the leading PC of inter-model EOF analysis applied to 850-hPa vorticity over [Eq.-60°N, 100°-160°E] simulated in the 25 CMIP3 models. (a) Precipitation (mm day^{-1}) and (b) 850-hPa vorticity (× 10^{-6} s^{-1}; contours) and wind (arrows). Contour intervals are (a) 0.5 (±0.25, ±0.75, ±1.25, …) and (b) 1 (±0.5, ±1.5, ±2.5, …). Light and heavy shading represent the confidence levels of 90 and 95 %, respectively, based on the t-statistic. (c) Scatter diagrams showing (abscissa) the standardized leading PC of the inter-model EOF analysis and (ordinate) pattern correlation of the model PJ patterns with the observational counterpart over [Eq.-60°N, 100°-160°E] at the 850-hPa level. Horizontal error bar indicates projection of the observed PJ pattern, dimensionalized by ±1 standard deviation of the corresponding PC, onto the inter-model EOF1 pattern (b).

along the South Pacific Convergence Zone (SPCZ) may play a role equivalent to a monsoon system. The associated mean poleward and equatorward flow in the lower and upper troposphere, respectively, and the westward temperature gradient, are overall consistent with the mean state over WNP, showing a consistency between the meridional teleconnections and the particular mean states.

The PJ pattern in the climate models

The aforementioned importance of the climatological mean state on the PJ pattern is examined by a set of multi-model 20th-century climate simulations (20C3M) for the phase 3 of the Coupled Model Intercomparison Project (CMIP3; Meehl et al. 2007) for the period 1980-1999. Reproducibility of the summertime climatological mean field over the WNP is investigated through an analysis named "inter-model empirical orthogonal function (EOF)". Specifically, a conventional EOF analysis is applied to a set of the 25 climatological mean fields simulated by the individual CMIP3 models, in order to extract the most dominant pattern of model bias for a given variable. In practice, it was conducted for the climatological mean 850-hPa vorticity fields for JJA over [Eq.-60°N, 100°-160°E]. The leading inter-model EOF (inter-model EOF1) explains as much as 49% of the total inter-model variance and therefore can be used as a measure of the reproducibility of the mean field. As shown in Figs. 4a-b, the inter-model EOF1 is characterized by a meridional dipole of zonally-elongated bias in the lower-tropospheric vorticity (Figure 4a), in combination with precipitation bias that is positive over the SCS and to the east of the Philippines and negative in the vicinity of the Meiyu-Baiu front (Figure 4b). These features of the model bias well correspond to the observed characteristics of the PJ pattern (Figs. 1a-b).

A possible reason for the dominance of the PJ-like model bias may be that the PJ pattern is associated with precipitation anomalies in the tropics, which can be sensitive to cumulus parameterization and therefore manifested as one of the prominent uncertainties. Another reason may be that the PJ pattern is a preferred mode of variability. Provided that the major features of the climatological mean circulation systems are simulated in a more or less realistic manner forced with a land-sea thermal contrast, a PJ-like pattern can be a preferred mode of variability that may emerge as the most sensitive model bias.

Relationship between the configuration of the climatological mean state and the reproducibility of the PJ pattern in the 20C3M dataset is examined based on a scatter diagram shown in Figure 4c. The observed PJ pattern is defined as the leading conventional EOF mode of 850-hPa vorticity over the WNP (Eq.-60ºN, 100º-160ºE) based on the JRA-25. The model PJ pattern is defined as a linear combination of the leading and second modes obtained by the same EOF analysis as for the JRA-25, with combination coefficients determined so that the pattern correlation with the observed PJ pattern is maximized. In Figure 4c, this pattern correlation is plotted as the ordinate, while the abscissa indicates the standardized principal component (PC) corresponding to the inter-mode EOF1.

Projection of the observed (JRA-25) climatological mean 850-hPa vorticity onto the inter-model EOF1, also plotted in Figure 4c, is considerably smaller, indicating a fairly high reproducibility of the summertime climatology observed for the WNP. The scattering in Figure 4c indicates a tendency for those models with smaller model bias (i.e., smaller PC with higher reproducibility of the climatological mean fields) to have higher reproducibility of the PJ anomaly pattern. This result is straightforward in a sense that, in general, structure of an anomaly pattern depends rather sensitively on a configuration of the background state in which the pattern is embedded. The tendency is also consistent with the characteristic of the PJ pattern as a dynamical mode.

Concluding remarks

The climatological mean field over the summertime WNP exhibits pronounced zonal asymmetries, accompanying climatologically heavy precipitation in tropics as well as in midlatitudes. The PJ pattern is manifested as one of the dominant modes of low-frequency variability and additionally an important source of model bias that yields inter-model diversity over the summertime WNP. The pattern exhibits distinct characteristics that suggest its modal nature. Still, moist processes and their interaction with dry dynamics discussed in this paper require further investigation (KN06; KN10a). Its interaction with other variability patterns and its possible future modulations under the warmed climate in future also remain to be addressed.

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An electronically accessible catalogue of climate extremes 1948-present

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Introduction

It is commonplace to point out that the extremes of weather and climate are the most important, because they have potentially the most impact on human society, be it in terms of life or property. Articles on extremes have been published in very visible journals (e.g. Easterling et al. 2000a and 2000b), and book-size discussions of the subject are available as well (Diaz and Murnane 2008). Thus, it is logical to ask how well we can presently predict such extremes, what it would take to improve predictions, and whether the prediction skill for extreme situations differs from that of weather and climate in general. Our emphasis here is inter-annual prediction—not tomorrow's weather, and not climate change. Before we subject any existing hindcast data from a prediction model like NCEP's Climate Forecasting System (Saha et al 2006) to these questions, we need to know where and when these extremes have happened. Obviously, one first has to define an "extreme". We here describe a 'catalogue' (or atlas, that one can leaf through) of climate extremes over global land for the period 1948-2009, using seasonal mean data for temperature, precipitation and soil moisture. We describe the data sets we use, present a definition for an extreme, and discuss some of the overall findings in putting this catalogue together. Our results can only be as good as the data we use, and some data problems are quite evident. Another challenge is climate change, which is tilting the odds of extremes, especially for temperature. Regardless, the catalogue should be an easy tool for anybody to quickly find out whether an extreme happened at a certain time at a certain place. Access to the catalogue is described.

Input data sets

The authors use the in-house data sets developed at and maintained in real time by the Climate Prediction Center (CPC, NOAA/NWS/NCEP) in Washington DC. We consider three variables: surface air temperature (T), precipitation (P) and soil moisture (w), 1948-present at ½ degree latitude by ½ degree longitude resolution, over global land. Typically we use three-month means as low-pass filter. For soil moisture it is unnecessary to apply any time average as a postprocessor, because it is in the nature of the variable w to be integrated in time already. While w is technically the instantaneous value at the end of the month, soil moisture is effectively akin to a quantity filtered over several months. The data sets used are described extensively in Fan and Van den Dool (2008) for global T, in Fan and Van den Dool (2004) for global w, and in Chen et al. (2002) for global P. All fields are on the same ½ by ½ degree grid. Soil moisture is obtained by integrating the "leaky bucket model", a one-layer hydrological model (Huang et al 1996).

Defining a climate extreme.

The definition of an extreme is not without ambiguity, especially if impact on society is considered. Before defining "extreme", we want to distinguish a weather extreme from a climate extreme. Examples of weather extremes include a strong storm that lasts a few days or less, a heavy rainfall event of hours or days, or a heat wave on the synoptic timescale. By studying time means, specifically the seasonal mean, we can more or less filter out the daily aspect, and capture climate extremes.

If X is a variable, either temperature (T), precipitation (P), or soil moisture (w), we first define a seasonal climatology μ as the mean of X over 1948-2009 as a function of location and calendar month. The anomaly in physical units is then given by X - μ, and the standard deviation is given by sd=sqrt(Σ (X - μ)²/N), where N is the number of years (N=62) and summation is over all years. Hence, sd is a function of month and location. The standardized anomaly is given by (X - μ)/sd.

Our working definition of an extreme is simply

$|(X - \mu)|/sd > 1.645$. (1)

Our emphasis is seasonal to inter-annual variability, and ultimately about causes and predictability of a particularly cold, warm or dry/wet season. Extremes, as per Eq (1), are defined in a local 'relative' sense, i.e. relative to their own climatology (which is a complete probability density function (pdf)), e.g. the eastern Sahara is not always extremely dry according to (1), and winter in Siberia is not always extremely cold. We do this because societal impact is important—even a moderate climate has, relative to its own climatology, extremes to which society can be sensitive.

The criterion expressed by Eq (1) is entirely objective and does not have explicit reference to the impact on humans, animals and plants, except in that we use 'relative' climatology. Nevertheless, we expect all extremes that had an impact on society to be in our data base. The data base may also contain 'extremes' that have not been noted for their impacts at the time by humans. For instance, warm temperatures in October or November in the Northern Hemisphere have fewer detrimental impacts than a particularly cold January or warm July. Again, our focus is climate extremes, not weather extremes (no matter how devastating) which are shorter-lived. The 90-day accumulation/average is a crude attempt to integrate weather into climate. Currently, we only use three calendar month means (as opposed to running 90-day averages), which is a limitation. Eq (1) does not have explicit reference to duration or spatial extent, features commonly associated with an extreme. By taking a three-month mean, the issue of duration is somewhat addressed, but the criterion is applied locally by grid point. The examples below illustrate the spatial scales.

For the variables P and w we first did a quick-and-dirty power transform (e.g. P**(1/4)) to make the distribution more symmetric (otherwise 'drought' would never be extreme in many areas). T is Gaussian to the first order as is, and so does not require transformation. For soil moisture we work only with 1949-present data to avoid spin-up during 1948. In addition to three-month means for the three variables, we also kept the results for one-month means for T.

A few examples

Fig.1a shows the normalized monthly mean T anomaly in February 1956 – note there are 12*62 such maps in our atlas just for T. We show a color on the map if the standardized departure from the 1948-present climatology is at least +/- 1.645 which, on average, should happen in about 10% of the locations and 10% of the times. For T we use colors red and blue in areas where T departs from climatology by more than the threshold, blue (red) denoting cold (warm). In the lower left corner of each map is the percentage of gridpoints (with cosine weighting) that satisfies the criterion for a -ve or +ve extreme. The expected value for either extremes is 5%, but at certain times the planet appears more prone to extremes than at others. For example, February 1956 was cold over land, showing close to 12% of the land area in extreme cold (extreme as defined). Europe was especially cold over a very large area with intensity far above the threshold; anomalies larger than three standard deviation are seen.

In search of an example regarding P or w, we should first point out that, in contrast to T in Fig.1a, extremes in P and w never cover large coherent areas. While they may be devastating

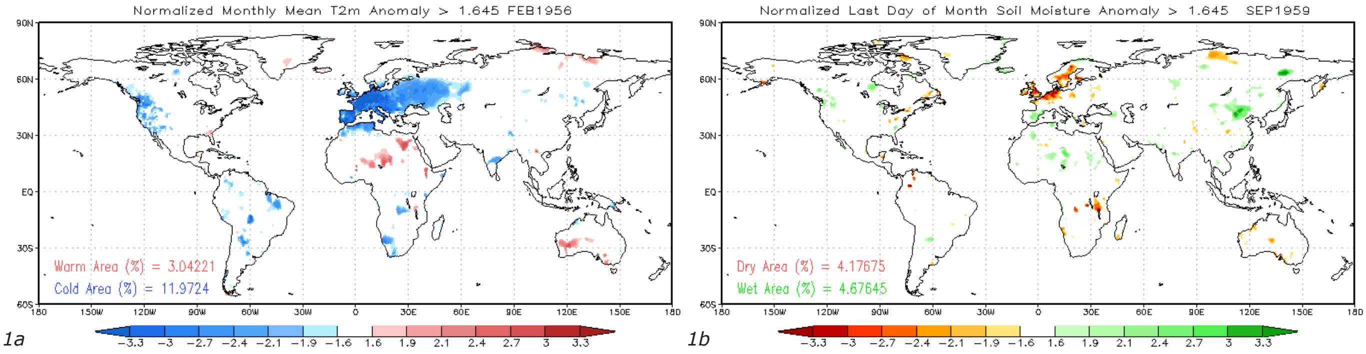

Figure 1 a) Standardized monthly mean T2m anomalies in February 1956. Positive (negative) anomalies are shown as red (blue). b) Standardized soil moisture anomalies in February 1956. Positive (negative) anomalies are shown as green (brown). Absolute values smaller than 1.645 are masked out, and shown as white, thus leaving only the extremes. The scale starts at 1.6, deeper colors are used for stronger anomalies.

regionally, it is striking how small hydrological anomalies are on a global map, at least compared to temperature. Fig.1b gives us an example for soil moisture in September 1959. Green is for wet conditions, and brownish red for dry. We have between 4 and 5% of the area covered with extremes of either sign (close to expected) but they occur in small or very small specks. The drought in NW Europe at the end of summer 1959 is the largest feature at this time, but it still covers only a relatively small area.

Overall Results

We provide 3 line graphs (Figure 2a-c) that show how the percentage of gridpoints that satisfies the criterion has varied for each month from 1948-present (1949-present for soil moisture). Overall, the numbers should be around 5%. We see wild variations from month-to-month (thin dashed lines); these variations are larger for T (Fig. 2a) than for P (Fig. 2b) or w (Fig.2c) because T has far fewer degrees of freedom (or much larger spatial scales) than P and w. In addition to the month-to-month variation in percentage land covered by extremes, we see clear secular variations, some of which are real, and some of which are not. For the temperature data set (Fig.2a) we see a clear demonstration that extreme warm (cold) anomalies have become more common (rare) from 1995 onward. This agrees with global mean temperature going up (hardly a new finding) AND the whole pdf moving to the right, making warm extremes (as defined) more common, and cold extremes (as defined) less common. Perhaps a sliding definition of the climate is required.

For three-month mean precipitation (Fig. 2b), the eye is struck by discontinuities. A blatant discontinuity happens in late 2004 when extremes of both signs suddenly have become much rarer – we think this is artificial, as reduced data input (gauge only) may force the analysis to stay too close to climatology; this could be regional. A more subtle changeover happens to soil moisture in the 10 years around 1980, see Fig.2c. Before 1980 extremes on the wet side are more common than extremes on the dry side, but this pattern reverses after 1980. While this would be consistent with a slow downward trend in precipitation, P (Fig. 2b) does NOT show the reversal around 1980, and instead, this may be caused by increasing temperature (higher evaporation). The line graph for soil moisture extremes (Fig. 2c) shows the discontinuity in 2004, which we think is caused by a problem in the P input data. Peculiarly, as defined, dry extremes are on the whole more common than wet extremes. Perhaps we have overdone the power transform (w30**(1/4)). This may be finessed later.

Access

The entry link is: http://www.cpc.ncep.noaa.gov/soilmst/extreme.htm

This gives access to links for each variable, where you find about 744 maps per variable which can be seen one by one or in a loop.

Also shown are the line graphs and a brief explanation.

Conclusion

We have made global LAND 0.5 degree latitude by 0.5 degree longitude maps of climate extremes (by some definition) and stored the results of this exercise in a 'monthly' data base that allows the user to flip through the results with some ease. The period is 1948-present, the variables are Precipitation (P), Temperature (T) and Soil Moisture (w), and the domain is global land (even though the proposal for which we do this work speaks about the Americas only). Note that soil moisture starts in 1949 to avoid spin-up. While P&T are observed, the soil moisture is calculated as per Huang et al(1996). The climatology and standard deviation are calculated for each variable, by month, from the entire record. All data sets are due to the best CPC analyses we know about. We acknowledge support from NOAA's Climate Program Office under grants GC08-392.

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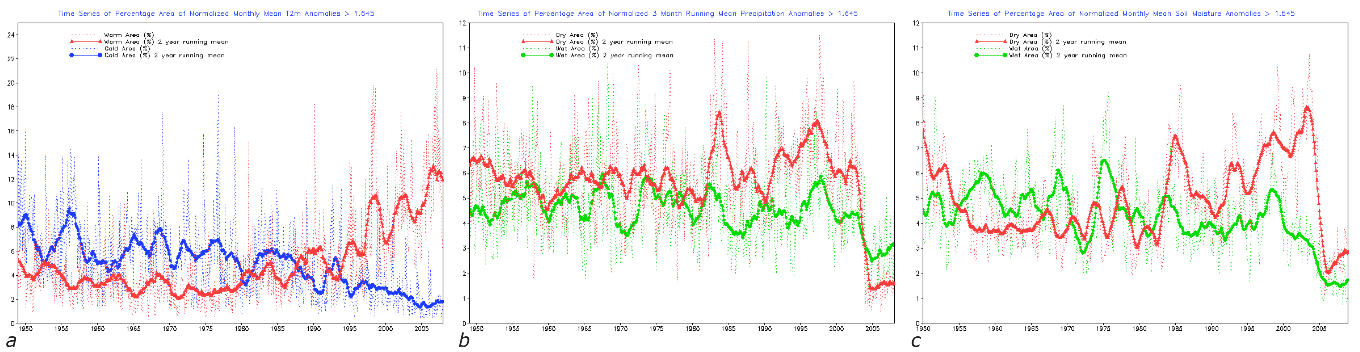

Figure 2. Time series for the percent area of global land covered by extremes in a) monthly mean temperature1948-2008 (blue for cold anomalies, red for warm anomalies), b) 3 month mean precipitation 1949-2008 (red for dry anomalies, green for wet anomalies), and c) soil moisture 1948-2008 (red for dry anomalies, green for wet anomalies). Thin dashed line for each month, the heavier lines have a 2 year running mean applied.

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South Atlantic Meridional Overturning Circulation (SAMOC) - Third Workshop

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Organising Committee
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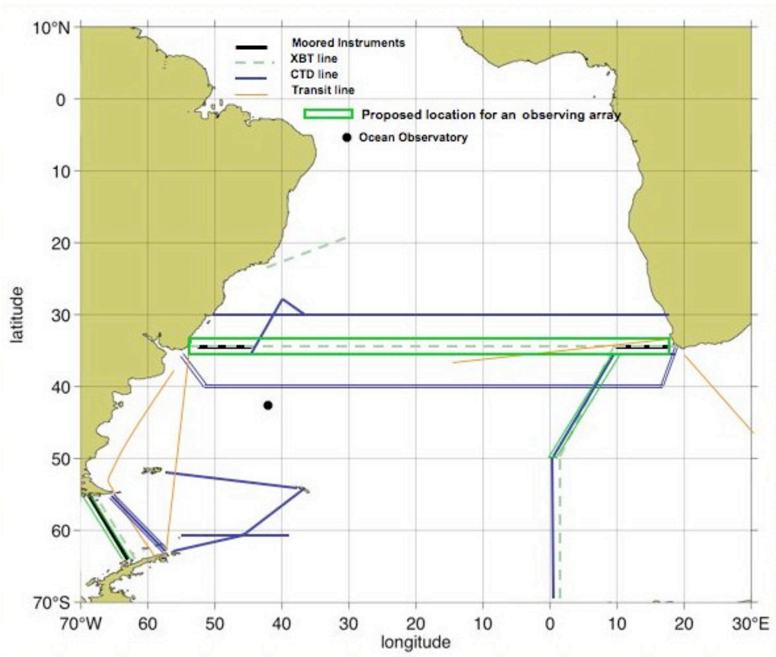
The third workshop for the South Atlantic Meridional Overturning Circulation (SAMOC 3) took place in Niteroi, Rio de Janeiro, Brazil on 11-13 May 2010. The Agenda, the list of participants, copies of the presentations and details on the observational plans can be obtained at: www.aoml.noaa.gov/phod/SAMOC/.

The main objective of SAMOC 3 was to design the basis for an observational program for the Meridional Overturning Circulation in the South Atlantic. Models and observations have shown that the strength of the AMOC is significantly correlated with the northward heat transport across 35°S, and hence to the global climate system. The goal of the workshop was to discuss how the present observation systems may contribute to estimating the meridional and inter-basin fluxes of mass, heat and salt; how the array ought to be upgraded to better capture these fluxes and their variability; and how to transition from the initial array to a long-term sustained program. The workshop discussions were aimed at determining what parameters should be observed, how to observe them with the best possible observation strategies, where are the observations needed, and who will be interested in carrying them out. The workshop also aimed to foster international cooperation and coordination, which is of crucial importance to fulfill these objectives.

Observations and models consistently indicate that the South Atlantic is not just a passive conduit for the passage of water masses formed in other regions of the world ocean but instead actively participates in their transformation. Water mass transformations occur across the entire basin but are more intense in regions of high mesoscale variability, particularly the Brazil/Malvinas Confluence and the Agulhas Retroflection. Models and observations also show that the South Atlantic



The figure shows current plans for observations in 2010 and 2011.

Moored instruments are indicated by a solid black line at: the Drake passage, cDrake (US), off the South American coast, SAM (US/Argentina/Brazil), and off the coast of South Africa, GoodHope (France). Tall moorings are also deployed along the GoodHope line (Germany). The black circle indicates the location of a planned Ocean Observatory (US).
Blue lines indicate CTD lines. The line along 30°S will be occupied in 2011 as part of the CLIVAR CO2 program. The lines along 40°S will be conducted by the UK and Brazil. CTD lines on the Drake passage are from Russia, UK and US. The GoodHope line (Cape Town to Antarctica,), will be conducted by France and Russia, as well as the lines on the Vema channel, the SAM region, the Drake Passage, and the Scotia Sea and Georgia Island. CTD lines will be also conducted on the lies of moorings twice a year (Brazil, Argentina, US, Russia).
Dashed green lines indicate XBT lines, are repeated quarterly with the exception of the line GoodHope line (twice a year during the southern Hemispheric summer) (US, Brazil, Argentina, South Africa).
Green rectangles indicate the recommended observations: A CTD line nominally at 35°S; a line of moored instrumentation at the same nominal latitude; enhancement of observations PIES/CPIES along the GoodHope line up to the sub-Antarctic front; maintain an optimal distribution of instruments at cDrake.
Transit lines (Yellow lines) are conducted every year and can be made available for Argo float deployments or any other observation.

plays a significant role in the establishment of oceanic teleconnections. Anomalies generated in the Southern Ocean, for example, are transmitted through inter-ocean exchanges to the northern basins. The Agulhas leakage influence reaches the northern hemisphere and models suggest that changes occurring in the South Atlantic alter the global MOC. These results highlight the need for sustained observations in the South Atlantic and in the choke points in the Southern Ocean, which, in conjunction with modeling efforts, would improve our understanding of the processes necessary to formulate long-term climate predictions.

Long-term sustained observations are needed to estimate the net meridional heat, salt and mass fluxes in the South Atlantic. Theoretical model results on the stability of the MOC as well as products of numerical models were discussed and analyzed to determine the optimal latitude to observe the MOC. Based on the results of these models, it is proposed to instrument and sustain a zonal trans-basin South Atlantic line that will, together with ongoing studies in the two Southern Ocean chokepoints (Drake and Good Hope), allow for the observation, quantification and attribution of heat, salt and mass fluxes and their changes at a nominal latitude of 35°S. The main in situ array will consist of short moorings on and inshore of the continental shelf break, and a mixed array of tall dynamic height moorings and pressure-equipped inverted echo sounders in the interior close to both boundaries. Moored instruments will be deployed with a higher spatial density near the boundaries to measure the deep-water export in collaboration with existing arrays in Drake and Good Hope Passages (the latter may need some additional augmentation). The proposed array will also allow for monitoring of Agulhas ring shedding, and the fate of these rings as they enter the Atlantic due to their potentially crucial role in the meridional salt transport. Further model analyses are ongoing to decide the precise number and distribution of instruments along the zonal line and along the Good Hope line where the existing mooring array is insufficiently dense for the monitoring purposes proposed herein. A reduced version of the C-Drake array will be deployed at the end of that program to assure the continuation of monitoring in Drake Passage. The working group on model evaluation and design studies is simulating mooring configurations using different combinations of instruments and a variety of models, initially focusing on Ocean Circulation and Climate Advanced Modeling project (OCCAM) and OGCM For the Earth Simulator (OFES), later including Estimating the Circulation and Climate of the Ocean, Phase II (ECCO2) and Nucleus for European Modeling of the Ocean (NEMO/DRAKKAR).

The crucial role that hydrographic observations in the region can play in support of these moored observations was also discussed. It is proposed to conduct an east-west transatlantic hydrographic survey encompassing the western and eastern boundary current arrays (nominally along 35°S). Full depth hydrography across the south Atlantic will provide detailed information on the baroclinic meridional fluxes between the warm route (Agulhas) and the cold route (Drake). It will provide an assessment of the basin-wide MOC while time series will be built based initially only on the observations along the boundaries. Geochemical and biogeochemical observations will also be collected along the hydrographic sections. These observations will aid in the evaluation of the contribution from each route and their associated variability.

Agreements were made for the sharing of resources, particularly ship-time, from countries at the margins of the basin as well as from countries with ongoing research operations in the South Atlantic. In particular, ships from Argentina, Brazil, Russia and South Africa were proposed for the program. A SAMOC Data Management Plan will be developed.

The meeting was hosted by Edmo Campos (University of Sao Paulo) at the Brazilian Navy's Diretoria de Hidrografia e Navegação (DHN). It was chaired by Silvia L. Garzoli (AOML), Sabrina Speich (LPO, France), and Alberto Piola (SHN, Buenos Aires). The workshop was attended by scientists from Argentina, Brazil, France, the Netherlands, Russia, South Africa, the United Kingdom, Uruguay, and the United States. Funding for the workshop was provided by the NOAA CPO, the US CLIVAR Office, Ifremer (France), the Brazilian Council for Scientific and Technological Development (CNPq), the São Paulo State Foundation for the Support of Research (FAPESP), through the Project INCT-Mudanças Climáticas, and the Brazilian Navy.

Report of the NPOCE Inauguration Meeting: a CLIVAR newly endorsed international joint program

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The Northwestern Pacific Ocean Circulation and Climate Experiment (NPOCE) inauguration meeting was held on May 30, 2010 in Qingdao, China under the auspices of CLIVAR and Chinese Academy of Sciences (CAS), and hosted by the Institute of Oceanology, Chinese Academy of Sciences (IOCAS). Over 60 scientists from Australia, China, Germany, Indonesia, Japan, Korea and the USA, and representatives of CLIVAR, CAS, the Ministry of Science and Technology of China (MOST), the National Natural Science Foundation of China (NSFC) and the State Oceanic Administration of China (SOA) attended the meeting.

Academician Zhongli Ding, vice-president of CAS, welcomed all participants and expressed support to NPOCE on the opening of the meeting. Prof. Martin Visbeck co-chair of CLIVAR SSG, announced the endorsement of NPOCE by CLIVAR as an international joint program, and praised the accomplishment of the NPOCE Science/Implementation Plan and the leadership of China and Academician Dunxin Hu of IOCAS in this international collaboration. He also announced the recruitment of Dr. Xiaohui Tang of IOCAS to the International CLIVAR Project Office (ICPO) as a close link between Asia and CLIVAR. Academician Congbin Fu and Academician Guoxiong Wu conveyed congratulations and good wishes to NPOCE on behalf of the International Council for Science (ICSU), the China Association for Science and Technology (CAST), and the International Association of Meteorology and Atmospheric Sciences (IAMAS), respectively.

Right after the opening of the meeting, Prof. Dunxin Hu, Chair of the NPOCE Scientific Steering Committee (SSC), gave the audience a brief introduction to NPOCE. He reviewed the background and history of NPOCE organization, its objectives, scientific themes, as well as implementation strategies. Representatives from participating countries presented the on-going or planned projects which will contribute to NPOCE implementation. At the closure of the meeting, Prof. Hu thanked CLIVAR leadership for its support, and emphasized that NPOCE today is really a result of the collective effort of all involved in the project. Dr. Wenju Cai, chair of the CLIVAR Pacific Panel encouraged participants to proceed with this effort of international collaboration to achieve NPOCE's science goals.

The inauguration meeting was seen to be very successful and is a milestone in the development of NPOCE. With the joint effort of international scientists, and under the framework of CLIVAR coordination, NPOCE will start a new chapter on the NWP ocean circulation and air-sea interaction research.

Figure 1. Dr. Wenju Cai (first left) Prof. Martin Visbeck (second left), Prof. Dunxin Hu (third to the right), and some of NPOCE SSC members attending the meeting

NPOCE Background

NPOCE is a multinational and multi-institutional program, designed to observe, simulate, and understand the structure, variability, and dynamics of the northwestern Pacific Ocean circulation and its role in modulating both regional and global climate systems. It was mainly initiated by Chinese scientists but has been joined by scientists from various countries including Australia, China, Germany, Indonesia, Japan, Korea, the Philippines and the USA. So far nineteen institutions have committed to participate in NPOCE with on-going or planned projects. NPOCE's Science and Implementation Plan was submitted to CLIVAR in early March, 2010 nearly two months after the International Workshop on NPOCE Implementation held on Jan. 17-18, 2010 in Xiamen, China. The CLIVAR SSG endorsed NPOCE as an international joint program on April 23, 2010. The organization of NPOCE can be found on the project's website: http://npoce.qdio.ac.cn/. The NPOCE program is conducted under the leadership of its Scientific Steering Committee (SSC). The constitution of the NPOCE SSC is as follows:

NPOCE Scientific Steering Committee (SSC)

Chair:
- Dunxin Hu; Institute of Oceanology, Chinese Academy of Sciences, China

Members:
- Rameyo Adi, BRKP, Ministry of Marine Affaires and Fisheries, Indonesia
- Kentaro Ando Japan Agency for Marine-Earth Science and Technology, Japan
- Dake Chen, Second Institute of Oceanography, State Oceanic Administration, China
- William Kessler, National Oceanic and Atmospheric Administration, US
- Jae-Hak Lee, Korea Ocean Research and Development Institute, Korea
- Bo Qiu, University of Hawaii, US
- Stephen Riser, University of Washington, US
- Cesar Villanoy, University of the Philippines, Philippines
- Fan Wang, Institute of Oceanology, Chinese Academy of Sciences, China
- Lixin Wu, Ocean University of China, China

The Northwestern Pacific (NWP) features a complicated ocean circulation system with intensive multiscale air-sea interactions. It is provides a crossroads and major pathways for different water masses from mid- and high-latitudes and the southern hemisphere to enter the equatorial thermocline. As the origin of several major currents including the northward Kuroshio, the eastward North Equatorial countercurrent, the Indonesian Throughflow (ITF), as well as the recently identified the South China Sea Throughflow, the NWP strongly interacts with the ambient oceans and marginal seas, and participates in the recharge-discharge process of the western Pacific warm pool. The changes in the NWP water properties and ocean circulation can influence the heat and freshwater budget and hence the atmospheric deep convection over the Indo-Pacific warm pool, thereby playing a role in modulating ENSO cycle and the East Asian Monsoon (EAM) variations, as well as in the development and evolution of the NWP tropical cyclones. Although significant advances have been made over the past several decades, our understanding of the mean circulation in the NWP still remains incomplete, and variability of the low latitude western boundary currents (LLWBCs) is largely

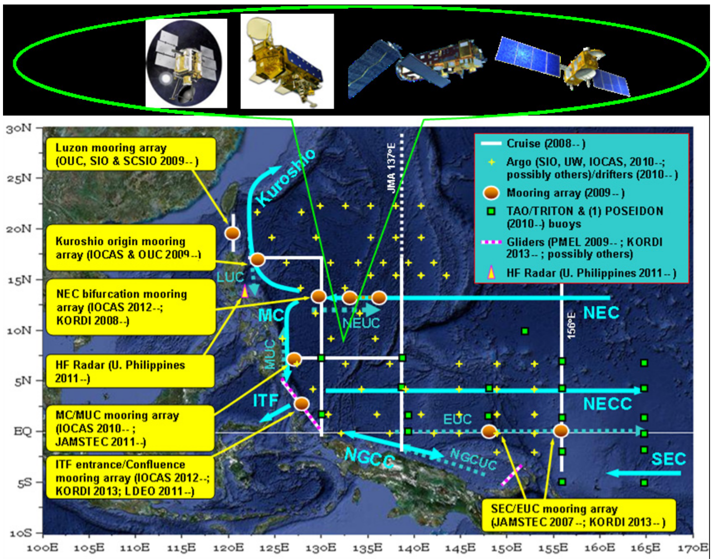

Figure 2. Design of NPOCE field experiments

unknown, mainly hindered by the lack of long-term in-situ observations. Therefore, the coordinated observational program and modeling analysis of NPOCE will provide a more complete description of structure and variability of the ocean circulation in the NWP, help improve prediction of the climate drivers discussed above, and provide a projection of local/regional ocean and climate conditions.

The primary goal of NPOCE is to understand the dynamics of the NWP circulation and its roles in warm pool maintenance and low-frequency variability, and modulation of the ENSO cycle, EAM variability, and the NWP tropical cyclones. Major objectives include: 1) Observe and elucidate the structure, variability and dynamics of the ocean circulation in the NWP region with special attention to LLWBCs, and clarify their interactions with marginal seas, the ITF and the subtropical ocean circulation; 2) Assess roles of the far western Pacific heat and freshwater transport and air-sea fluxes in the maintenance and variability of the warm pool, and in regional and global climate variability by a combination of observational and modeling studies; 3) Evaluate the societal impacts and provide the scientific basis for developing a sustained program to monitor the currents and their heat and mass transports for future climate prediction. The NPOCE scientific foci are archived into four research themes, namely the western boundary currents, interaction with ambient circulation systems, roles of the Northwestern Pacific in warm pool maintenance and variability, and regional air-sea interaction and climatic impact.

The NPOCE implementation will be carried out around the four scientific themes, integrating different approaches with emphasis on coordinated observational and modeling effort. NPOCE coordinates observations to elucidate structure of the general ocean circulation in the NWP region. These include in-situ measurements by moorings, Argo floats, gliders, CPICES, etc. in conjunction with hydrographic surveys and existing observational networks (Figure 2). NPOCE observations will leave a sustainable monitoring network for the NWP circulation system, and also bridge the Southwest Pacific Ocean Circulation and Climate Experiment (SPICE) and the extended INSTANT programs in the equatorial Pacific. The modeling approaches will integrate analyses of existing models' outputs and focused numerical experiments with a wide range of models from global scale ocean and coupled GCMs to Intermediate models.

Several large-scale projects over the NWP area have been recently launched by Chinese funding agencies. These include three National Basic Research Key projects (named as 973 projects) funded by MOST and one major project funded by NSFC, representing coordinated efforts of multi-institutes from CAS, the Ministry of Education, and SOA. These projects consist of field measurements in conjunction with modeling and theoretical studies to address some of scientific issues proposed by NPOCE. It is in the aforementioned spirit that NPOCE seeks to establish links with other on-going and planned ocean/climate observational programs in the low-latitude western North Pacific region, in particular SPICE and the extended INSTANT.

Corrigendum: Ship-based observation of drizzling stratocumulus clouds from EPIC to VOCALS

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We sincerely apologize to the authors of the above paper, published in the last edition of Exchanges (No.53), for not inserting the intended version of their Figure 2. The figure that should have been inserted is that reproduced below.

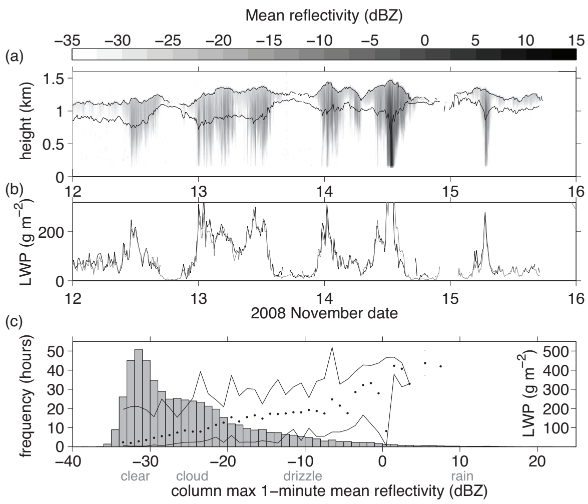

Figure 2. (a) Mean reflectivity from the W-band cloud radar for November 12-15, when the ship was near 20°S, 75°W. Thin lines are cloud top height estimated from the radar and cloud base height from the ceilometer. (b) Liquid water path (LWP) from the microwave instrument (black) and adiabatic LWP from cloud thickness (gray). There are two distinct peaks in cloud top, liquid water, and precipitation for each day, especially November 13-14. Bars in (c) show the frequency of occurrence in hours of column maximum reflectivity (dBZ) of 1-minute samples for all 538 hours of the VOCALS cloud radar record. The median and range of 10-minute LWP (g m-2, dots and lines) are binned by column maximum reflectivity.

Contents

The CLIVAR Newsletter Exchanges is published by the International CLIVAR Project Office
ISSN No: 1026 - 0471

Editors: Antonio Caltabiano and Howard Cattle
Layout: Sandy Grapes
Printing: Indigo Press, Southampton, UK

CLIVAR Exchanges is distributed free of charge upon request (email: icpo@noc.soton.ac.uk)

The ICPO is supported by the UK Natural Environment Research Council and NASA, NOAA and NSF through US CLIVAR.

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