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Joint Edition of the Newsletter of the Climate Variability and Predictability Project (CLIVAR) Exchanges and the CLIVAR Variability of the American Monsoon Systems Project (VAMOS)

VAMOS !

Exchanges

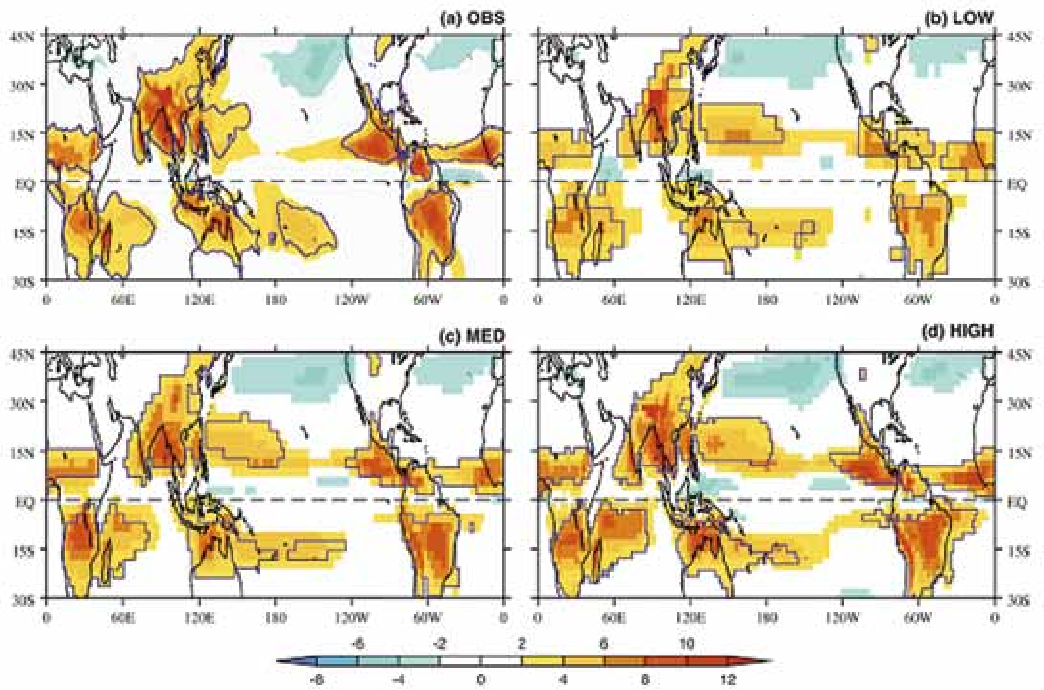

*Figure 1: Climatological annual precipitation range (shading; mm/day) and monsoon domains (contours). (a) Observations, and the group ensemble means of (b) LOW, (c) MED, and (d) HIGH resolution models. (From Kim et al., 2008) // Figura 1: Rango climatológico anual de precipitación (sombreado; mm/día) y dominios monzónicos (contours). (a) Observaciones, y medias del ensamble de grupos de (b) BAJA, (c) MEDIA, y (d) ALTA. (de Kim et al., 2008). (**See article on page 16// Vea el artículo en página 16)***

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.

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Editorial

One of the things I have always been conscious of in looking at geophysical data is the question of how representative the data are both in space and time, an issue drummed into me by my first research supervisor. However, the need for caution from this perspective seems to have completely escaped me in the publication on the front cover of the last edition of CLIVAR Exchanges of two pictures showing snow and ice cover on Mount Kilimanjaro. I am grateful therefore to Georg Kaser and Ian Allison who, in their article on pages 7-8, point out that the pictures as published give a very wrong impression of the magnitude of the retreat of glaciers on the mountain. Sean Heuser and Fred Semazzi respond to comments on pages 9-10. Despite its name, this is, I think, almost the first time we have had such an exchange of views in my over 6 years of editing CLIVAR Exchanges and I would like to encourage other such "correspondence", where appropriate, on articles in the future.

As you will see, this edition on CLIVAR Exchanges also incorporates VAMOS!, the Newsletter of CLIVAR's Variability of the American Monsoons (VAMOS) Panel. VAMOS! has previously been published as a separate volume and earlier editions can be downloaded from CLIVAR's website at www.clivar.org/organization/vamos/vamos_publications.php. As its name implies, VAMOS provides the focus for CLIVAR's activities on the monsoon systems of North and South America. Many of these activities are joint with WCRP's Global Energy and Water Experiment (GEWEX), bringing together scientists with expertise from both WCRP projects. The VAMOS structure is split into two major activity areas, the Monsoon Experiment South America (MESA) and the North American Monsoon Experiment (NAME). Major past activities have been the South American Low level Jet field Experiment (SALLJEX – see Exchanges 29), aimed at obtaining improved temporal and spatial description of the tropospheric flow over South America for the validation and improvement of short-and long-term predictions over the region, and the NAME field experiment, NAME 2004 (see Exchanges 45), aimed at study of the sources and limits of predictability of warm season precipitation over North America. These field programmes provided us with a rich observational base on which to build a variety of subsequent analytical and modelling studies resulting in improvements to operational seasonal prediction in the regions concerned, for example, through the NOAA Climate Test Bed facility.

Current major VAMOS activities focus on the La Plata Basin, the South East Pacific and the Intra-American Seas. The CLIVAR/GEWEX La Plata Basin Regional Hydroclimate Project centres on the La Plata Basin as a climate-hydrology system with components that are potentially predictable with useful skill for seasons in advance and whose variability has important impacts on human activities and well-being. Presently underway, the VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS, see page 29) includes the VOCALS Regional Experiment (VOCALS REx) to better understand the physical and chemical processes central to the climate system of the Southeast Pacific (SEP) region. VOCALS-Rex, an internationally coordinated field experiment which took place in October-November 2008, has been designed to make observations of critical components of the climate system of the SEP that are poorly understood and poorly represented in models.

For the future, the Intra American Study of Climate Processes (IASCLIP) is aimed at bridging the gaps between the climate research for North America (NAME), South America (MESA, the Pacific and Atlantic. IASCLIP, which will investigate the role of the Intra-American Seas in the climate variability of the Americas, will act as a scientific connection among all of the science components already established. It is introduced as a new VAMOS component in the edition of VAMOS! incorporated here. Indeed, this edition of VAMOS! takes a rather different cut at VAMOS activities from that described above, focussing on "cross cutting activities linking the American monsoons" overall and helping to provide a good example of how the regional activities within CLIVAR can contribute to the overall cross cutting themes of WCRP under it's strategic plan.

Further information on VAMOS can be found on the CLIVAR web site at www.clivar.org/organization/vamos/vamos.php, which also provides information on links to VAMOS datasets. VAMOS has very much benefited from coordination and dataset management by UCAR/JOSS (the Joint Office for Science Support of the University Corporation for Atmospheric Research, Boulder, USA – see www.joss.ucar.edu/). This has added substantially to the success of VAMOS activities .

Turning to the CLIVAR Exchanges component of this joint Newsletter, a regional modelling focus for Africa is presented in the article by Anyah et al with a link to CLIVAR's Variability of the African Climate System (VACS) Panel. Regional modelling is being given increasing focus within WCRP overall with the establishment of a Regional Modelling Task Group at the last meeting of the Joint Scientific Committee (JSC) for WCRP and it is pleasing to include this paper. Other articles provide an outline of the outcomes of several CLIVAR meetings and demonstrating some of the wider science issues CLIVAR is addressing. Two important meetings coming up over the next couple of months are the next annual meeting of the JSC for WCRP (April) and a meeting of the CLIVAR SSG in May. The JSC meeting will focus on WCRP intermediate and long term planning and new science issues and CLIVAR has been developing it's input to the discussions on this (see the Editorial in Exchanges 47 which gives some of the background). The SSG meeting will focus on CLIVAR's future strategy and how we best respond to the outcomes of the JSC meeting as well as progress in CLIVAR science by its Panels and Working Groups.

Finally, a little later in the year, the OceanObs'09 meeting will be an important future event (see enclosed flyer and www.oceanobs09.net/) as will World Climate Conference-3 (www.wmo.int/pages/world_climate_conference/index_en.html), both to be held in the September 2009 timeframe.

Howard Cattle

The Horn of Africa Regional Climate Model Inter-comparison Project

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Background

The most recent IPCC projections highlight Africa's unique vulnerability to extreme impacts associated with global climate change (IPCC, 2007). However, a comprehensive assessment of the potential impacts of climate change on many of Africa's natural ecosystems is hampered by current lack of understanding of the fundamental physical and dynamical processes that govern the evolution, variability and changes in the climate systems of the region. This is partly due to inadequate and/or insufficient observations that can be used for their comprehensive empirical analysis. The lack of data also greatly inhibits evaluation of the skill of climate model simulations. The Horn of Africa Regional Climate Model Inter-comparison Project (AFRMIP) is designed as one of the ways of attempting to address this information gap, by first focusing on the Greater Horn of Africa (GHA) sub-region. The GHA has complex terrain that includes some of the well-known, tropical, glacier-covered high mountains of Kilimanjaro, Kenya and Rwenzori as well as the Great Rift Valley System (GRVS). The GRVS that runs north-south across the region has several freshwater lakes that include Lake Victoria (the second largest freshwater lake after Lake Superior) and Lake Tanganyika (the second deepest freshwater lake, after Lake Baikal). As a whole the complex GHA terrain presents an environment within which local and large scale climate systems frequently interact to create highly variable climate in both space and time. This also means that the ecosystems here are particularly sensitive and vulnerable to climate anomalies either triggered by external forcing (global warming) or amplified by local scale processes.

The GHA sub-region (Figure 1) has distinct climate characteristics compared to the rest of the continent. For, instance, the inter-tropical convergence zone (ITCZ) migrates, north-south, across the region twice a year. The ITCZ thus tends to impose a significant influence on the climatological rainfall and temperature patterns. The ITCZ's influence is credited for defining three distinct rainfall zones based on the onset, spatial-temporal evolution and withdrawal pattern. These are the Southern, Equatorial, and Northern Sectors. The Southern Sector, which extends from central to southern Tanzania has a unimodal peak rainfall regime experienced between December and April. The Equatorial Sector, covering northern Tanzania, southern Uganda, Rwanda, Burundi, Kenya, southern and parts of eastern Ethiopia, southern Sudan, and the southern half of Somalia generally exhibits a bimodal rainfall regime. The bimodal rainfall pattern, experienced over many parts during March to May (long rains) and October to December (short rains), is associated with the north-south migration of the ITCZ. In the Northern Sector there is one dominant rainy season (between June and September), but a few areas do receive a secondary rainfall peak from March to May. Normally, the passage of the ITCZ leads the onset of the two rainy seasons by 3-4 weeks, but this may be modulated from season to season by the interactions between the ITCZ and perturbations in the global climate circulation, as well as with changes in the local circulation systems initiated by land surface heterogeneity induced by variable vegetation characteristics (Figures 2 and 3), large inland lakes and topography.

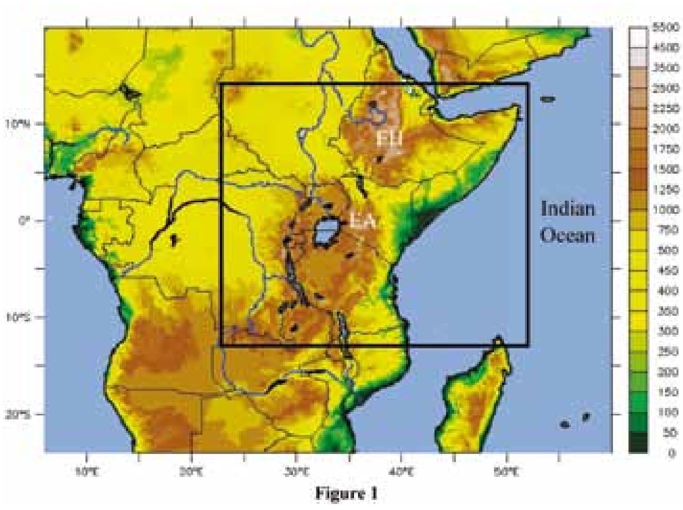

Figure 1: Terrain height (meters) and other physical features considered key drivers of the climate of the Greater Horn of Africa.(box). EH: Ethiopian Highlands. EA: East African Highlands

The inter-annual variability of the GHA climate is linked to perturbations in the global SSTs, especially over the equatorial Pacific and Indian Ocean basins, and to some extent, the Atlantic Ocean (Ogallo, 1988; Nicholson and Kim, 1997; Mutai and Ward, 2000; Indeje et al., 2000; Saji et al., 1999; and Goddard and Graham, 1999, amongst others). In particular, El Niño/Southern Oscillation (ENSO) anomaly patterns play a dominant influence on the interannual variability of the equatorial eastern Africa climate (Ogallo, 1988; Indeje et al., 2000). The zonal temperature gradient over the equatorial Indian Ocean, often referred to as the Indian Ocean Dipole Mode (IOD) (e.g., Saji et al., 1999) and the coupled IOD-ENSO influence have also been linked to some of the wettest periods in the region, such as 1961, 1997 and 2006 (Black et al., 2003; Bowden and Semazzi, 2007). Mid-tropospheric flow from the equatorial Atlantic Ocean via the tropical (Congo) rainforest which interacts with the moist Congo air mass has also been suggested to affect the climate over western and northern/northwestern parts of eastern Africa (Anyamba, 1984). In other words, SST anomalies occurring over the Pacific, Atlantic and Indian Oceans either all at the same time or each at different times, intriguingly influence the interannual variability of the GHA climate. At the same time, complex topographic features, including the large East African freshwater lakes, extensive and high mountains, orographic channeled flow (Turkana low-level jet) and spatially variable land use/land cover characteristics, are significant contributors to the variability of the GHA climate (Sun et. al., 1999; Anyah et al., 2006; Anyah and Semazzi, 2006).

Due to the complex interplay between global and regional scale processes on the GHA climate system, improving

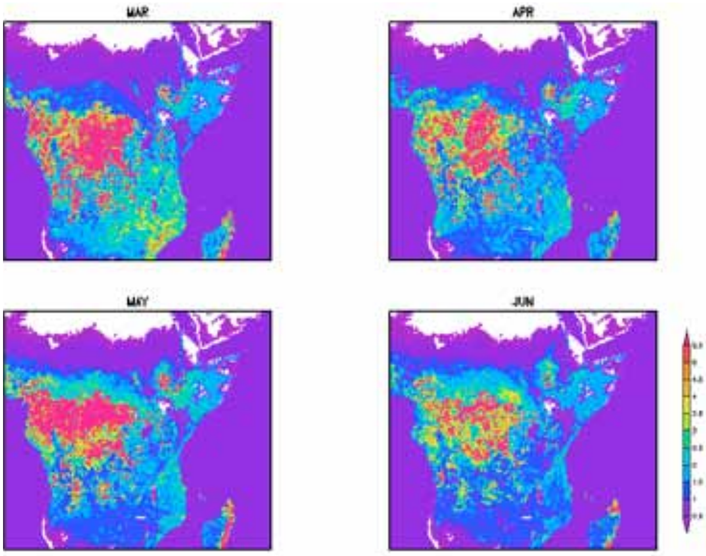

Figure 2: Monthly changes in vegetation cover during the long rainy season (MAMJ) based on LAI (m^2/m^2) derived from USGS NDVI data

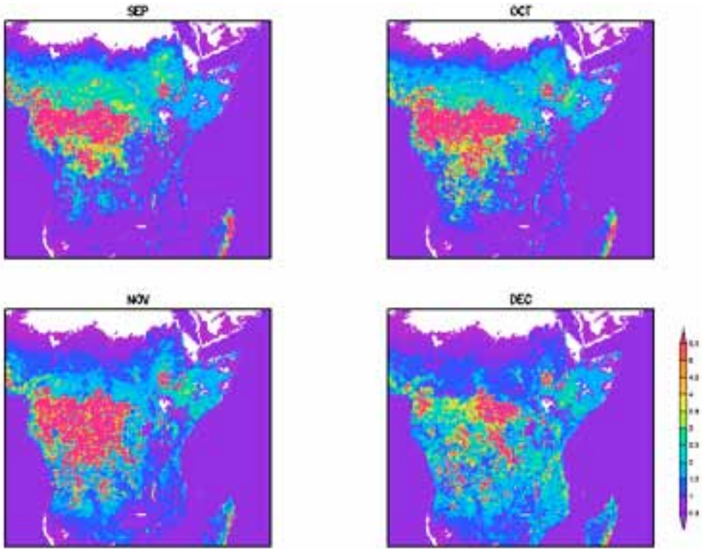

Figure 3: Monthly changes in vegetation cover during the short rainy season (SOND) based on LAI (m^2/m^2) derived from USGS NDVI data

our understanding of the regional climate variability requires a comprehensive investigation of the interactions and feedbacks among these drivers. It is also important to note that interactions among multiple climate drivers over the region present additional challenges in terms of quantitative understanding of regional climate systems based on empirical techniques. Empirical methods, which primarily employ limited and / or sparse observational data over the region and other proxies, do not offer adequate scope to sufficiently define the cause-effect relationships between regional climate variability and individual, or a combination of, processes. Such cause-effect relationships may be better understood through sensitivity studies applying physically-based (dynamical) models. Regional climate modelling is presently one of the fundamental techniques used to provide detailed information for a broad spectrum of applications. When coupled to appropriate land surface, hydrologic, lake, or ecological models, the enhanced resolution of regional climate models (RCMs) provides a rich test-bed for examining the influence, response, and feedbacks to individual, or a combination of, processes. Therefore, RCMs could be effective tools if used to help fill the gaps in the presently available body of knowledge on GHA climate variability.

However, the weaknesses and strengths of RCMs have been challenging to diagnose. It is true that evaluating such models has been relatively successful in some of the developed countries that have advanced Climate Modelling Centers as well as properly maintained observational data networks (useful for model evaluation). Conversely, evaluation and customization of such models over the African continent, and the GHA sub-region in particular, is still riddled with numerous challenges, primarily due to insufficient climate observational data networks. However, recent improvements in the spatial coverage of meteorological satellite and other remotely sensed data offers a growing opportunity so that these models can now satisfactorily be evaluated in regions such as the GHA.

Overview of the AFRMIP Project

The motivation behind the AFRMIP project is to undertake a comprehensive evaluation and improvement of regional climate simulations of the GHA climate. The project is partly funded by NSF as a component of a 3-year project "Research on Modelling Climate Variability and Change of the Horn of Africa". To achieve its core objective AFRMIP will systematically, and as comprehensively as possible, investigate some of the deficiencies and uncertainties in regional model simulations of the Greater Horn of Africa (GHA) climate through model inter-comparison. Lessons learned from earlier regional climate model intercomparison projects over different parts of the globe (mainly in the developed world) provide reasonable evidence that a powerful method for improving regional climate simulations is the comparison of simulations produced by different models (Takle et al., 1999). In this way, the strengths and weaknesses of model structures, numerics and parameterizations can be assessed side-by-side. The GHA sub-region is one of the unique geographical regions of Africa, not only in terms of physical features (terrain, vegetation type, etc.), but also in terms of its very unique climate compared to other parts of the African continent. Therefore, AFRMIP is expected to contribute toward addressing the challenges of using RCMs to understand the physical and dynamical mechanisms associated with GHA climate variability. This effort will hopefully contribute to the development of objective criteria for customization of RCMs for the region and application of RCMs for generating high-resolution climate change scenarios, based on several IPCC-AR4 projections, for regional climate change impact assessments.

In general, some of the specific questions AFRMIP is expected to address include, but are not limited to:-

1. Given the complexity of the GHA terrain, what processes (for example, topography induced and lake induced circulation) are inadequately represented in the simulations by different regional models?
2. What are the appropriate adjustments to current physical process parameterizations that need to be made in order to improve representation of most, if not all, of the complex features of the GHA domain?
3. What is the level of inter-model variability / uncertainty in current regional climate models over the Horn of Africa and how well can these models represent natural variability and anthropogenic change?
4. What can be learned about the biases experienced in the simulations of the Horn of Africa climate by using different regional climate models?

The above questions can be answered by targeting specific science issues as described in the section that follows.

Science Questions to be addressed

AFRMIP activities are specifically designed to address some of the outstanding science questions that would enhance understanding of the physical and dynamical processes associated with the GHA climate systems. To achieve this goal the participating AFRMIP scientists have strongly recommended that the design of model experiments and choice of computational domain should provide model output at a spatial and temporal frequency that can be analysed to shed light on the following:-

(i) Topographic influence on the regional climate
(ii) Convergence of flows originating from the surrounding tropical Oceans and the atmospheric circulation control on precipitation processes. There is going to be a specific focus on the partitioning of moisture sources that contribute to regional climate, with respect to Indian Ocean moisture sources, Atlantic Ocean moisture sources, and Tropical (Congo) Forest moisture sources.
(iii) The influence of the cross-equatorial low level, Somali Jet
(iv) The physical and dynamical drivers of the East African "dipole mode" pattern on GHA precipitation characterized by drying/wetting south/north of the equator
(v) Surface-atmosphere coupling and impacts on regional climate: The role of land-ocean coupling over the GHA with regard to both land and ocean surface forcing,
(vi) Vegetation/crop (land use/cover changes) and impacts on regional climate
(vii) Impact of the diurnal cycle of land surface-atmosphere interactions on regional climate, including African easterly waves
(vi) Groundwater water processes and how they are impacted by regional climate variability
(vii) Fluctuations of Lake Victoria water levels and how they are associated with rhythms of regional climate patterns and global climate regimes.
(viii) The dynamics of the African and Asian monsoons and their relationships to rainfall variability over the Horn of Africa.

First AFRMIP Planning Workshop

The first AFRMIP workshop to plan the modelling activities was held at Rutgers University, USA on 27 and 28 March, 2008. The primary goal of this meeting was to bring together various regional climate modelling experts who had expressed an interest in volunteering part of their time and research resources to contribute toward AFRMIP activities. It was also deemed important to involve these experts right at the start in order to agree the way forward in planning and undertaking all the activities of the Project.

The following participants attended the workshop:-

1. Kerry Cook (Cornell University)
2. Fredrick Semazzi (North Carolina State University)
3. William Gutowski (Iowa State University)
4. Lai-Yung(Ruby) Leung (Pacific Northwest National Laboratory)
5. Sara Rauscher (Representing Filippo Giorgi: ICTP-Italy)
6. Mark Tadross (University of Cape Town, South Africa)
7. Jeremy Pal (Loyola Marymount University, California)
8. Liqiang Sun (IRI, Columbia University, New York)
9. Jian-Hua (Joshua) Qian (IRI, Columbia University, New York)
10. Neil Davis (University of North Carolina, Chapel Hill)
11. Jared Bowden (Graduate student, North Carolina State University)
12. Emily Riddle (Graduate Student, Cornell University)
13. Ying Fan (Rutgers University)
14. Alan Robock (Rutgers University)
15. Richard Anyah (Rutgers University)

Note: The participating regional climate models include Weather Research and Forecast (WRF); Mesoscale Model version 5 (MM5); Eta-vertical coordinate model (Eta) model; Regional Climate Model version 3 (RegCM3); Regional Atmospheric Modeling System (RAMS); Regional Spectral Model(RSM). The GCMs which will provide boundary driving fields will include National Center for Atmospheric Research (NCAR) Community Climate System Model version 3 (CCSM3); European Community Hamburg model (ECHAM); Finite Volume Global Circulation Model (FvGCM); Hadley Center Coupled Model version 3 (HadCM3)

Model Experiments

The first AFRMIP planning meeting recommended that the numerical experiments should not just be focused on running different models and generating mean statistics. Instead, participants agreed that the design of the experiments should aim at addressing key climate science issues that would enhance understanding of important questions regarding the physical and dynamical mechanisms associated with GHA climate variability and change. The details of specific science questions being addressed are stated in the preceding section, but can also be found in the report of the first AFRMIP planning workshop held on 27-28 March, 2008.

Generation of Initial and Boundary Conditions

The generation of the atmospheric initial and lateral boundary conditions (ICBCs) from the ECMWF Reanalysis (ERA40) data has been accomplished and distributed through a public website. The choice of ERA40 over NCEP Reanalysis was agreed upon at the first AFRMIP workshop after a comment was made that previous experience had shown that ERA40 tended to reproduce the observed features of the GHA climatology better than the NCEP reanalysis (Kerry Cook, personal communication). The ICBC data have been created in a common format so that all the models are initialized with the same data as far as possible.

Two different types of datasets have been generated.

(i) Climate-mode datasets: 1-year, monthly mean, data have been derived for the period 1981-2000 (20-years). The data have then been interpolated in time to generate 6-hourly data for updating the lateral boundary conditions. This data is to be used to drive 12-month simulations that will form a monthly model climatology. This is a new approach that has been tested by some of the participating modellers and found to generate a credible regional climate model climatology, comparable to running the model for a longer period to generate the same climatology. This method has the advantage of cutting down computational cost and time by several factors. However, at the same time some RCMs will also be run in both climate and continuous modes to compare and ensure the model climatology that is generated is credible.
(ii) 10-Year 6-hourly data (1997-2006): This period is being simulated because it encompasses some of the major extreme events that have occurred over the GHA during

the past decade. In 1997/98 there was a major ENSO event that coincided with flooding over many areas. The year 2005/6 on the other hand was a major drought period over the region.

Climate change simulations

Two categories of climate change experiments will be performed.

(i) GCM driven (climate change) runs (perturb climate mode (1981-2000 mean) from different GCMs for A1B future climate) and

(ii) Regional Climate model downscaling of A1B scenario for the period 2046-2065 using selected RCMs

Progress of Climate-Mode Simulations

The climate-mode simulations are currently ongoing. Most of the participating modelling groups are near to completing the climate-mode runs, with a few already beginning the 10-year (1997-2006) continuous simulations. Overall the level of progress made so far running the model simulations is remarkable given that the planning of the model runs only began after the 27-28 March, 2008 workshop.

Model Output archiving and analysis

The participants at the first AFRMIP workshop recommended that in order to accommodate the different map projections used by different RCMs, all the model output should be in standard format. In general, model output should be in NetCDF format, and all model output by all participating groups should try to use CF-standard, native horizontal grid as applied in the IPCC-CMIP3 and/or the NARCCAP projects. It was further recommended that the model output data archived should not just contain the monthly mean fields, but also high frequency data that can be used to study the diurnal (and even sub-diurnal) cycles of land-surface - atmosphere-fluxes exchanges and coupled variability. In other words the data should include;

(i) 2D and 3D variables: similar to NARCCAP variables saved on standard pressure levels (NARCCAP reference site: http://rcmlab.agron.iastate.edu/narccap/output_archive.html)

(ii) Daily variables

(iii) Sub-daily variables; averaged/instantaneous quantities: every 3 hrs.

Model Evaluation Datasets

Due to the paucity of observational data networks over the GHA region, it was recommended that as many complimentary datasets as possible be used in order to evaluate regional model simulations comprehensively. Therefore sparse observed data over the region will be augmented with other sources of remotely sensed data as well as satellite data. There is already ongoing consultation between the PI and the Director of the IGAD Climate Predication and Applications Center (ICPAC-Nairobi) on how to obtain daily, dekadal and monthly meteorological data for evaluating AFRMIP model simulations. ICPAC is the Regional Climate Research and Applications center where data from 10 Horn of Africa countries is archived. Other potential datasets for model evaluation include; NASA's Tropical Rainfall Measuring Mission(TRMM) precipitation estimates, Global Land Data Assimilation System, University of Deleware (Wilmot) spatially interpolated rainfall observations University of Vienna soil moisture retrievals for Africa, University of New Hampshire runoff, Pinker's surface radiation "observations"

Summary

The overriding goal of AFRMIP is to develop a comprehensive strategy for regional climate model evaluation and customization for the Greater Horn of Africa region. Regional climate modelling permits systematic examination of the interactions between locally induced and large-scale processes through a suite of sensitivity experiments. However, the effective application of a regional climate modelling technique can only be accomplished after comprehensive evaluation of the performance of RCMs; assessing and taking a rigorous audit of their strengths and weaknesses with a view to improving the appropriate physics parameterizations. Such a rigorous evaluation of the skills of different regional models would provide an objective framework within which to adopt regional climate models for the region.

This project is also expected, for the first time, to provide baseline regional climate change scenario data for the Greater Horn of Africa. The most recent IPCC projections highlight Africa's unique vulnerability to extreme impacts associated with global climate change (IPCC, 2007) and thus there is a need for high resolution regional climate change scenarios that can be useful in formulating climate change impact assessments and adaptation mechanisms over the region. In addition, AFRMIP will contribute significantly toward the broader climate research and applications priorities that have been identified by the CLIVAR/VACS implementation plan. The fact that some of the participating regional climate modelers are members of the CLIVAR/VACS panel (including the PI, Richard Anyah) will likely make it possible for the outcome of this project to be disseminated to broader interest groups, including the national climate change impacts assessments agencies. Furthermore, through the AFRMIP project a broad coalition of international regional climate modelling experts is being built in order to address some of the challenges in understanding the regional climate dynamics and predictability of the Greater Horn of Africa.

Acknowledgements

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The Snows of Kilimanjaro*: A critical comment on Numerical Simulations of the Role of Land Surface Conditions on the Climate of Mt. Kilimanjaro Region

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Widespread retreat of glaciers and ice caps is one of the clearest visible indications of the effects of climate change. The IPCC Fourth Assessment Report estimated that between 1990 and 2003, there was an average global loss of mass from glaciers and ice caps (excluding the ice sheets of Antarctica and Greenland) of 280 ± 79 billion tonnes per year (Gt/yr). This mass loss has contributed an average of 0.77 ± 0.22 mm/yr to sea level rise (Lemke et al., 2007). Glaciers and ice caps are retreating in all regions of Earth, including the tropics, where they have shrunk from a maximum in the mid-19th century, generally following the global trend. The wastage of tropical glaciers, including those on Mt. Kilimanjaro, East Africa (30°4'S, 37°21'E), has been strong since the 1970s and, as in other mountain ranges, the smallest glaciers are more strongly affected.

However, the images published on the front cover of CLIVAR Exchanges (No. 47; Vol 13#4, Heuser and Semazzi, 2008) give a very wrong impression of the magnitude of the retreat of glaciers on Mt. Kilimanjaro. These images of Kilimanjaro's highest peak, Kibo (5893 m), in February 1993 and February 2000 merely show changes in the transient snow cover – not the glaciers. These images originally appeared on the NASA Earth Observatory website (http://earthobservatory.nasa.gov/IOTD/view.php?id=3054) on December 20, 2002 and have been frequently misinterpreted. The caption on this NASA website was modified in 2005 to make it clearer that the images cannot be used as an indication of the rate of the loss of ice.

Neither of the images allows identification of the perennial

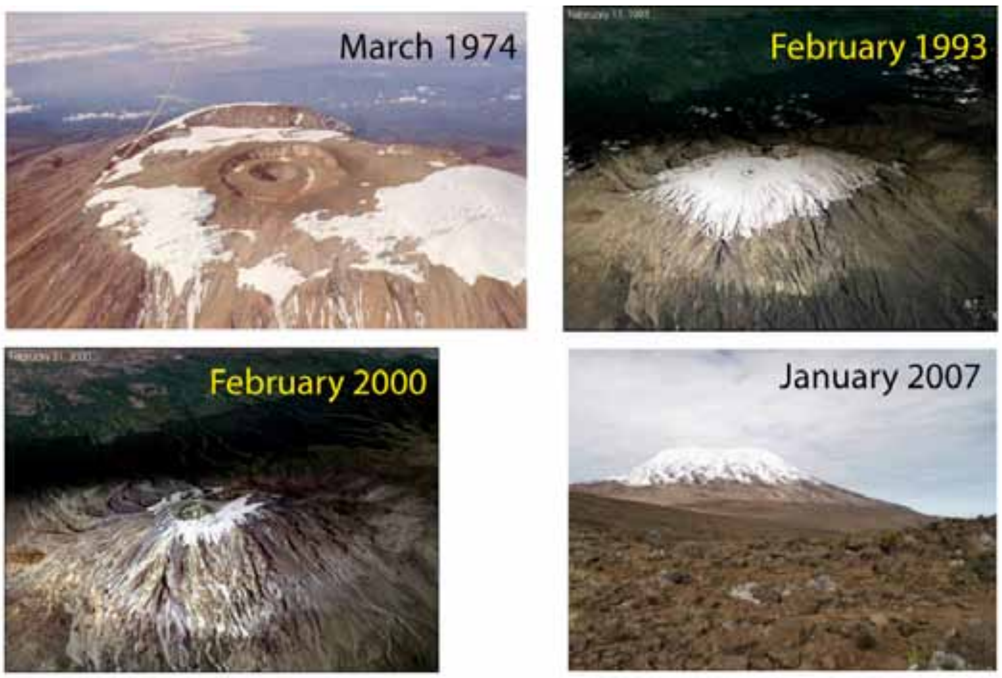

Figure 1: Ice and snow cover on Kibo in 1974, 1993, 2002, and 2007, each at the end of the so-called East African Short Rains. Pictures from Hastenrath (1984) upper left; NASA Earth Observatory (http://earthobservatory.nasa.gov/IOTD/view.php?id=3054) upper right and lower left, and G. Kaser, lower right.

**The title of this note unashamedly copies that of Ernest Hemmingway's short story. Hemingway's famous story has elevated the symbolism of Kilimanjaro and its glaciers as a key indicator of anthropogenic climate change. But his heroic symbol of a frozen leopard near the summit of the mountain might also be considered as a symbol of human perseverance and invention in the face of the environmental problems that we create for ourselves.*

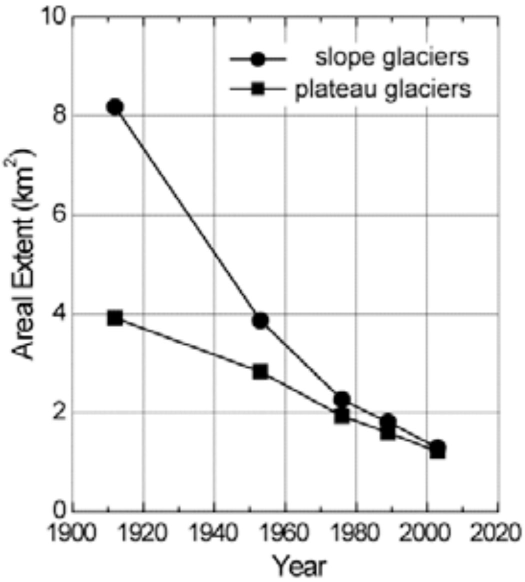

Figure 2: Change of areal extent of Kibo glaciers between 1912 and 2003. Modified from Cullen et al., (2006)

ice (glacier) extent. The 1993 image shows the entire mountain covered with snow roughly to the limit of the little ice age glacier extent, while even in the 2000 image only about 60 – 70 % of the white surface is perennial ice, the rest being snow. Snow cover on Kibo (as well as on the second highest Kilimanjaro peak, Mawenzi) stems either from a single isolated precipitation event or from a series of events during the "short rains" (October, November, December) and during the "long rains" (March, April, May). The snow cover can persist from a couple of hours to more than a year. For example, portions of the exceptionally heavy snow cover in January 2007 (up to 0.9 m measured on the Northern Ice Field) lasted beyond February 2008. If snow and ice are not clearly distinguished, a very false indication of glacier changes may be derived. The image series in Figure 1, for example, falsely suggests spectacular 'glacier expansion' up to Little Ice Age extents between 1974 and 1993 and again between 2000 and 2007. The actual glacier surface area, as carefully analysed and presented by Cullen et al. (2006), show a fairly steady monotonic retreat (Figure 2).

There are two different glacier regimes on Kibo that lead to different rates of decrease in glacier area (Figure 2). The plateau glaciers are too shallow for much ice deformation to occur and are bedded on horizontal surfaces that exclude basal sliding; the slope glaciers are frozen to the bed and move only slowly by deformation (Cullen et al., 2006). Changes in surface area of the plateau ice are exclusively due to the retreat of the vertical ice walls that are exposed either to the south or the north. Their retreat is mainly driven by solar radiation during the respective dry seasons (Kaser et al., 2004; Mölg et al., 2003). Changes to both plateau and slope glaciers reflect a long period of dry climate that probably started in the 1880s (Cullen et al., 2006; Kaser et al., 2004; Mölg et al., 2008; Mölg et al., 2003). Seasonal and inter-annual variability in snowfall frequency and amount affect the annual mass balance of both horizontal and inclined ice surfaces (Cullen et al., 2007; Mölg et al., 2008; Mölg and Hardy, 2004) but have no impact on the extent of the plateau glaciers which is exclusively determined by the retreat of the vertical walls. It has also been shown that precipitation anomalies over the Kilimanjaro region correlate significantly with the Indian Ocean Dipole (Mölg et al., 2006) and that the drivers of the anomalies have a large spatial scale.

Heuser and Semazzi (2008) used a high resolution atmospheric model to investigate how changes to land surface conditions in the region surrounding Mt. Kilimanjaro might modify precipitation. Although the retreat of the glaciers of Kilimanjaro was not the main focus of their study they do claim that "our modelling results support our hypothesis that the response of precipitation to land use change is significantly greater than that of temperature, and therefore a more likely factor for modulating the glacial volume over the Kilimanjaro summit". The specific studies of Kilimanjaro glacier changes cited above do not support this conclusion.

Heuser and Semazzi (2008) claim that the main mass loss on Kilimanjaro is due to sublimation. Although this is correct for the horizontal and slope glacier surfaces in the highest glacier regions (Mölg and Hardy, 2004; Mölg et al. 2008), it is not for ablation neither in the terminal regions of slope glaciers nor on the vertical walls that dominate the shrinkage of the plateau ice. For the latter, about 80% of ablation occurs by melting driven by the micro-meteorological conditions, even though air temperatures never reach the melting point. The dry season increase in sunlight does not primarily govern the turbulent latent heat flux between the ice and the atmosphere as claimed by Heuser and Semazzi (2008), but does provide energy to the surface that, if combined with a lack of turbulent heat loss (no wind), leads to melting (Kuhn, 1987). Melting often occurs on the vertical ice walls (Kaser et al., 2004; Mölg et al., 2003).

Finally, Hemp (2005) shows that forest fires have caused a decrease in mountain forest south of Mt. Kilimanjaro, but this is not impacted by glacier recession. The decrease of forest area does decrease the amount of precipitation that is captured from fog (Hemp, 2005), and this has a larger impact on the hydrology of the Mt. Kilimanjaro region than glacier changes.

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Response to: 'The Snows of Kilimanjaro', by Kaser and Allison

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For the reasons stated in Kaser and Allison's comments article (pages 7-8 this issue of CLIVAR Exchanges) we concede that caution should be exercised in the interpretation of the figure on the cover of the recent CLIVAR Exchanges (No. 47; Volume 13#4) taken from the Heuser and Semazzi article (pages 20-23). In making their case Kaser and Allison's comment article includes a line plot (see Figure 2 of their article) showing the time evolution of the changes in the areal extent of the slope and plateau glaciers over this east African Mountain.

Although this is certainly an effective form of depicting the changes, in part, because it separates the areal extent of the two different kinds of glacier, there is still valuable insight that may be gained by presenting the changes in two dimensions as we attempted to do in our original article. In retrospect, it is desirable to use a less controversial figure from IPCC-Fourth Assessment Report (Boko et al., 2007) which for convenience is reproduced in Figure 1. It conveys an equally and perhaps even more compelling depiction of the dramatic decrease in the areal extent of Mt. Kilimanjaro glaciers from 1912 to 2003, which is the primary target of our study.

Kaser and Allison have also objected to our claim that precipitation is a more likely factor than temperature in modulating glacial extent. Apparently, there is no consensus on this question yet. For example, in another study by Molg and Hardy (2004), also cited in Kaser and Allison's article, it is stated that "Horizontal Glacier Surfaces (HGSs) on Kibo are extremely sensitive to precipitation but much less so to air temperature variability, which leaves precipitation

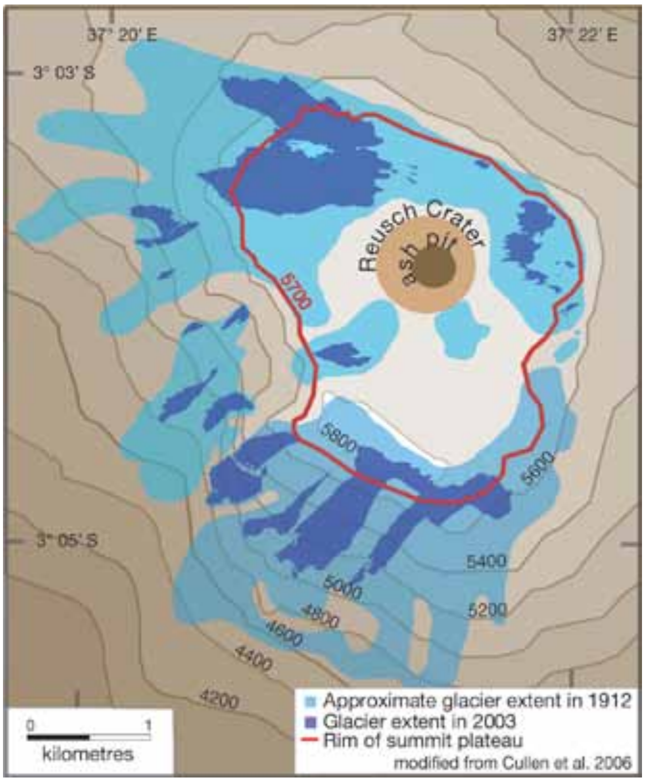

Figure 1: Decrease in surface area of Mt. Kilimanjaro glaciers from 1912 to 2003. This figure is a reproduction of Figure 9.2 of the IPCC Fourth Assessment Report (Boko et al, 2007).

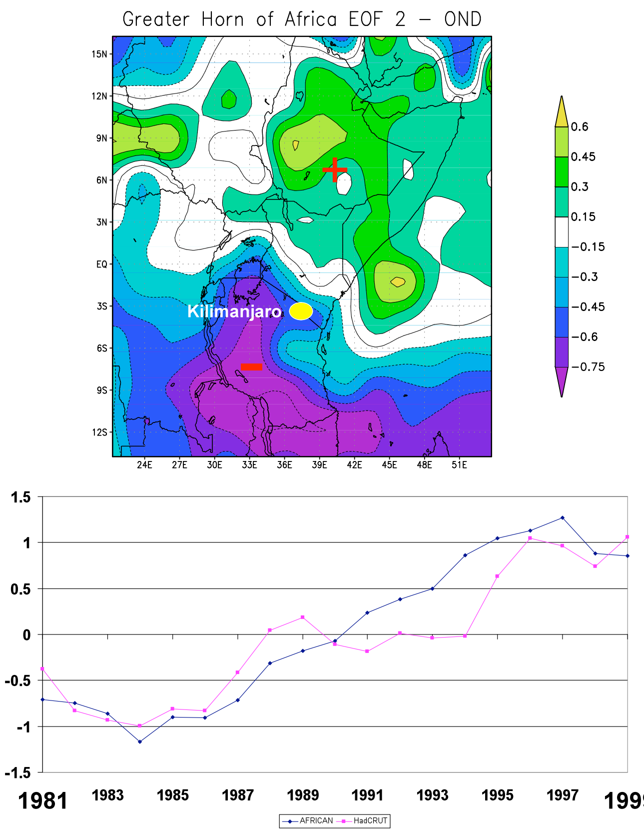

Figure 2: Eastern Africa rainfall climate dipole mode, (top) EOF2 CMAP precipitation loading pattern; and bottom, the pink curve is the hemispheric average of the observed HadCRUT surface temperature and the dark blue line is the EOF2 time series of the Eastern Africa CMAP rainfall. A five-year running mean has been applied to both time series and they have also been scaled to use a common vertical axis coordinate,(figure adapted from Schreck and Semazzi, 2004).

as the most important variable for mass balance of HGSs". This is in direct support of our hypothesis and conclusions but inconsistent with Kaser and Allison's specific objection to our position on this question. Moreover, our claim regarding greater importance of precipitation than temperature was made in the context of changes associated with land use factors, and more specifically albedo changes associated with modified land use cover. We recognize that there are other non-local climatic factors that are in play in contributing to the decrease in the Kilimanjaro glaciers. One of these factors that we believe is playing a major and perhaps primary role during the past few decades, is the Eastern Africa climatic dipole mode (Schreck and Semazzi, 2004; Bowden and Semazzi, 2007) which was also briefly mentioned in our original CLIVAR Exchanges article. Because of its relevance to this response to Kaser and Allison's comments we show it in Figure 2. It is clear that Mt. Kilimanjaro is situated in the drying sector of the dipole thus contributing to the recession of the Kilimanjaro glaciers. Because of its association with low-frequency decadal variability this mode is perhaps more significant in explaining the monotonic recession of the Kilimanjaro glaciers than their relationship with role of the Indian Ocean mode that Kaser and Allison have pointed out in their comments article.

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The third Mediterranean Climate Variability and Predictability - European Science Foundation (MedCLIVAR-ESF) workshop and the first MedCLIVAR-ESF summer School

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The Mediterranean Sea dominates the environmental, cultural and economic life of its coastal states which consist of developed European states and developing states with high vulnerability to climatic change and climate extreme events.

From the atmospheric point of view, the Mediterranean area is under the influence of some of the major regional to large-scale circulation patterns that are modified by the interaction of the Asian, African and European continents, the Atlantic Ocean and the Mediterranean Sea itself. The strong topographic variability permits the development of localised phenomena which dominate at regional and local scales although they remain linked with larger scale and global forcing.

From the oceanographic point of view, the existence of deep water formation in both the eastern and western Mediterranean basins, and the balancing of the excess of evaporation over precipitation and river influx through hydraulically controlled straits, produce a fascinating semi-enclosed sea for studying key processes and the impacts of large and regional scale climate forcing.

Changes in the oceanic and atmospheric/climatic parameters of the Mediterranean region have been well documented although their forcing has not always been resolved in the context of climate variability.

Funded by the MedCLIVAR-European Science Foundation (ESF) programme, a summer school and a workshop were organized at the Hydrobiological Station and Aquarium of Rhodes, Island of Rhodes, Greece by the Hellenic Centre for Marine Research.

The Summer School took place from the 17th-27th September, 2008. The sessions concerned atmospheric processes, in the mornings, and oceanic processes, in the afternoons. In addition, student poster sessions were held

Figure 1: From the opening of the 1st MedCLIVAR-ESF School. The participants and some of the lecturers. Front row from the left, Dr. A Theocharis (2nd), Prof Henry Weiss (3rd), Dr. Elena Xoplaki (4th), Prof. Harry Bryden (7th), Mr. Hatzimarcos (8th), Mr. Andreas Sioulas (9th), Dr. D. Georgopoulos (10th), Dr. M. Tsimplis (11th).

during the breaks and practicals during the evenings. More than 50 post-graduate students and young researchers participated in what proved to be a lively and interactive school. Issues ranging from observational techniques, homogenization of data, regional and spatial changes in the Mediterranean atmospheric and oceanic climate and their relationships with regional and global changes were discussed, together with the more basic issues of the forcing of the Mediterranean oceanic circulation, its monitoring and modeling efforts.

The workshop followed the School and took place at the same venue between 29th September and October 1st. The focus of the workshop was on the changing status of the Mediterranean circulation and sea level and their links with climate change. Long term changes as well as abrupt changes were discussed. Changes in the dense water characteristics both of the eastern and western Mediterranean caused by significant alterations of the large scale thermohaline circulation during the last two decades, as well as important developments in understanding sea level variability in the region, were presented.

The local and national media gave wide publicity to both events including an extensive live television interview. In parallel with the Summer School and the workshop, outreach activities took place, which were open to, and helped to inform, the local community. Moreover, three talks were delivered by members of the organising team to local secondary schools.

Many of the presentations given, together with the student posters, can be found at http://www.medclivar.eu/summerschool1.html. The programme, presentations and abstracts for the workshop can be found at http://www.medclivar.eu/.MedCLIVAR will be organizing two further workshops and one summer school before the programme ends in 2011. In addition, exchange grants are provided for appropriately qualified candidates. Information can be found at the MedCLIVAR web address.

Report of the Ninth Session of the Asian–Australian Monsoon Panel

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The ninth Session of CLIVAR's Asian-Australian Monsoon Panel (AAMP9) was held at the China Meteorological Administration (CMA), Beijing, China from 22-25 October 2008. AAMP9 was held jointly with the fourth WMO International Workshop on Monsoons (IWM4), the fifth Asian Monsoon Years (AMY) International Workshop and the second Pan-WCRP workshop. This was a unique opportunity to bring together scientists with a CLIVAR focus and scientists/forecasters with a WWRP operational forecasting and application focus.

During the joint session with AMY the panel received an update on the status of recently completed summer field campaigns and plans for ongoing work during the winter monsoon. Over the past two years, one of the major efforts of the AAMP has been its active engagement in AMY science planning and infrastructure organization along with GEWEX/MAHASRI. AMY successfully entered its field campaign phase during 2008. After this initial stage the panel has agreed to continue its involvement in coordination of the AMY modeling activity. Dr. Bin Wang, Dr. Harry Hendon, Professor In-Sik Kang and Dr. Akio Kitoh will work with the AMY community to promote this. Priority will be given to monsoon intraseasonal prediction and associated hydrological extreme events, as well as the assessment of the impacts of improved land initialization and land-atmosphere interaction on monsoon seasonal and intraseasonal prediction. AAMP and AMY will seek to hold a joint modeling workshop later in 2009.

The AAMP was also actively involved in the second Pan-WCRP Workshop, and participated in the discussion on cross cutting activities and in the development of the proposed joint activities. The panel is particularly interested in the possible development of a WCRP/WWRP Project on Simulation and Prediction of Monsoon Intra Seasonal Oscillation (MISO), which would be complementary to the historical intraseasonal prediction project that panel members have been advocating. The AAMP agreed to help formulate and refine the Pan-WCRP project as it evolves.

The panel reviewed the current status of monsoon simulation and prediction and agreed the need to develop a Climate-System Historical Forecast Project (CHFP) for prediction of hydrologically relevant fields in the monsoon region. Dr. Hendon will convey the interest of the monsoon community in developing this activity to CLIVAR's Working Group on Seasonal to Intrannual Prediction (which hosts the CHFP) at their meeting in Miami, in January 2009.

The panel discussed how to contribute to the Year of Tropical Convection (YoTC) initiative. Knowing that the initial 2 yr term of the US CLIVAR Madden Julian Oscillation (MJO) working group (MJO WG) has now expired, the AAMP agreed on the need to encourage the creation of a new MJO WG, perhaps as a cross-monsoon activity. Particular emphasis should be on further development of MJO diagnostics/metrics, especially as pertaining to forecast assessment and verification, development of diagnostics suitable for poleward propagating intraseasonal variability during the Asian summer monsoon, and development of diagnoses that provide physical insight into the shortcomings of convective parameterizations of the MJO.

AAMP reviewed the new developments in the Indian Ocean and Western Pacific observing systems, the ocean's role in the A-A monsoon, and emerging initiatives of interest to the panel. The panel also reviewed the objectives and background of the TRIO ("Thermocline Ridge of the Indian Ocean") project and cruise. AAMP considers that this project, in conjunction with the Vasco-Cirene experiment and other projects mentioned in the TRIO science plan focussing on the Seychelles-Chagos Thermocline Ridge (SCTR), are of direct relevance to CLIVAR in the Indian Ocean and the Asian-Australian monsoon system. The panel agreed to endorse the project and to provide assistance to the TRIO PIs, if required, to help develop a science plan for supporting modelling activities. The AMMP9 was also an opportunity to receive an update of the activities of both CLIVAR's Indian (IOP) and Pacific Ocean (PP) panels. In particular the panel considered the current status of the field experiment CINDY2011 (Cooperative Indian Ocean experiment on intra-seasonal variation in the Year 2011), a project developed to investigate the initiation process of the MJO-convection and relevant atmospheric and oceanic variability in the Indian Ocean. The panel agreed on the relevance of the CINDY science plan to the AAM system, and offered assistance with the modelling/prediction plan (case study prediction for the field program). The North-western Pacific Ocean Circulation Experiment (NPOCE) and the Southwest Pacific ocean circulation and Climate Experiment (SPICE) were also reviewed. The panel recognised that both observational efforts are relevant to the AAM research and will establish linkages for future collaborations. The panel asked that the IOP and PP keep them up to date with the development of these programs via the joint panel members (Vecchi/IOP; Bo/PP).

Further information about the meeting and AAMP activities can be found at: http://www.clivar.org/organization/atlantic/atlantic.php

Report from the 12th Session of the Working Group on Coupled Modelling (WGCM)

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The Working Group on Coupled Modelling (WGCM) held a historic meeting in Paris, France on 22-24 September 2008. H. Le Treut, P. Braconnot and C. Michaut of the World Climate Research Programme Strategic Support Unit generously hosted the meeting at the Ecole Normale Superiéure.

Representatives from 20 of the global coupled climate modelling centres from around the world were invited to hear about the next climate model intercomparison project (CMIP5) that WGCM is coordinating. This framework was originally proposed by the WGCM/Analysis, Integration and Modelling of the Earth System (AIMES) community in 2006 (Meehl and Hibbard, 2007; Hibbard et al., 2007) and a full summary of the finalised CMIP5 experimental design is to be published by Taylor et al. (2008). The scientific community has formulated the CMIP5 coordinated experiments to address key science questions so this has not been IPCC-driven. Since CMIP5 will be the major activity of the international climate change modelling community for the next five years or so, the global coupled climate modelling centres will commit huge resources over the next two years to perform the CMIP5 experiments. The meeting provided a unique opportunity for the modelling groups to work on reaching a consensus and to discuss ways of maximising the utility of the experiments for the wider scientific community (in particular the following activities of the WCRP CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP); WCRP's Global Energy and Water cycle Experiment (GEWEX), Stratospheric Processes and their role in Climate (SPARC) and Climate and Cryosphere Project (CliC); the WMO CAS/WCRP Working Group on Numerical Experimentation (WGNE) and IGBP's Analysis, Integration and Modelling of the Earth System (AIMES)). Results from these experiments will provide the basis for the next Intergovernmental Panel on Climate Change Assessment (AR5). Publication of the Working Group 1 AR5 report is due in early 2013 so model versions are to be finalized in late 2008-2009, model runs done in 2009-2010, data access/collection in late 2010, and analysis in 2011-2012.

The CMIP5 strategy for climate change modelling and emerging Earth System Models (ESMs) has been designed to improve links to the IPCC Working Group 3 (through the Integrated Assessment Modelling (IAM) Consortium) and hopefully to Working Group 2 too. The strategy proposed at the 2006 Aspen meeting (that would form the basis of the CMIP5 experiment design) is to use two classes of models to address two time frames and two sets of science questions (Hibbard et al., 2007; Meehl and Hibbard, 2007; also see the meeting report from the 11th Session of WGCM for a summary). The two model classes are summarized below:

- Longer term projections (to 2100 and beyond) - intermediate resolution (~200 km), carbon cycle, specified/simple chemistry and aerosols, new mitigation scenarios ("representative concentration pathways" (RCPs)), science question: e.g. the magnitude of feedbacks
- Near term projections (2005-2030) - higher resolution (~50 km), no carbon cycle, some chemistry and aerosols, single scenario, science question: e.g. regional extremes.

A first major link has been made between WGCM and WGSIP who, together with AIMES organised, an Aspen Global Change Institute workshop on Climate Prediction to 2030 (Meehl, et al., 2008). The near-term projection framework for the next five years and beyond now includes 10- and 30-year prediction studies and high-resolution time-slice experiments, as summarized in Taylor et al., 2008.

There are reasonable prospects for producing decadal forecasts that are of sufficient skill to be used by planners and decision makers. As well as being of considerable scientific interest, in addition the CMIP5 experimental design provides an opportunity for the international coordination of research and experimentation in this area. There are two aspects to the decadal problem; the externally forced signal (green-house gases and aerosols, volcanoes, solar, etc.) and the predictable part of the internally generated signal from oceanic mechanisms (e.g. Meridional Overturning Circulation, Antarctic Circumpolar Current), coupled processes (e.g. Pacific Decadal Oscillation, Atlantic Multi-decadal Oscillation, El-Nino Southern Oscillation), modulation of climate modes (e.g. Pacific-North American pattern, North Atlantic Oscillation, Northern Annular Mode, Southern Annular Mode) and potentially land and cryospheric processes. To date, climate projections have generally treated internal variability as a statistical component of uncertainty. Though there is no marked decadal peak in the spectrum of the climate system, long timescales exist and are potentially predictable. The challenge of prediction/predictability studies is to identify the mechanisms associated with regions/modes of predictability, to better understand the connection between oceanic modes and terrestrial climate variability, and to investigate predictive skill by means of prognostic (including multi-model) decadal predictions.

The results of predictability studies and demonstrations of forecast skill provide the foundations for initiating a coordinated WCRP study of decadal prediction/predictability. There are abundant scientific opportunities to improve and extend models and for the analysis of variability and of modes of variability. There are challenges to develop improved analysis methods, especially in the ocean, and for model initialization, verification and model development, as well as in ensemble generation and the use of multi-model ensembles for prediction on decadal timescales.

Modelling of climate change is not only a scientific challenge of the first order but also a major technological challenge and the Program for Climate Model Diagnosis and Intercomparison (PCMDI) will again play the lead role in supporting the international climate community as it will provide access to hundreds of petabytes of simulation data over the next three to seven years. A new federated, distributed architecture known as the Earth System Grid Centre for Enabling Technology (ESG-CET) is being developed in partnership with PCMDI to meet the needs of CMIP5. The ESG mission is to provide climate researchers worldwide with access to data, information, models, analysis tools, and computational capabilities required to make sense of the enormous climate simulation datasets. The federated architecture consists of a layered system based on Gateways and Nodes. Gateways are portals with search capability, distributed metadata, registration and user management. They may be customized to an institution's requirements and there are fewer sites, with a more complex architecture than nodes. Nodes are where data are stored and published.

In addition to serving the coupled modelling community with the CMIP5 coordinated experiments and data collection and archival needs, the WGCM meeting addressed the topic of improving models. In particular, it addressed the simulation of cloud and moist processes and emerging issues, including ice sheets and air chemistry.

Another major focus for WGCM is regional climate modelling and how this community can best organise itself at an international level. During the last decade, there has been a tremendous evolution in regional climate models (RCMs) and downscaling techniques. RCMs are being upgraded to non-hydrostatic, cloud-resolving frameworks in order to achieve sub-10 km resolutions. Running decadal to centennial simulations has become the "accepted standard", however this progress was not reflected in the AR4. RCM information is under-utilized in the current generation of climate change scenarios for impact/adaptation work because RCM studies have not been coherent and comprehensive enough to sufficiently characterize uncertainties in climate change projections. The RCM community feels the need for a global coordinated program (analogous to a CMIP5) to produce a next generation set of scenarios for use in the AR5 process. The WCRP JSC has requested that a Task Force on Regional Climate Modelling be set up to assess the RCMs and downscaling techniques that are available, for time scales from seasonal forecasts to IPCC time scales. WCGM has endorsed the formation of this Task Force, which will entrain appropriate expertise including scientists using RCMs and will involve WGNE, WGSIP, WGCM, World Climate Programme (WCP), and regional global change SysTem for Analysis, Research and Training (START) activities.

What became clear at this meeting was that, as the international climate modelling community takes on ever-increasing climate change modelling challenges, WGCM has been able to build tangible linkages through shared activities and direct communication with other groups representing the research communities involved with CMIP5. AIMES (IGBP) has worked with WGCM to formulate the CMIP5 experimental design. WGSIP and WGCM have formed a joint contact group to oversee the decadal predictability/prediction part of CMIP5. WGNE and GEWEX Cloud System Study (GCSS), through shared interests with WGCM in model development, processes, and parameterizations, have a joint stake in the cloud and moist process part of CMIP5. WGCM is now linked to the IPCC Working Group 3 integrated assessment modelers (IAMs) through the IAM Consortium where WGCM is working with them to formulate and coordinate the new RCP mitigation scenarios. SPARC and The Atmospheric Chemistry and Climate initiative (AC&C) are providing consultation on the chemistry and aerosol aspects of the long-term experiments with the new earth system models. Thus, as the models have become more complex with higher resolution, and the climate change modelling problem now has short term initialized aspects and long term earth system model components, the various panels and working groups are now functioning not so much as separate independent entities, but more as a network of communities through the coordinating and clearing house role of WGCM.

The 2008 WGCM meeting was the last one with John Mitchell as co-chair. He has stepped down to become an ex-officio member of the CMIP Panel as part of WGCM. John's service to WGCM extends back to the first incarnation of the committee in 1990, the Steering Group on Global Coupled Models (SGGCM) chaired by Larry Gates. Over the years John has been an active contributor to the activities of SGGCM, its transition to CLIVAR NEG2 from 1994-1997, and then finally to WGCM from 1997 to present. His most recent co-chairmanship has been marked by the successful completion of the CMIP3 coordinated climate model experiments and associated analyses that have changed the face of climate science research. Though we will miss John's thoughtful and insightful guidance as co-chair, we look forward to his continued presence on WGCM as part of the CMIP Panel. Succeeding John as co-chair is Sandrine Bony who, along with continuing co-chair Jerry Meehl, will work with WGCM in shepherding the new CMIP5 activity through the IPCC AR5 process and beyond, coordinating the latest phases of Paleoclimate Modelling Intercompairson Project (PMIP) and Cloud Feedback Model Intercomparison Project (CFMIP), and strengthening new connections to WGSIP, WGNE, the Integrated Assessment Modeling Consortium, GCSS and others. We thank John for his service, and we look forward to continued interactions with him.

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The fifth session of the CLIVAR/GOOS Indian Ocean Panel

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The fifth session of the CLIVAR/GOOS Indian Ocean Panel (IOP) took place in Bali Indonesia on 12-14 May, 2008. The meeting started by a minute of silence in rememberance of Prof. Fritz Schott who was an active IOP member. News of his death preceded the meeting by few days.

The first part of the meeting was dedicated to reviewing the Indonesian activities in the Indian Ocean, especially the Indonesian Tsunami Early Warning System (InaTEWES), the Indonesian Global Ocean Observing System (InaGOOS) and Indonesian developments in operational oceanography by the Southeast Asia Centre for Ocean Research and Monitoring (SEACORM). Indonesia will host the World Ocean Conference (WOC) in May 2009, which will focus on climate change impacts on the oceans and the role of the oceans in climate change (http://www.woc2009.org/home.php)

Realisation of the Indian Ocean Sustained Observation Plan published in 2006 (http://eprints.soton.ac.uk/20357/01/IOP_Impl_Plan.pdf) is progressing through the Indian Ocean Observing System (IndOOS). In addition, the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) is now almost half complete; the target Argo and drifter deployments have been reached and there are a number of recent enhancements from India, Australia, China and South Africa, amongst others, that provide significant improvements, particularly for the boundary regions. The IOP has been a driving force in increasing the national participations in IndOOS.

The panel reviewed the plan for a new multinational process study called CINDY (Cooperative Indian Ocean Experiment in the Year 2011). The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has approved the follow-on initiative of MISMO (Mirai Indian Ocean cruise for the Study of the Madden Julian Oscillation (MJO)-convection Onset), which took place in 2006 in the central equatorial Indian Ocean. They plan to conduct the stationary observations in the Indian Ocean for two months between October 2011 and February 2012 using the R/V MIRAI. They will also conduct meteorological measurements (cloud radar, lidar, radiosonde sounding etc.) on the Maldives. The French have proposed the continuation of the VASCO-Cirene process study in a project called TRIO (Thermocline Ridge of the Indian Ocean). It will explore air-sea interactions at synoptic (cyclone and tropical storm), intraseasonal (Madden-Julian Oscillation) and interannual timescales in the 5°S-15°S latitude band of the Indian Ocean. The TRIO cruise, proposed for 2011, will contribute to the development of the RAMA array and interact with several satellite programs, such as Megha-Tropiques (Water cycle in the tropical atmosphere in the context of climate change.), SMOS (Soil Moisture and Ocean Salinity) and AltiKa (A high accurate oceanography altimeter). TRIO will also have strong interactions with the synchronous SWICE (South West Indian Ocean Cyclone Experiment) project.

IOP is promoting the link between IndOOS and regional/coastal observational activities around the Indian Ocean, including the Mozambique Channel Long-term Ocean Climate Observations (LOCO), PACSWIN (Indonesian Throughflow: PACific Source Water INvestigation), the Australian Integrated Marine Observing System (IMOS), and the Indian Mooring Program in the Arabian Sea and Bay of Bengal. In addition, a new initiative in JAMSTEC will address societal issues and will connect the outputs from the observing system and end-users of marine climate information in a seamless way. It will focus on the Indian Ocean Dipole (IOD) as the first target, which will enhance the IOP engagement to socio-economic issues. IndOOS and RAMA have also initiated a collaboration with the Agulhas Somali Large Marine Ecosystems (ASCLME) Project, which conducts research cruises in the western Indian Ocean to fill gaps in our understanding of ecosystem-level processes, which affect sustainable management decisions. IOP will enhance engagement with Indian Ocean agencies by beginning collaboration with regional and coastal observing activities.

The next big challenge for IOP is to develop a research plan to address a range of issues relevant to Indian Ocean-climate, drawing on the background of a sustained observing system. Potential topics include improving ocean-predictability at time scales from MJO to IOD decadal and longer variation of the Indian Ocean circulation and its connectivity to the Pacific, Southern and Atlantic Oceans; improved estimation of heat, freshwater and momentum fluxes; and in collaboration with SIBER, basin-scale biogeochemical and ecological studies. The discussion will continue at IOP-6.

VAMOS !

Newsletter of the Variability of the American Monsoon Systems Panel

Editorial

This issue of the VAMOS! Newsletter has the main theme “Cross-cutting activities within VAMOS, linking the American Monsoons.” Four articles summarize the approach the VAMOS panel has chosen to update its agenda in response to new guidelines from WCRP: (1) VAMOS and Climate Extremes, (2) VAMOS interest on Anthropogenic Climate Change (ACC), (3) Modeling efforts in VAMOS, and finally (4) Cross-Hemispheric Interactions Between VAMOS Regions, which introduces IASCLIP (Intra-Americas Studies of Climate Processes), a new VAMOS science component.

Extremes in the Americas are important as they can have dramatic socio-economic impacts, not only in developing countries where vulnerability to such events is major, but also in developed countries where extremes affect the water resources and agricultural production upon which millions depend. The study of extremes – documenting, understanding, modeling and predicting – therefore constitutes an important cross-cutting theme for all the VAMOS Science Components (NAME, MESA, VOCALS and IASCLIP). VAMOS is in a unique position to utilize its continental perspective in linking extremes in warm season climate behavior to the circulation structures defined as the monsoon systems.

The article on VAMOS and ACC discusses the future interplay of societal and scientific aspects of climate change. It addresses the need to identify and understand important processes that control monsoonal climates and their variability and change in the Americas, and how these processes interact with broader societal issues, such as impacts, vulnerability, and adaptation.

The article on the VAMOS Modeling Plan presents implementation ideas and priorities, as based on integrated modeling, data analysis and assimilation approaches. The strategy is to take advantage of VAMOS enhanced observations, and is designed to simultaneously provide model-based guidance to the evolving multi-tiered VAMOS observing program. The VAMOS modeling plan makes significant contributions to the WCRP strategic framework relevant activities conducted within CLIVAR, in particular with respect to assessing and improving seasonal forecasts and model simulations.

Finally, the note on IASCLIP presents examples of cross-hemispheric interactions, like those between the western hemisphere warm pool and the southeast Pacific, and the physical processes in Amazonia that are linked to the Tropical/Subtropical North Atlantic. Understanding these interactions cannot be addressed by one single VAMOS program but by collaborations between them. In this issue we also include a short contribution highlighting the successful VAMOS Ocean - Cloud - Atmosphere - Land Study Regional Experiment (VOCALS-REx).

Due to budgetary reasons, this issue of the VAMOS Newsletter will appear as a supplement of CLIVAR Exchanges for the printed version, but will remain available in digital form

El tema principal de la presente edición es “Actividades transversales en VAMOS, conectando los monzones americanos”. El enfoque que escogió el panel de VAMOS para actualizar su agenda en respuesta a los nuevos lineamientos de WCRP se sintetiza en cuatro artículos: (1) VAMOS y los extremos climáticos, (2) interés de VAMOS en el cambio climático antrópico (ACC), (3) esfuerzos de modelado en VAMOS y por último (4) interacciones interhemisféricas entre las regiones de VAMOS, que presenta IASCLIP (Estudios Intraamericanos de los Procesos Climáticos), un nuevo componente científico del panel.

Los eventos extremos en las Américas son importantes ya que pueden tener efectos socioeconómicos catastróficos, no sólo en países en desarrollo donde la vulnerabilidad a estos eventos es mayor, sino también en los países desarrollados donde afectan los recursos hídricos y la producción agrícola de los que dependen millones de personas. El estudio de los eventos extremos -su documentación, comprensión, modelado y pronóstico- constituye entonces un importante tema transversal a todos los componentes científicos de VAMOS (NAME, MESA, VOCALS e IASCLIP). VAMOS está en una posición única para aprovechar su perspectiva continental para vincular los eventos extremos del comportamiento del clima de la estación cálida con las estructuras de circulación definidas como sistemas monzónicos.

El artículo sobre VAMOS y ACC analiza las interacciones futuras entre los aspectos sociales y científicos del cambio climático. Trata la necesidad de identificar y comprender procesos importantes que controlan los climas monzónicos y su variabilidad y cambio en las Américas, y cómo estos procesos interactúan con cuestiones sociales más amplias, como los impactos, la vulnerabilidad y la adaptación.

El artículo sobre el Plan de Modelado de VAMOS presenta ideas y prioridades de implementación, basadas en los enfoques integrados del modelado, análisis y asimilación de datos. La estrategia consiste en aprovechar las observaciones intensivas de VAMOS, y está diseñada para brindar al mismo tiempo una orientación apoyada en los modelos a la evolución del programa de observación en múltiples niveles de VAMOS. El plan de modelado de VAMOS hace aportes significativos a las actividades relevantes al marco estratégico de WCRP que se realizan dentro de CLIVAR, en particular respecto de la evaluación y mejora de los pronósticos y las simulaciones estacionales.

Finalmente, la contribución sobre IASCLIP presenta ejemplos de interacciones interhemisféricas, como las que tienen lugar entre la piscina cálida del hemisferio occidental y el Pacífico sudoriental, y los procesos físicos de Amazonia que están conectados con el Atlántico Norte Tropical/Subtropical. Ninguno de los programas de VAMOS por sí solo puede intentar comprender estas interacciones sino sólo cooperando con los demás.

on the VAMOS web site. As a result, many people who used to receive a hard copy of VAMOS! will no longer receive it. However, we will continue to send a limited number of printed copies of VAMOS! to institutions that are registered on our mailing list. We take the opportunity to thank Carlos Ereño for his continuous support in all VAMOS activities, and Howard Cattle, International Project Office of CLIVAR, for the generous offer to publish VAMOS! in association with CLIVAR Exchanges. This will guarantee the continuity of our Newsletter as long as VAMOS continues to exist as a panel.

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En este número incluimos también una breve nota sobre el exitoso Experimento Regional del Estudio del Océano-Nubes-Atmósfera-Tierra de VAMOS (VOCALS-REx).

Por razones presupuestarias este número de VAMOS! aparecerá como suplemento de la versión impresa de CLIVAR Exchanges, pero continuará estando disponible en formato digital en el sitio web de VAMOS. Es así que muchas personas que solían recibir copia impresa de VAMOS! dejarán de hacerlo. Sin embargo, continuaremos enviando una cantidad limitada de copias impresas a instituciones que están registradas en nuestra lista de distribución. Aprovechamos esta oportunidad para agradecer a Carlos Ereño por su permanente apoyo a todas las actividades de VAMOS, y a Howard Cattle, Oficina Internacional del Proyecto CLIVAR, por el generoso ofrecimiento de publicar VAMOS! junto con CLIVAR Exchanges, lo que asegurará la continuidad de nuestra revista mientras VAMOS exista como panel.

Activities on anthropogenic climate change

Introduction

The increased recognition that our climate is changing due to human and natural influences has produced a growing demand for climate change information for use in integrated assessments. Rapid flow of this information to decision makers and planners is extremely important for impact studies, directed towards the proposal of adaptation measures. In the Variability of American Monsoons Systems (VAMOS) context, the future interplay of societal and scientific aspects of climate change includes the need to identify and understand important processes that control monsoonal climates, their variability and change in the Americas, and how these processes interact with broader societal issues, such as impacts, vulnerability, and adaptation.

Relevant Scientific Issues

Here we summarize the current scientific understanding of the observed and projected impacts of climate change on monsoon-related processes in the Americas and identify relevant scientific issues that need to be better addressed by the VAMOS community. This summary is based on the first report of the VAMOS Anthropogenic Climate Change (ACC) task force (Cavazos et al., 2008), which builds upon key results of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) and other recent findings.

Assessments of model performance and uncertainty analyses

An important area of research is the design of metrics to test the ability of models to simulate well-observed features of the current climate. Such metrics provide guidance about overall strengths and weaknesses of individual models, as well as of the general state of modeling. Kim et al., (2008) for example evaluated the global monsoon variability simulated by 21 Coupled Global Circulation Models (CGCMs) of the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 (CMIP3) multimodel dataset that participated in the IPCC-AR4. Medium and high resolution models adequately reproduced the summer monsoon rainfall patterns (Figure 1, cover), but the spread among the models was large, particularly on the windward side of narrow mountains, such as in Mexico. CGCMs simulations have also shown large biases in the structure and evolution of the Intertropical Convergence Zone and the El Niño-Southern Oscillation (ENSO). CMIP3 model assessments for South America (e.g., Vera et al., 2006) showed that the models were able to reproduce the main features of the seasonal cycle of precipitation during the 20th century, but there was considerable variation regarding the ENSO amplitude and the Southern Hemisphere circulation response to ENSO.

Actividades relacionadas con el cambio climático antrópico

Introducción

El reconocimiento de que nuestro clima está cambiando por influencias humanas y naturales ha generado una demanda cada vez mayor de información sobre el cambio climático para ser usada en evaluaciones integradas. Un flujo rápido de esta información hacia los tomadores de decisiones y planificadores es de suma importancia para los estudios de impacto, que tienen por objeto proponer medidas de adaptación. En el contexto de la Variabilidad de los Sistemas Monzónicos Americanos (VAMOS, por sus siglas en inglés), la interacción futura de los aspectos sociales y científicos del cambio climático incluye la necesidad de identificar y comprender procesos importantes que controlan los climas monzónicos, su variabilidad y cambio en las Américas y el modo en que estos procesos interactúan con cuestiones sociales más amplias como los impactos, la vulnerabilidad y la adaptación.

Temas científicos relacionados

Sintetizamos aquí los conocimientos científicos actuales de los impactos, observados y proyectados, del cambio climático en los procesos relacionados con los monzones en las Américas e identificamos temas científicos pertinentes que requieren un mejor abordaje por parte de la comunidad de VAMOS. Este resumen se basa en el primer informe del grupo de trabajo de VAMOS sobre Cambio Climático Antrópico (ACC) (Cavazos et al., 2008), que se apoya en resultados clave del Cuarto Informe de Evaluación (AR4) del Grupo Intergubernamental de Expertos sobre el Cambio Climático (IPCC) y otras conclusiones recientes.

Evaluación del desempeño de los modelos y los análisis de incertidumbre

Una importante área de investigación es el diseño de métricas para evaluar la habilidad de los modelos para simular características conocidas del clima actual. Dichas métricas dan una idea acerca de las fortalezas y debilidades generales de los modelos, así como del estado general del modelado. Kim et al., (2008), por ejemplo, evaluaron las simulaciones de la variabilidad monzónica global realizadas por 21 Modelos de Circulación General Acoplados (CGCMs) de la base de datos de múltiples modelos de la tercera fase del proyecto de intercomparación de modelos acoplados (CMIP3) del Programa Mundial de Investigaciones Climáticas que participaron en el IPCC-AR4. Los modelos de resolución media y alta reprodujeron adecuadamente los patrones de precipitación monzónica estival (Figura 1, tapa), pero la dispersión entre los modelos resultó ser grande, especialmente en la ladera de barlovento de montañas estrechas como las de México. Las simulaciones de los

Improvement of simulation and understanding of major tropical and monsoon-related modes of variability

The global monsoon systems all involve general circulation connections between the tropics and the subtropics that depend on many factors, from regional air-sea interactions and land processes to teleconnection influences (e.g., ENSO, Pacific Decadal Oscillation and Atlantic Multidecadal Oscillation). The monsoon regions of the Americas have experienced significant increases in surface temperatures during the last quarter of the 20th century with further warming of approximately 1°C to 4°C likely to occur in North America at the end of the 21st century. Such an increase could potentially affect the land-sea thermal contrast, which is known to influence the position of the upper-level monsoon anticyclone and hence the onset and intensity of the monsoon rainfall. However, sea surface temperatures have also exhibited significant positive trends in the last quarter of the 20th century which would likely counterbalance the land-sea thermal contrast. To date little is known about the trends in differential heating between the North American continent and the surrounding oceans and their possible influence on monsoon dynamics. It could be hypothesized that the summer monsoons would increase in strength in the future, but model results are not as straightforward as this simple prediction as they show a weakening of the tropical circulation by the late 21st century, as well as a weakening of the South American monsoon system (SAMS).

At intraseasonal timescales, the simulation of the Madden-Julian Oscillation in contemporary CGCMs also remains unsatisfactory; models underestimate the strength and coherence of convection and wind variability. It has been suggested that inadequate representation of cloud radiative interactions and/or convection-moisture interactions in climate models may be responsible for this bias.

Aerosols, land cover and land use

Anthropogenic activities impacting the global concentration of greenhouse gases or changes in land use are apparent over portions of the SAM region. Studies indicate that increased aerosol loading in the atmosphere may have strong impacts on monsoon evolution through changes in local heating of the atmosphere and the land surface. The uncertain role of aerosols complicates the nature of future projections of monsoon precipitation. If only the direct effect of the aerosol increase is considered, surface temperatures may not warm as much because the aerosols reflect solar radiation. For this reason, the land-sea temperature contrast may become smaller than presently occurs thereby weakening the summer monsoon circulation. However, how regional circulation and rainfall changes will occur over the SAM remain unclear. Presently aerosol impacts on the North American monsoon region are unknown.

The American monsoon regions are vulnerable to climate change and especially to extreme climate events such as intense droughts and floods. In the Amazon, the temperature rise is expected to cause greater evapotranspiration, leading to the acceleration of the hydrological cycle and to greater loss of soil moisture, with potential alterations of the Amazonian biome. Vegetation and land cover are thought to play a significant role in modulating monsoon variability through land surface fluxes and moisture recycling to the atmosphere. However, it is not yet clear how expected changes in land cover, which are relatively uncertain, will impact precipitation processes.

Development of detection and attribution studies

A common conclusion from the variety of studies carried out by means of data analysis or simulations using CGCMs over the past 15 years is that much of the observed warming cannot be explained exclusively by natural factors. A substantial quantity of anthropogenic influence, in the form of greenhouse gas emissions and land cover change is necessary

CGCMs mostraron también la presencia de grandes sesgos en la estructura y evolución de la Zona de Convergencia Intertropical y El Niño-Oscilación Sur (ENSO). En las evaluaciones de los modelos de CMIP3 para América del Sur (por ejemplo, Vera et al., 2006) se vio que los modelos podían reproducir las características principales de la marcha estacional de la precipitación en el siglo XX, pero que existían importantes variaciones respecto de la amplitud del ENSO y la respuesta de la circulación en el hemisferio sur a este fenómeno.

Mejoras en la simulación y comprensión de los principales modos de variabilidad tropical y monzónica

Los sistemas monzónicos globales tienen conexiones con la circulación general entre los trópicos y los subtrópicos que dependen de numerosos factores, desde las interacciones regionales aire-mar y procesos terrestres hasta las influencias de las teleconexiones (por ejemplo, ENSO, Oscilación Decenal del Pacífico y Oscilación Multidecenal del Atlántico). La temperatura en superficie en las regiones monzónicas de las Américas ha aumentado significativamente durante los últimos 25 años del siglo XX y es probable que aumente todavía entre aproximadamente 1°C y 4°C en América del Norte hacia fines del siglo XXI. Este aumento podría afectar el contraste térmico tierra-mar, que tiene un efecto conocido en la ubicación del anticiclón monzónico de altura y por lo tanto en el inicio e intensidad de la precipitación monzónica. Sin embargo, la temperatura de la superficie del mar también mostró tendencias positivas significativas en los últimos 25 años del siglo XX, que podrían contrarrestar el contraste térmico tierra-mar. Hasta ahora poco se sabe acerca de las tendencias en el calentamiento diferencial entre el continente norteamericano y los océanos que lo rodean y su posible influencia en la dinámica de los monzones. Podría suponerse que la intensidad de los monzones estivales aumentaría en el futuro, pero los resultados de los modelos no son tan sencillos como esta predicción supone ya que muestran un debilitamiento de la circulación tropical hacia fines del siglo XXI, así como un debilitamiento del sistema monzónico de América del Sur (SAMS, por sus siglas en inglés).

En escalas intraestacionales, la simulación de la Oscilación de Madden-Julian tampoco es satisfactoria en los CGCMs actuales; los modelos subestiman la fuerza y la coherencia de la variabilidad de la convección y del viento. Se ha sugerido que este sesgo puede tener su origen en una representación incorrecta de las interacciones radiativas de las nubes y/o las interacciones entre la convección y la humedad en los modelos .

Los aerosoles y la cobertura y uso de la tierra

En algunas partes de la región del monzón sudamericano, son evidentes las actividades del hombre, como el cambio en el uso de la tierra, que afectan la concentración global de gases de invernadero. Los estudios indican que un aumento en la carga de aerosoles en la atmósfera puede tener grandes impactos en la evolución de los monzones a través de variaciones en el calentamiento local de la atmósfera y la superficie terrestre. El papel incierto de los aerosoles complica la naturaleza de las proyecciones futuras de la precipitación monzónica. Si sólo se tiene en cuenta el efecto directo del incremento de los aerosoles, la temperatura en superficie puede no sufrir grandes aumentos ya que los aerosoles reflejan la radiación solar. Es por ello que el contraste de temperatura tierra-mar puede reducirse a valores menores que los actuales, debilitando así la circulación monzónica estival. Sin embargo, no está claro cómo tendrán lugar los cambios en la circulación y precipitación regional en SAM. Actualmente se desconocen los impactos de los aerosoles en la región del monzón de América del Norte.

Las regiones monzónicas de América son vulnerables al cambio climático y en particular a los eventos climáticos extremos como las sequías o las inundaciones severas. En Amazonia, se espera que las mayores temperaturas provoquen más evapotranspiración, llevando a la aceleración del ciclo hidrológico y a una mayor pérdida de humedad del suelo, con cambios to explain the warming. However, most existing studies fall short in confidently attributing trends in regional precipitation patterns, particularly in the monsoon regions. As such, there has been little if any work published to date on the attribution of specific changes in regional precipitation to climate change or other possible mechanisms.

Regional climate downscaling for integrated assessments of climate change

Within the impacts and adaptation community there is a growing shift toward integrated assessments, wherein regional climate change projections form a principal factor for decision support systems aimed to reducing vulnerability and to lay the methodological basis for future adaptation studies. At present the regional projections are perhaps the weakest link in this process and the bulk of information readily available for policy and resource managers is largely derived from CGCMs. The CREAS initiative (Regional Climate Change Scenarios for South America) was recently implemented in South America (Marengo et al., 2008). It aims to provide high resolution climate change scenarios for raising awareness among government and policy makers in assessing climate change impacts, vulnerability and in designing adaptation measures for different sectors. To date, much of the work remains at the level of methodological development. Regional climate change scenarios for impacts and adaptation studies remain to be thoroughly explored in the VAMOS regions.

The use of regional climate models and downscaled CMIP3 climate change scenarios in developing countries has expanded thanks to portable models such as the International Centre for Theoretical Physics-Regional Climate Research NETwork (ITCP-RegCM), the PRECIS-CARIBE scenarios (http://precis.insmet.cu/Precis-Caribe.htm), the statistically downscaled CMIP3 climate projections for the United States and northern Mexico (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections), and the CREAS dynamical downscaling climate change projections for South America (http://www.cptec.inpe.br/mudancas_climaticas).

Concluding remarks

It is critical that the VAMOS community develops common process-oriented metrics at different timescales to examine the ability and uncertainties of the CGCMs in the monsoon regions of the Americas. The cascade of uncertainties in CGCM fields needs to be understood since they will be transmitted to the regionalization tools and to the climate change assessments. Observations of sufficient detail and scope are required to improve validation, models, and model ensembles and to ensure that monsoon-related processes can be adequately elucidated, predicted and projected. Therefore, there is the need to create or improve regional databases that include observations, model simulations, and regional downscaling simulations at daily and monthly timescales, for impact assessment studies.

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potenciales en el bioma amazónico. Se cree que la vegetación y la cobertura de la tierra juegan un papel importante en la modulación de la variabilidad de los monzones mediante los flujos de la superficie de la tierra y el reciclado de humedad a la atmósfera. Sin embargo, aún no está claro el impacto que tendrán los relativamente inciertos cambios esperados en la cobertura de la tierra en los procesos de precipitación.

Desarrollo de estudios de detección y atribución

Una conclusión que es común a diferentes estudios realizados en los últimos 15 años mediante el análisis de datos o las simulaciones con CGCMs es que los factores naturales no explican por sí solos gran parte del calentamiento observado. Para explicar el calentamiento se necesita una influencia antrópica sustancial, en forma de emisiones de gases invernadero y cambios en el uso de la tierra. Sin embargo, la mayor parte de los estudios existentes no logran atribuir con confianza tendencias en los patrones regionales de precipitación, especialmente en las regiones monzónicas. En este sentido, poco o nada se ha publicado hasta el momento acerca de la atribución de cambios específicos en la precipitación regional al cambio climático u otros mecanismos posibles.

Downscaling climático regional para evaluaciones integradas del cambio climático

La comunidad de impactos y adaptación se está volcando cada vez más a las evaluaciones integradas, en las que las proyecciones de cambio climático constituyen un factor importante de los sistemas de apoyo a las decisiones dirigidos a reducir la vulnerabilidad y establecer las bases metodológicas para estudios de adaptación en el futuro. Actualmente, las proyecciones regionales constituyen quizá el eslabón más débil de este proceso y la mayor parte de la información al alcance del sector de políticas y de manejo de recursos proviene en gran medida de CGCMs. Recientemente se implementó la iniciativa CREAS (Escenarios de cambios climáticos regionales para América del Sur) (Marengo et al., 2008) que tiene por objeto brindar escenarios de cambio climático de alta resolución para crear conciencia entre los gobiernos y los responsables de políticas en la evaluación de los impactos del cambio climático, la vulnerabilidad y en el diseño de medidas de adaptación para diferentes sectores. A la fecha, gran parte del trabajo se encuentra en la fase de desarrollo metodológico. Los escenarios de cambios climáticos regionales para estudios de impacto y adaptación deben examinarse minuciosamente en las regiones de VAMOS.

El uso de modelos climáticos regionales y escenarios de cambio climático reducidos en escala de CMIP3 en países en desarrollo se ha expandido gracias a los modelos portátiles como el modelo del Centro Internacional de Física Teórica -Red de Investigaciones Climáticas Regionales (ITCP-RegCM), los escenarios de PRECIS-CARIBE (http://precis.insmet.cu/Precis-Caribe.htm), las proyecciones climáticas por downscaling estadístico CMIP3 para Estados Unidos y norte de México (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections), y las proyecciones de cambio climático por downscaling dinámico de CREAS para América del Sur (http://www.cptec.inpe.br/mudancas_climaticas).

Comentarios finales

Es fundamental que la comunidad de VAMOS desarrolle una métrica común orientada a procesos en distintas escalas temporales para examinar las habilidades y las incertidumbres de los CGCMs en las regiones monzónicas de las Américas. Es necesario comprender la cascada de incertidumbres en los campos de los CGCM ya que éstas serán transmitidas a las herramientas de regionalización y a las evaluaciones de cambio climático. Es necesario contar con observaciones con alcance y detalle suficiente para mejorar la validación, los modelos y los ensambles de modelos y garantizar que los procesos relacionados con los monzones puedan dilucidarse, predecirse y proyectarse adecuadamente. Es decir que se requiere crear o

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mejorar las bases de datos regionales que incluyan observaciones, simulaciones de modelos, y simulaciones de downscaling regional en escalas diarias y mensuales, para realizar estudios de evaluación de impactos.

Modeling issues: an update after 11th panel meeting

The Variability of the American Monsoon Systems (VAMOS) modeling implementation is based on an integrated modeling, data analysis and assimilation strategy, which will facilitate the project meet its overarching goal. The strategy selected takes advantage of VAMOS enhanced observations, and is designed to simultaneously provide model-based guidance to the evolving multi-tiered VAMOS observing programme. The modeling implementation plan also makes significant contributions to the World Climate Research Program strategic framework relevant activities conducted within Climate Variability and Predictability (CLIVAR), in particular with respect to assessing and improving seasonal forecasts and model simulations.

The model challenges in VAMOS are several and of the first order. The region itself represents a unique challenge for climate modeling and data assimilation, since it is marked by complex terrain and characterized by a wide range of phenomena including: a strong diurnal cycle and associated land-sea breezes, low level moisture surges, low level jets, tropical easterly waves, intense monsoonal circulations, intraseasonal variability, and continental-scale variations that link the different components of the monsoon. These challenges become evident in seasonal prediction assessments, as documented by Saunier (2007) using DEMETER multi-model seasonal hindcasts (Palmer et al., 2004). For example, Figure 1 shows large model biases in precipitation, affecting critical areas in the Pan-VAMOS domain.

Land surface processes play important roles in Pan-American climate variability. Vegetation in semi-arid regions, which shows pronounced seasonal and interannual variability, acts as an atmospheric boundary condition that affects momentum transfer, radiation, heat and moisture fluxes. The Amazon region acts as a source of humidity for the South American Monsoon system (SAMS), through the large amount of evapotranspiration. Deforestation in the region can affect the energy balance and the atmospheric circulation over South America (e.g., Nobre et al., 1991; Robertson et al., 2003), and,

Cuestiones de modelado: una actualización luego de la 11a reunión del panel

La actividad de modelado de la Variabilidad de los Sistemas Monzónicos Americanos (VAMOS) se apoya en una estrategia integrada de modelado, análisis y asimilación de datos, que contribuirá a que el proyecto alcance su objetivo principal. La estrategia elegida aprovecha las observaciones intensivas de VAMOS y está diseñada para brindar al mismo tiempo una orientación apoyada en los modelos para la evolución de este programa de múltiples niveles de observación de VAMOS. El plan de implementación de modelado también hace importantes aportes a las actividades relacionadas con el marco estratégico del Programa Mundial de Investigaciones Climáticas que lleva adelante el Programa de Variabilidad y Predictabilidad del Clima (CLIVAR), especialmente respecto de la evaluación y la mejora de los pronósticos y las simulaciones estacionales.

Los desafíos de modelado de VAMOS son varios y de primer orden. La región en sí misma representa un desafío único para el modelado del clima y la asimilación de datos, ya que está marcada por un terreno complejo y caracterizada por una amplia gama de fenómenos entre los que se cuentan una fuerte ciclo diurno y las brisas tierra-mar asociadas, irrupciones de humedad en niveles bajos, las corrientes en chorro de capas bajas, ondas tropicales del este, circulación monzónica intensa, variabilidad intraestacional y variaciones de escala continental que conectan los diferentes componentes del monzón. Estos desafíos se vuelven evidentes en las evaluaciones de los pronósticos estacionales, según documentó Saunier (2007) utilizando los hindcasts estacionales del sistema multi-modelo DEMETER (Palmer et al., 2004). Por ejemplo, la Fig. 1 muestra grandes sesgos en la precipitación modelada, que afectan áreas críticas del dominio Pan-VAMOS.

Los procesos en la superficie continental tienen un papel importante en la variabilidad del clima panamericano. La vegetación de las zonas semiáridas, que exhibe una pronunciada variabilidad estacional e interanual, actúa como condición de contorno de la atmósfera afectando la transferencia de impulso, la radiación y los flujos de calor y humedad. Por su gran evapotranspiración la región amazónica actúa como una

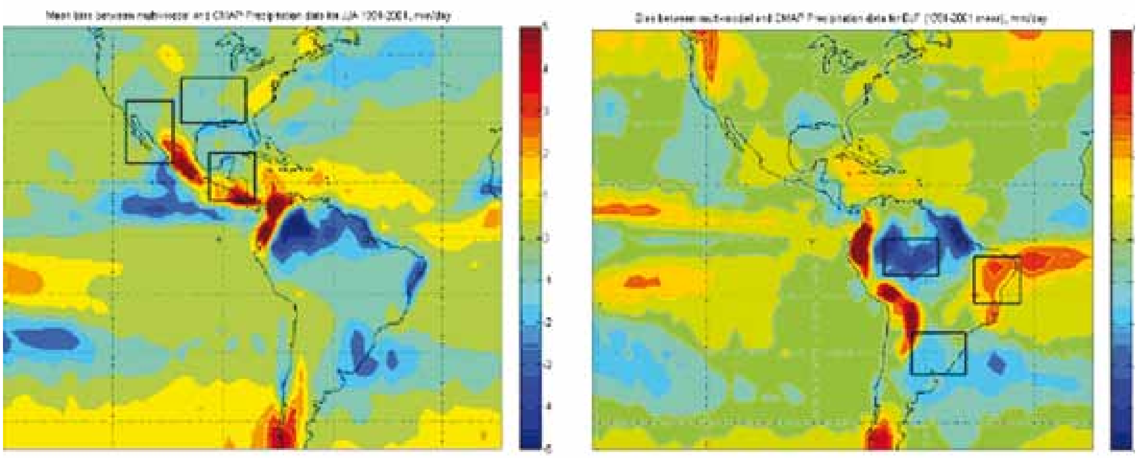

Figure 1: Mean daily precipitation bias in mm/day (DEMETER multi-model hindcasts with respect to CMAP precipitation data): a) For JJA 1991-2001 (hindcasts started on May of each year); b) for DJF 1991/1992 -2001/2002 (hindcasts started on November of each year). From Saunier 2007. // Figura 1: Sesgo en la precipitación media diaria en mm/día (hindcasts del multi-modelo DEMETER respecto de los datos de precipitación de CMAP): a) para los JJA de 1991-2001 (hindcasts iniciados en mayo de cada año); b) para DEF de 1991/1992 -2001/2002 (hindcasts iniciados en noviembre de cada año). De Saunier 2007.

perhaps have a remote influence on the evolution of ENSO (e.g., Hu et al., 2004).

Recent studies, focusing on increased predictability through land-atmosphere interactions (e.g., Dirmeyer et al., 2008) locate several regions in the Americas that exhibit a considerable degree of coupling, as measured through soil moisture memory. Particularly for the North American Great Plains and for portions of the southern La Plata Basin, these areas show up all year round.

In addition to the surface conditions on sea-surface temperature (SST) and soil moisture, atmospheric aerosols can have a significant influence on the climate of the Americas. Aerosols are an important atmospheric constituent in southwestern North America and Central South America. When the synoptic circulation is weak, anthropogenic sources from urban areas can significantly attenuate and reflect shortwave radiation. Dust is an important factor in the spring and early summer, when green vegetation is sparse, soils are dry and surface winds are strong. In South America, biomass burning, mainly in the central regions, is the main source of aerosols for the atmosphere.

Aerosols are also important in the oceanic regions whose variability is linked to the American Monsoon systems region. In the southeastern Pacific where the VAMOS Ocean-Cloud- Atmosphere-Land Study (VOCALS) component of VAMOS is focused, the geographical diversity in the distribution of atmospheric aerosol and its potential impacts on stratocumulus cloud and radiation results in feedbacks between aerosols and boundary layer cloud evolution. Near the equator, humid lower-tropospheric easterly flow overlies the cloud-topped boundary layer, likely affecting its radiation balance, turbulence and microphysics. South of 15°S, the air above the boundary layer tends to be very dry and clean, having mainly come from the southwest out of storm systems in mid-latitudes and the South Pacific Convergence Zone. The exception is near the South American coast, where along-shore winds allow both industrial and biogenic aerosols to accumulate both within and above the boundary layer.

In regard to prediction, the variability of the American Monsoon Systems exhibits large-scale coherence with several known phenomena that have important impacts on diurnal to intraseasonal, interannual and even decadal time scales. Hence there are building blocks that serve as the foundation for climate forecasting. The El Niño-Southern Oscillation (ENSO) phenomenon is the best understood of these phenomena, but previous research on the Pan-American monsoon has also identified several others, including the Madden-Julian Oscillation (MJO), the Pacific Decadal Oscillation (PDO) and the Tropical Atlantic SSTs. The relative influences of these phenomena on the warm season precipitation regime over the region are not well understood. Conversely, the large scale convective maximum associated with the monsoon affects circulation elsewhere, and understanding and predicting these effects remains a daunting challenge. The Pacific North America (PNA) and the Pacific South America (PSA) patterns can link

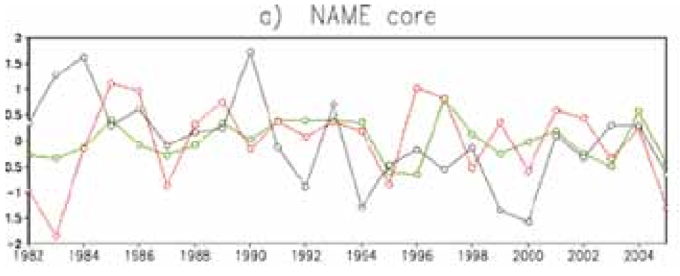

Figure 2: Interannual precipitation variability from Climate Prediction Center gridded data (black), CFS ensemble (red) and RSM ensemble (green) after Mo (2008). // Figura 2: Variabilidad interanual de la precipitación de datos de grilla del Centro de Predicción del Clima (negro), ensamble CFS (rojo) y ensamble RSM (verde), según Mo (2008)

fuente de humedad para el sistema monzónico sudamericano (SAMS). La deforestación en la región puede afectar el balance de energía y la circulación atmosférica en América del Sur (ej., Nobre et al., 1991; Robertson et al., 2003) y quizás tener una influencia remota en la evolución del ENSO (ej., Hu et al., 2004).

Estudios recientes centrados en mejorar la predictabilidad a través de las interacciones tierra-atmósfera (ej., Dirmeyer et al., 2008) identifican varias regiones en las Américas que muestran un nivel considerable de acoplamiento, según mediciones del "efecto memoria" de la humedad en el suelo. En particular, estas áreas aparecen durante todo el año en las Grandes Planicies norteamericanas y partes de la cuenca del Río de la Plata en el sur.

Además de afectar las condiciones de superficie de la temperatura de la superficie del mar (SST) y la humedad del suelo, los aerosoles atmosféricos pueden tener una influencia significativa en el clima de las Américas. Los aerosoles son un componente importante de la atmósfera en el sudoeste de América del Norte y en el centro de América del Sur. Cuando la circulación sinóptica es débil, las fuentes antrópicas de áreas urbanas pueden atenuar significativamente la radiación de onda corta y reflejarla. El polvo es un factor importante en primavera y comienzos del verano, cuando la vegetación verde es escasa, los suelos están secos y los vientos son fuertes. En América del Sur, la quema de biomasa, principalmente en las regiones centrales es la fuente principal de aerosoles en la atmósfera.

Los aerosoles también son importantes en las regiones oceánicas cuya variabilidad está conectada con la región de los sistemas monzónicos americanos. En el Pacífico sudoriental sobre la que se concentra el componente de VAMOS llamado Estudio del Océano-Nubes-Atmósfera-Tierra de VAMOS (VOCALS, por sus siglas en inglés), la diversidad geográfica en la distribución de los aerosoles atmosféricos y sus potenciales impactos en los estratocúmulos y la radiación resulta en retroacciones entre los aerosoles y la evolución de las nubes en la capa límite. Cerca del ecuador, el flujo húmedo del este de la tropósfera baja está encima de la capa límite coronada por nubes, lo que probablemente afecta su balance de radiación, turbulencia y microfísica. Al sur de 15°S, el aire por encima de la capa límite tiende a ser muy seco y limpio, proveniente desde el sudoeste, principalmente de sistemas de tormentas de latitudes medias y de la Zona de Convergencia del Pacífico Sur. La excepción es la zona cercana a la costa sudamericana, donde los vientos paralelos a la costa permiten que los aerosoles industriales y biogénicos se acumulen tanto dentro como por encima de la capa límite.

En cuanto a los pronósticos, la variabilidad de los sistemas monzónicos americanos muestra una coherencia de gran escala con varios fenómenos conocidos que tienen importantes impactos en escalas que van desde la diurna a la intraestacional, interanual e incluso decenal. He ahí los bloques que sirven de fundamento para el pronóstico del clima. El fenómeno del El Niño-Oscilación Sur (ENSO) es el más comprendido de estos fenómenos, pero estudios anteriores del monzón panamericano identificaron también varios otros como la Oscilación de Madden-Julian (MJO), la Oscilación Decenal del Pacífico (PDO) y las SSTs del Atlántico Tropical. La influencia relativa de estos fenómenos sobre el régimen de precipitación de la época cálida en la región no es muy conocida. Por el contrario, el máximo de convección de gran escala asociado al monzón afecta la circulación en otras áreas, y la comprensión y pronóstico de estos efectos continúa siendo un desafío sobrecogedor. Los patrones Pacífico- América del Norte (PNA) y Pacífico- América del Sur (PSA) pueden vincular la convección del Pacífico tropical con las anomalías en América del Norte y América del Sur, respectivamente. Nuestra capacidad para simular estas interacciones de escala global es una parte integral del éxito en los pronósticos estacionales en las Américas.

Partiendo de escalas menores de variabilidad, la simulación precisa del ciclo diurno de la precipitación continúa tropical Pacific convection to anomalies over North America and South America, respectively. Our ability to simulate these global scale interactions is integral to successful seasonal predictions over the Americas.

Starting from the shorter scales of variability, accurately simulating the diurnal cycle of precipitation remains a daunting challenge. Models tend to produce excessive rainfall in the afternoon and to underestimate the nocturnal precipitation maxima, as documented in Falvey and Garreaud (2008).

Focusing on seasonal time scale Schemm (2008) emphasized three regions of interest for both the Northern Annular Mode (NAM) and the Southern Annular Mode (SAM). After analyzing several experiments at different horizontal resolutions (T62, T126 and T382) and different forecast lead-times (1 and 3-month lead) the author concludes that the NAM core region is a good example of increased accuracy with increasing model resolution and with shorter lead-times. During the SAM, however significant differences were not found between runs with 1 and 3 month lead forecasts, and in both cases the author found a double peak in precipitation over Northern Brazil that does not agree with observations.

With regard to longer time scales, Mo (2008) argued that both a regional climate model (the Regional Spectral Model –RSM) and the global forcing model (Climate Forecast System; CFS), have marginal skill in reproducing the interannual JJAS precipitation variability, as seen in Figure 2.

Prospects for improving these predictions on seasonal-to-interannual time scales hinge on the inherent predictability of the system, our ability to tap into this potential predictability and our ability to quantify the initial states and forecast the evolution of the surface forcing variables (e.g. SST and land state including soil moisture). In addition to understanding the role of remote SST forcing throughout the Pacific and Atlantic Oceans, we must understand the nature and role of nearby SST anomalies such as those that form in the Gulf of California, the Gulf of Mexico, the Intra American Sea, the south eastern Pacific, tropical Atlantic and the South Atlantic, just to name a few. The land surface has many memory mechanisms in addition to soil moisture, especially over the western US and in the lee of the southern Andes. Snow extends surface moisture memory across winter and spring.

The VAMOS modeling plan recognizes three distinct, but related roles that observations play in model development and assessment. These are (1) to guide model development by providing constraints on model simulations at the process level (e.g. convection, land/atmosphere and ocean/atmosphere interactions); (2) to help assess the veracity of model simulations of the various key Pan-American phenomena (e.g. low level jets, land/sea breezes, tropical storms), and the linkages to regional and larger-scale climate variability; and (3) to provide initial and boundary conditions, and verification data for model predictions. (Note: Research plans related to improving the basic diagnostic understanding of VAMOS programs are contained within their respective program science plans).

One of the underlying premises of VAMOS modeling is that while many of these processes are, indeed, local to the specific region of interest, there are particular problems and questions relevant throughout the Pan-American region. For example, the interactions with the surface provide, among other things, organization and memory to atmospheric convection so that the problems of modeling land/atmosphere and ocean/atmosphere interactions are intertwined with the deep convection problem. The relatively poor simulation of the diurnal cycle, some aspects of the low level jets, planetary boundary layer processes, clouds and ocean mixing are all Pan-American monsoon problems that necessarily require a regional multi-scale focus but also are critical issues for improving global model simulations and predictions. Improvements on these “process-level” issues will require both fundamental

siendo un desafío extraordinario. Los modelos tienden a producir un exceso de precipitación en la tarde y a subestimar los máximos de precipitación nocturna, según documentaron Falvey y Garreaud (2008).

Concentrándose en la escala estacional, Schemm (2008) señaló tres regiones de interés para el Modo Anular del Norte (NAM) y el Modo Anular del Sur (SAM). Luego de analizar varios experimentos con distinta resolución horizontal (T62, T126 y T382) y diferentes tiempos de pronóstico (1 y 3 meses) el autor concluye que la región central del NAM constituye un buen ejemplo del aumento de la precisión proporcionado por el aumento de la resolución del modelo y tiempos de pronóstico más breves. Sin embargo, durante el SAM, no se encontraron diferencias significativas entre las corridas de pronósticos a 1 y 3 meses, y en ambos casos el autor halló un doble máximo de precipitación en el norte de Brasil que no se corresponde con las observaciones.

Respecto de escalas mayores, Mo (2008) sostuvo que tanto el modelo climático regional (el Modelo Regional Espectral – RSM) como el modelo forzante global (Sistema de Pronóstico del Clima; CFS), tienen una habilidad marginal para reproducir la variabilidad interanual de precipitación de JJAS, como se ve en la Figura 2.

Las perspectivas de mejorar estos pronósticos en las escalas estacionales a interanuales depende de la predictabilidad inherente del sistema, de nuestra capacidad de captar esta predictabilidad potencial y nuestra habilidad de cuantificar los estados iniciales y pronosticar la evolución de las variables forzantes de superficie (ej., la SST y el estado de la tierra incluyendo la humedad del suelo). Además de entender el papel del forzante remoto de la SST a través del Pacífico y el Atlántico, debemos comprender la naturaleza y el papel de las anomalías de SST cercanas como las que se forman en el Golfo de California, el Golfo de México, el Mar Intraamericano, el Pacífico Sudoriental, el Atlántico tropical y el Atlántico Sur, por nombrar algunas. La superficie continental tiene muchos mecanismos de memoria además de la humedad del suelo, particularmente sobre el oeste de Estados Unidos y a sotavento de los Andes australes. La nieve amplía la memoria de cantidad de humedad en superficie a través del invierno y la primavera.

El plan de modelado de VAMOS reconoce tres funciones diferentes pero relacionadas de las observaciones en el desarrollo y evaluación de los modelos. Estas son (1) orientar el desarrollo de modelos mostrando las limitaciones de las simulaciones de los modelos en el nivel de procesos (ej. convección, interacciones tierra/atmósfera y océano/atmósfera); (2) ayudar a evaluar la veracidad de las simulaciones de distintos fenómenos panamericanos clave (ej. corrientes en chorro en capas bajas, brisas tierra/mar, tormentas tropicales), y las conexiones con la variabilidad climática regional y de mayor escala; y (3) brindar las condiciones de contorno iniciales y los datos de verificación para los modelos de predicción. (Nota: Los planes de investigación relacionados con la mejora de los conocimientos de diagnóstico básicos de los programas de VAMOS están incluidos en sus respectivos planes científicos).

Una de las premisas subyacentes de las actividades de modelado de VAMOS es que mientras muchos de estos procesos son efectivamente locales a la región específica de interés, existen problemas particulares e interrogantes pertinentes a toda la región panamericana. Por ejemplo, las interacciones con la superficie proveen, entre otras cosas, organización y memoria a la convección atmosférica de manera que los problemas del modelado de las interacciones tierra/atmósfera y océano/atmósfera están entrelazados con el problema de la convección profunda. La relativamente pobre simulación del ciclo diurno, algunos aspectos de las corrientes en chorro de capas bajas, los procesos de la capa límite planetaria, las nubes y la mezcla en el océano son problemas de los monzones panamericanos que necesariamente requieren un enfoque regional en múltiples escalas pero que a la vez constituyen cuestiones críticas para mejorar las simulaciones y pronósticos de los modelos globa-

improvements to the physical parameterizations, and improvements as to how we model the interactions between the local processes and regional and larger scale variability in regional and global models.

Development efforts are envisioned that simultaneously tackle these issues from both a "bottom-up" and a "top-down" approach. In the former, process-level modeling is advanced and scaled-up to address parameterization issues in regional and global modeling, while in the latter, regional and global models are scaled-down to address issues of resolution and the breakdown of assumptions that are the underpinnings of the physical parameterizations. The modeling issues/problems described below require a multi-scale or multi-tiered approach with an emphasis on how the various space and time scales interact and are represented in the global and regional models.

To achieve its objectives, VAMOS has adopted a multi-scale approach, which includes monitoring, diagnostic and modeling activities on local, regional, and continental scales. In this multi-scale approach, local processes are embedded in, and are fully coupled with, larger-scale dynamics.

The modeling strategy is organized into four science themes: (A) simulating, understanding and predicting the diurnal cycle, (B) predicting and describing the Pan-American monsoon onset, maturation and demise stages, (C) modeling and predicting SST variability in the Pan-American Seas, and (D) improving the prediction of droughts and floods. It is clear that all four of these science themes are interdependent; indeed, some of the scientific questions such as issues related to scale interactions transcend all four themes. Nevertheless, this organizational structure provides the focus required to tackle the most important modeling issues. Over time these themes will need to be revisited and modified according to improvements in modeling and understanding. The principal cross-cuts among these themes include improving prediction made with global models, multi-scale interactions, data assimilation, and analysis and model improvements. Each science theme includes a comprehensive assessment of how well the models simulate and predict the relevant phenomena on multiple space and time scales. This assessment necessarily requires the identification of indices and metrics for model evaluations and prediction verification. The assessment also involves collaboration within CLIVAR (e.g., Working Group on Seasonal to Interannual Prediction (WGSIP), Working Group on Coupled Modelling (WGCM) and with operational forecast providers (National Centers for Environmental Prediction, International Research Institute for Climate and Society, Centro de Previsão de Tempo e Estudos Climáticos, European Centre for Medium-Range Weather Forecasts) in terms of access to coupled prediction and simulation data. In particular, within WGSIP there is a Climate-system Historical Forecast Project (CHFP) which is a multi-model and multi-institutional experimental framework for sub-seasonal to decadal physical climate system prediction. Given the strong interest that VAMOS community has on these issues, there will be a mirror site of the CHFP at CIMA (Centro de Investigaciones del Mar y la Atmósfera - http://chfp.cima.fcen.uba.ar/index.html), that will aid in strengthening collaboration between model providers and model users at regional level.

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Hu, Z., E.K. Schneider, U.S. Bhatt, and B.P. Kirtman, 2004: Potential mechanism for response of El Niño-Southern

les. Las mejoras en estas cuestiones en el "nivel de proceso" requerirán mejoras fundamentales en las parametrizaciones físicas y en la forma en que simulamos las interacciones entre los procesos locales con la variabilidad regional y de mayor escala en los modelos regionales y globales.

Se planean esfuerzos de desarrollo que aborden simultáneamente estas cuestiones con enfoques "bottom-up" y "top-down". En el primero, se hacen avances en el modelado en el nivel de proceso y se aumenta su escala para abordar cuestiones de parametrización en el modelado regional y global, mientras que en el segundo, se disminuye la escala de los modelos regionales y globales para tratar cuestiones de resolución y la descomposición de los supuestos que son las bases de las parametrizaciones físicas. Las cuestiones/problemas del modelado que se describen a continuación requieren de un enfoque en múltiples escalas y etapas con énfasis en cómo interactúan las diferentes escalas espaciales y temporales y cómo están representadas en los modelos regionales y globales.

Para lograr sus objetivos, VAMOS adoptó un enfoque multi-escala, que incluye actividades de monitoreo, diagnóstico y modelado en escalas locales, regionales y continentales. En este enfoque de múltiples escalas, los procesos locales están inmersos en una dinámica de mayor escala y acoplados a ella.

La estrategia de modelado se organiza alrededor de cuatro temas científicos: (A) simulación, comprensión y predicción del ciclo diurno, (B) predicción y descripción de las etapas de inicio, maduración y fin del monzón panamericano, (C) modelado y pronóstico de la variabilidad de la SST en los mares panamericanos y (D) mejora en el pronóstico de las sequías y las inundaciones. Está claro que estos cuatro temas científicos son interdependientes; en efecto, algunos de los interrogantes científicos como las cuestiones relacionadas con las interacciones entre escalas trascienden los cuatro temas. No obstante, esta estructura organizativa provee el foco necesario para abordar los problemas más importantes de modelado. Estos temas deberán ser revisados con el paso del tiempo y modificados de acuerdo con los avances que se logren en el modelado y la comprensión. Los principales ejes transversales entre estos temas incluyen mejorar los pronósticos de los modelos globales, las interacciones multi-escala, la asimilación de datos y los análisis y modelos. Cada tema científico incluye una evaluación exhaustiva de cuán bien los modelos simulan y pronostican los fenómenos pertinentes en múltiples escalas espaciales y temporales. Esta evaluación requiere necesariamente la identificación de índices y métricas de las evaluaciones de los modelos y la verificación de los pronósticos. La evaluación también incluye la cooperación dentro de CLIVAR (ej., Grupo de Trabajo sobre Pronósticos Estacionales a Interanuales (WGSIP), Grupo de Trabajo sobre Modelado Acoplado (WGCM) y con proveedores de pronósticos operativos (Centros Nacionales de Pronósticos Ambientales -NCEP, Instituto de Investigación Internacional para el Clima y la Sociedad -IRI, Centro de Pronóstico del Tiempo y Estudios Climáticos -CPTEC, Centro Europeo de Pronóstico del Tiempo a Mediano Plazo -ECMWF) en términos de acceso a datos acoplados de pronóstico y simulación. En particular, dentro de WGSIP está el Proyecto de Pronóstico Histórico del Sistema Climático (CHFP) que es un marco experimental de múltiples modelos e instituciones para el pronóstico del sistema físico del clima en escalas desde sub-estacional hasta la decenal. Dado el gran interés que tiene en estos temas la comunidad de VAMOS, habrá un portal espejo del CHFP en el CIMA (Centro de Investigaciones del Mar y la Atmósfera - http://chfp.cima.fcen.uba.ar/index.html), que contribuirá a fortalecer la cooperación entre los proveedores y los usuarios de los modelos en el nivel regional.

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Cross-hemispheric interactions between variability of the American monsoon systems regions

Two large tropical heating centers, Amazonia and the Western Hemisphere warm pool (WHWP) (Wang and Enfield, 2001), dominate the summer climates from the pampas of northern Argentina to the south-central United States, and from Meso-America to West Africa. Monsoons within these regions wax and wane, with the heating centers in a seasonal see-saw between the northern and southern hemispheres. In Climate Variability and Predictability - Variability of the American Monsoon Systems (CLIVAR-VAMOS) we have become accustomed to focus on one or other region or season through a series of targeted observational campaigns designed to enhance our understanding and improve our predictive capabilities. These observational programs include, but are not limited to: EPIC (Eastern Pacific Investigation of Climate processes); SALLJEX (South American Low-Level Jet Experiment); NAME (North American Monsoon Experiment); MESA (Monsoon Experiment - South America); VOCALS (VAMOS Ocean-Clouds-Atmosphere-Land Studies); and the most recently started IASCLIP (Intra-Americas Study of Climate Processes). Each of these programs has focused on a single monsoon system and season or, as in the case of NAME and IASCLIP, a part of a monsoon system. Because of the need to focus research effort, and due to their orthogonality in time, each of these experiments has had to ignore the other, even though our conventional wisdom tells us that neighboring regions interact. Thus, for example, the EPIC region receives moisture from the Atlantic (IASCLIP), and the MESA region is connected to the southeast Pacific (VOCALS) through trans-Andean circulation modes. Least studied of all interactions, however, are the connections between the hemispheres. In this article, we wish to highlight a few examples of these cross-hemispheric interactions.

Example 1: Warm pool to Southeast Pacific

In an observational study of the Atlantic warm pool (AWP) and its connections with climate anomalies, Wang et al., (2006) pointed to a significant region in the Southeast (SE) Pacific where rain signals associated with warm pool anomalies are detected after the direct influence of El Niño-Southern Oscillation (ENSO) is removed (Fig. 1a). This is part of a larger region where subsidence over the SE Pacific subtropical high pressure system is influenced by the strength of the regional Hadley circulation which is, in turn, energized by diabatic heating over the WHWP in boreal summer (Fig. 1b). The rain signal is detected in satellite data and is most likely due to drizzle under the stratocumulus cloud deck (e.g., Wang et al., 2004). When the AWP is large (tropical North Atlantic warm), the boreal summer Hadley cell is energized, subsidence increases off South America, and the drizzle west of Peru tends

Interacciones interhemisféricas entre regiones de variabilidad de los sistemas monzónicos americanos

Dos grandes centros cálidos tropicales, Amazonia y la piscina cálida del hemisferio occidental (WHWP, por sus siglas en inglés) (Wang y Enfield, 2001), dominan los climas estivales desde la región pampeana en el norte de Argentina hasta el centro sur de Estados Unidos, y desde Centroamérica hasta África Occidental. Los monzones en estas regiones se fortalecen y debilitan, con los centros cálidos en una oscilación estacional entre los hemisferios norte y sur. En el Programa sobre Variabilidad y Predictabilidad del Clima - Variabilidad de los Sistemas Monzónicos Americanos (CLIVAR-VAMOS) nos hemos acostumbrado a concentrarnos en una región o estación dada mediante campañas de observación estructuradas para mejorar nuestros conocimientos y capacidad de pronóstico. Entre estos programas de observación se cuentan (aunque no son los únicos): EPIC (Investigación de los Procesos Climáticos en el Pacífico Oriental); SALLJEX (Experimento de la Corriente en Chorro en Capas Bajas de Sudamérica); NAME (Experimento del Monzón de Norteamérica); MESA (Experimento del Monzón de Sudamérica); VOCALS (Estudios de VAMOS sobre Océano-Nubes-Atmósfera-Tierra); y el más reciente IASCLIP (Estudio Intra-americano de los Procesos Climáticos). Cada uno de estos programas se concentró en un sistema monzónico y en una estación en particular o, como en el caso de NAME e IASCLIP, en una parte de un sistema monzónico. Debido a la necesidad de concentrar los esfuerzos de investigación, y por causa de su ortogonalidad en el tiempo, cada uno de estos experimentos tuvo que ignorar a los otros, aun cuando nuestra opinión clásica sugiere que las regiones vecinas interactúan entre sí. Así, por ejemplo, la región de EPIC recibe humedad del Atlántico (IASCLIP), y la región de MESA está conectada con el Pacífico sudoriental (VOCALS) a través de modos de circulación transandina. Las menos estudiadas de todas las interacciones, sin embargo, son las conexiones entre los hemisferios. En este artículo, queremos destacar algunos ejemplos de interacciones interhemisféricas.

Ejemplo 1: Piscina cálida hacia el Pacífico Sudoriental

En un estudio de observación de la piscina cálida del Atlántico (AWP, por sus siglas en inglés) y sus conexiones con las anomalías climáticas, Wang et al., (2006) indicaron una importante región del Pacífico Sudoriental (SE) donde se detectan señales de precipitación asociadas con las anomalías de las piscinas cálidas luego de removida la influencia directa de El Niño-Oscilación Sur (ENSO) (Fig. 1a). Esta es parte de una región más amplia donde la subsidencia sobre el sistema de alta presión subtropical del Pacífico SE se ve afectada por la fuerza de una circulación regional de Hadley, que a su vez, es activada por calentamiento diabático sobre el WHWP en el

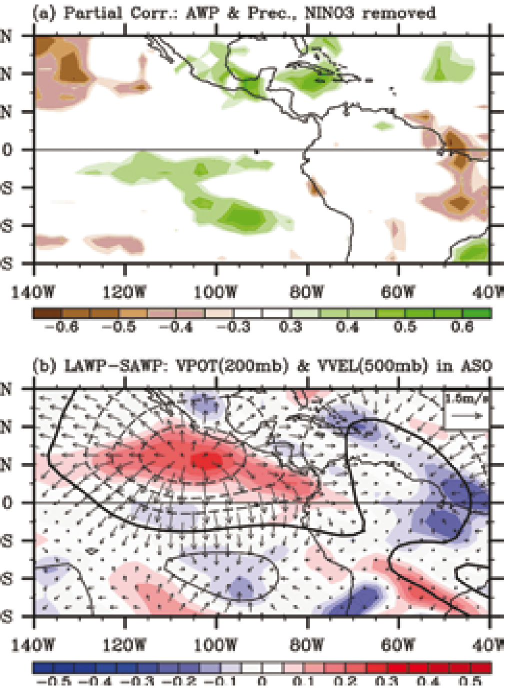

Figure 1. (a) Partial correlation of August-October rainfall anomalies with contemporaneous anomalies in the size of the Atlantic warm pool (AWP), with the influence of SSTA in the NINO-3 region removed (from Wang et al., 2006). (b) Composite average anomalies (upper minus lower quartiles of AWP size) of velocity potential (contours, 106 m2/sec, interval 5•106 m^2/sec), irrotational wind (vectors, inset reference arrow) and 500 hPa vertical velocity (red is upward, 10-1 Pa/sec) during August-October // Figura 1. (a) Correlación parcial de anomalías de precipitación de agosto-octubre con anomalías contemporáneas del tamaño de la poza cálida del Atlántico (AWP), luego de removida la influencia de la SSTA en la región NIÑO-3 (de Wang et al., 2006). (b) Composición de anomalías promedio (cuartiles superiores menos inferiores del tamaño de la AWP) del potencial de velocidad (isolíneas, 106 m2/sec, intervalo 5•106 m^2/sec), componente irrotacional del viento (vectores, vector de referencia en el recuadro) y velocidad vertical en 500 hPa (rojo indica hacia arriba, 10-1 Pa/sec) durante agosto-octubre.

to increase. The drizzle response is presumably unimportant as a climate impact in a region where nobody lives; but it is a "mine canary" for detecting subsidence anomalies over the larger SE Pacific region that can affect processes within the marine boundary layer, and thus influence the stratocumulus cloud cover and sea-surface temperature (SST) tendency. The possible cloud cover response, and its relevance to known biases in global coupled Global Climate Models (GCMs), lies at the heart of the rationale for VOCALS, and points to obvious connections with the IASCLIP program.

Example 2: Amazonia to the Tropical/Subtropical North Atlantic

Many studies have pointed out the connection between the Pacific's ENSO and SST anomalies in the tropical North Atlantic, thought to be due primarily to anomalous fluctuations in the northeast (NE) trades and their effects on evaporative heat loss from the ocean mixed layer (e.g., Enfield and Mayer 1997). One of the mechanisms proposed for this connection is the effect of ENSO on the strength of the diabatic heating over northern South America (Mestas-Nuñez and Enfield 2001; Wang 2002; Enfield et al., 2006). This is seen as a reduction in the velocity potential anomaly at 200 hPa over northern South America, and reduced upward motion at 500 hPa over the normal diabatic heating region (Fig. 2a). This is one aspect of ENSO's disruption of the Walker Circulation. At the peak of El Niño in the Pacific, the resulting weakening of the regional Hadley circulation toward the North Atlantic in boreal winter-spring then brings reduced subsidence over the North Atlantic subtropical high, a weakening of the NE trades and reduced evaporative heat loss over the tropical North Atlantic (TNA). The anomalous warming that results during spring brings about a

verano boreal (Fig. 1b). La señal de precipitación se detecta en los datos satelitales y lo más probable es que se deba a una llovizna debajo de la zona de estratocúmulos (por ejemplo, Wang et al., 2004). Cuando la AWP es grande (Atlántico Norte tropical cálido), la célula de Hadley del verano boreal se ve fortalecida, la subsidencia aumenta alejándose de Sudamérica, y la llovizna al oeste de Perú tiende a incrementarse. El impacto climático de esta respuesta en forma de llovizna en una región deshabitada supuestamente no es de importancia; pero constituye un "canario de minero" para detectar anomalías de subsidencia en la más amplia región del Pacífico sudoriental que pueden afectar los procesos en la capa límite marina, y así afectar la cubierta de estratocúmulos y la tendencia en la temperatura de la superficie del mar (SST). La posible respuesta de la cubierta de nubes y su relación con los sesgos conocidos en los modelos climáticos globales acoplados (GCMs), radica en el núcleo de los fundamentos de VOCALS, y señala conexiones obvias con el programa IASCLIP.

Ejemplo 2: Amazonia hacia el Atlántico Norte Tropical/ Subtropical

Muchos estudios mostraron la conexión entre el ENSO del Pacífico y las anomalías de la SST en el Atlántico Norte tropical, que se creía eran debidas principalmente a fluctuaciones anómalas en los alisios del noreste (NE) y sus efectos en la pérdida de calor por evaporación de la capa de mezcla del océano (por ejemplo, Enfield y Mayer 1997). Uno de los mecanismos propuestos para este vínculo es el efecto del ENSO en la intensidad del calentamiento diabático en el norte de Sudamérica (Mestas-Nuñez y Enfield 2001; Wang 2002; Enfield et al., 2006). Este se ve como una reducción en la anomalía del potencial de velocidad en 200 hPa sobre el norte de Sudamérica, y una reducción en el movimiento ascendente en 500 hPa sobre la región de calentamiento diabático normal (Fig. 2a). Este es un aspecto de la alteración que produce el ENSO en la circulación de Walker. Durante el máximo de El Niño en el Pacífico, el debi-

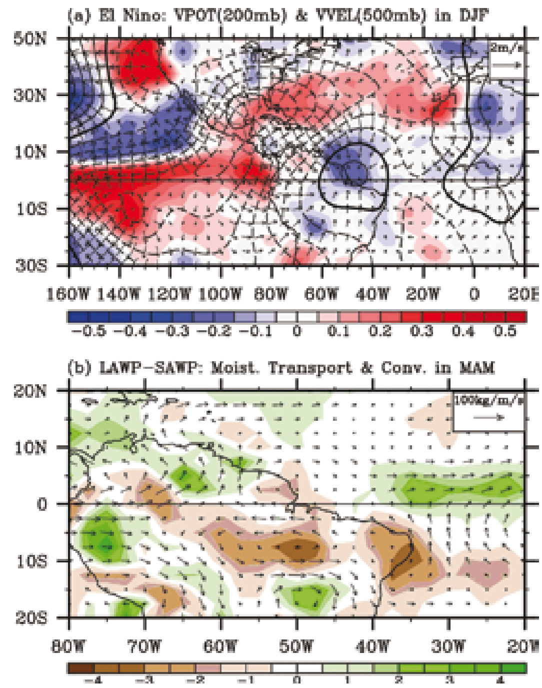

Figure 2. (a) As in Figure 1b, but composite-average anomaly of 5 strong El Niño events during December-February. (b) Vertically averaged March-May moisture transport (arrows, inset reference arrow) and moisture convergence (green positive, 10-5 kg/m^2/s) averaged for large minus small quartiles of AWP size during August-October. // Figura 2. (a) Como en la Figura 1b, pero para la composición de anomalías promedio de 5 eventos El Niño fuertes durante diciembre-febrero. (b) Promedio vertical del transporte de humedad en marzo-mayo (flechas, flecha de referencia en el cuadro) y convergencia de humedad (verde es positivo, 10-5 kg/m^2/s) promediado para la diferencia entre cuartiles superiores menos inferiores del tamaño de la AWP en agosto-octubre.

large summer warm pool during the year following peak El Niño conditions (Enfield et al., 2006). If, however, this atmospheric bridge does not perist past March, the ENSO-related warming in the Atlantic fails to develop (Lee et al., 2008). Clearly, the concerns of IASCLIP cannot be isolated to the Intra-Americas Sea (IAS) region because processes important to South American VAMOS programs have the potential to influence the climate regime of the IAS.

Example 3: Tropical/Subtropical North Atlantic to Amazonia

A well-understood consequence of TNA warmth (large AWP) with respect to the tropical South Atlantic is the northward migration of the intertropical convergence zone (ITCZ) associated with the wind-evaporation-SST feedback process (Xie and Philander 1994). In Fig. 2b we can appreciate the consequences for northern South America during the boreal spring of years with a large AWP. Low-level winds cross the equatorial Atlantic from south to north, and westerly anomalies just north of the equator are co-located with anomalous moisture convergence and the northward displaced ITCZ. Less moisture flows into equatorial South America from the equatorial Atlantic, and anomalous moisture divergence (dryness) dominates the continent north of 15°S.

In all of the VAMOS programs, an overriding objective is to identify biases in the climate models and find ways to remedy them and improve predictions. The existence of these connections between regions tells us that model biases outside of a particular region can be just as important as the biases local to that region. In a recent paper, Chang et al., (2008) demonstrate that a CAM3 (Community Atmospheric Model, version 3) bias in the convection over the Amazon region can affect the zonal winds over the equatorial Atlantic, which in turn can compromise the performance of coupled climate models in the sensitive equatorial region. Because of the connection of diabatic heating in the Amazon region with the subsidence regime north of the equator, an Amazonian convection bias can affect the development of warm pool anomalies, and through them, the summer climates of Central and North Americas. Similarly, model convection biases in the AWP region may inter-hemispherically affect model deficiencies over the SE Pacific where the VOCALS program is focused.

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litamiento resultante de la circulación regional de Hadley hacia el Atlántico Norte en el invierno-primavera boreal causa una reducción en la subsidencia de la alta subtropical del Atlántico Norte, un debilitamiento de los alisios del NE y una disminución en la pérdida de calor por evaporación en el Atlántico Norte tropical (TNA). El calentamiento anómalo que resulta durante la primavera da origen a una gran piscina cálida estival durante el año siguiente al máximo de las condiciones El Niño (Enfield et al., 2006). Sin embargo, si este puente atmosférico no persiste hasta pasado marzo, no se desarrolla en el Atlántico el calentamiento asociado al ENSO (Lee et al., 2008). Claramente, la incumbencia intereses de IASCLIP no pueden limitarse a la región de los Mares Intra-americanos (IAS) porque hay procesos importantes para los programas sudamericanos de VAMOS que tienen el potencial de influir en el régimen climático de IAS.

Ejemplo 3: Atlántico Norte Tropical/Subtropical hacia Amazonia

Una consecuencia bien entendida de un TNA cálido (una AWP grande) respecto del Atlántico Sur tropical es la migración hacia el norte de la zona de convergencia intertropical (ITCZ) asociada con el proceso de retroacción viento-evaporación-SST (Xie y Philander 1994). En los años con AWPs grandes se ven las consecuencias en el norte de Sudamérica durante la primavera boreal (Fig. 2b). Los vientos de niveles bajos atraviesan el Atlántico ecuatorial de sur a norte, y las anomalías en los oestes justo al norte del ecuador se dan en combinación con una convergencia anómala de humedad y el desplazamiento hacia el norte de la ITCZ. Hay un flujo menor de humedad hacia la Sudamérica ecuatorial desde el Atlántico ecuatorial, y una divergencia anómala de humedad (sequedad) domina el continente al norte de los 15°S.

Uno de los objetivos primordiales de todos los programas de VAMOS es identificar sesgos en los modelos climáticos y buscar formas de remediarlos y mejorar las predicciones. La existencia de conexiones entre regiones nos dice que los sesgos de los modelos fuera de una región en particular pueden tener la misma importancia que los sesgos locales de esa región. En un trabajo reciente, Chang et al., (2008) demuestran que un sesgo del CAM3 (Community Atmospheric Model, versión 3) en la convección sobre la región amazónica puede afectar los vientos zonales en el Atlántico ecuatorial, que a su vez pueden comprometer el desempeño de los modelos climáticos acoplados en la sensible región ecuatorial. Debido a la conexión del calentamiento diabático en la región amazónica con el régimen de subsidencia al norte del ecuador, un sesgo en la convección amazónica puede afectar el desarrollo de anomalías en las piscinas cálidas, y a través de ellas, los climas estivales de América Central y del Norte. Similarmente, sesgos en la convección modelada de la región de AWP pueden afectar interhemisféricamente las deficiencias del modelo sobre el Pacífico Sudoriental, foco del programa VOCALS.

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Variability of the American monsoon systems and extremes[1]

Extremes are an important issue in the Variability of the American Monsoon Systems (VAMOS) regions as they can induce dramatic socio-economic impacts, especially in the countries of Central and South America where vulnerability to such events is major. Over the United States, the National Climate Data Center (NCDC) have documented the billion dollar weather disasters for recent years (Lott and Ross, 2006). From 1980 to 2005, the 10 severe drought and flood events over the United States cost 144 billion dollars in damages. The study of extremes – documenting, understanding, modeling and predicting – therefore constitutes an important cross-cutting theme for all the VAMOS Programs (North American Monsoon Experiment (NAME), Monsoon Experiment - South America (MESA), VAMOS Ocean-Clouds-Atmosphere-Land Studies (VOCALS) and Intra Americas Study of Climate Processes (IASCLIP)). This work can also help assess changes in extremes in the VAMOS region, and to link research to society through the development of prediction and early-warning systems on one hand and of adaptation strategies aimed at reducing vulnerability on the other hand.

VAMOS is in a unique position to utilize its continental perspective in linking extremes in warm season climate behavior to the circulation structures defined as the monsoon systems. Previous studies have analyzed seasonal climate anomalies from a perspective of a large-scale flow pattern modification (e.g., the 1993 U.S. flooding, the 2001 drought of Southeastern-Central Brazil or the 2005 Amazon drought); however, few have linked such climate anomalies to perturbations in the monsoon circulation and/or the impact of warm season transients in monsoon regions that may modify the onset of the rainy season. Such a perspective would constitute a multi-scale approach to understanding the subtle interplay of processes occurring at different space and time scales within monsoon systems, such as terrain heating, vegetation-atmosphere coupling, land-sea breezes, regional moisture flux patterns, synoptic disturbances and oceanic teleconnections.

Defining extremes for the VAMOS regions

Many definitions have been proposed for extremes. For example, the IPCC computes specific Climate Model Extreme Indices (e.g., Frich et al., 2002), and a modified list of definitions for extreme precipitation have been proposed for the Coordinated Energy and Water Cycle Observations Project/Global Energy and Water Cycle Experiment (CEOP/GEWEX) (Burford, 2006). Broadly, two classes of extremes can be defined. One class of definition refers to some statistical property of a meteorological variable typically indexing its severity or rareness. The other class of definition refers to the impact of the event, usually quantified in terms of economic loss or ecological disturbance. Within the latter class of definition, extreme events are relative to the sector of study (e.g., reservoir management or agriculture) and its vulnerability (e.g., infrastructures, early-warning systems, emergency plans). While the definition of extremes based on societal impact is of great interest for stakeholders and should be investigated further in the coming years, its sectoral and societal specificity makes it difficult to provide a general guideline for the VAMOS regions. For the cross-cutting activity on extremes within VAMOS we do not define extreme events based on impacts, but we do acknowledge the need to address those impacts in the context of our definitions. Individual regional VAMOS programs are encouraged to work on sectorally- and locally-specific definitions, where appropriate, as they will be of major importance to link scientific research and society.

La variabilidad de los sistemas monzónicos americanos y los extremos[1]

Los extremos son un tema importante en las regiones de Variabilidad de los Sistemas Monzónicos Americanos (VAMOS) ya que pueden inducir impactos socioeconómicos espectaculares, particularmente en los países de América Central y del Sur donde la vulnerabilidad a tales eventos es mayor. En Estados Unidos, el Centro Nacional de Datos Climáticos (NCDC) documenta los desastres climáticos que causaron pérdidas de miles de millones de dólares (Lott y Ross, 2006). Entre 1980 y 2005, los 10 eventos severos de sequía e inundación ocurridos en Estados Unidos provocaron daños por 144 mil millones de dólares. El estudio de extremos -su documentación, comprensión, modelado y pronóstico- constituye por lo tanto un tema transversal de importancia para todos los programas de VAMOS (Experimento del Monzón de Norteamérica (NAME), Experimento del Monzón de Sudamérica (MESA), Estudio de Océanos-Nubes-Atmósfera-Tierra de VAMOS (VOCALS) y Estudio Intraamericano de los procesos climáticos (IASCLIP)). Este trabajo también puede ayudar a evaluar cambios en los eventos extremos en la región de VAMOS, y vincular la investigación con la sociedad mediante el desarrollo de sistemas de pronóstico y alerta temprana por un lado y de estrategias de adaptación dirigidas a reducir la vulnerabilidad por el otro.

VAMOS está en una posición única de utilizar su perspectiva continental para vincular extremos en el comportamiento del clima en la época cálida con las estructuras de circulación definidas como sistemas monzónicos. Estudios anteriores analizaron las anomalías climáticas estacionales desde el punto de vista de alteraciones en el patrón del flujo de gran escala (por ejemplo, la inundación de 1993 en EE.UU., la sequía de 2001 en el sudeste y centro de Brasil o la sequía de 2005 en Amazonia); sin embargo, pocos han vinculado esas anomalías climáticas con las perturbaciones en la circulación monzónica y/o el impacto de los sistemas transitorios de la estación cálida de las regiones monzónicas que pueden modificar el inicio de la época de lluvias. Esta perspectiva constituiría un acercamiento en múltiples escalas para comprender la sutil interacción de procesos que tienen lugar en diferentes escalas espaciales y temporales dentro de los sistemas monzónicos, como el calentamiento del terreno, el acoplamiento vegetación-atmósfera, las brisas tierra-mar, los patrones regionales del flujo de humedad, las perturbaciones sinópticas y las teleconexiones oceánicas.

Definición de extremos para las regiones de VAMOS

Se han propuesto numerosas definiciones de extremos. Por ejemplo, el IPCC calcula Índices específicos de Extremos en Modelos Climáticos (ej., Frich et al., 2002), y hay propuesta una lista modificada de definiciones de precipitación extrema para el Proyecto de Observaciones Coordinadas del Ciclo de la Energía y el Agua /Experimento Global sobre el Ciclo de la Energía y el Agua (CEOP/GEWEX) (Burford, 2006). En líneas generales, pueden definirse dos clases de extremos. Una clase de definiciones se refiere a alguna propiedad estadística de la variable meteorológica que en general asigna un índice para su severidad o rareza. La otra clase se refiere a los impactos del evento, que generalmente se cuantifica en términos de pérdidas económicas o disturbios ecológicos. En esta última clase, los eventos extremos son relativos al sector de estudio (ej., manejo de reservorios o agricultura) y su vulnerabilidad (ej., infraestructura, sistemas de alerta temprana, planes de emergencia). Mientras que la definición de extremos basada en los impactos sociales es de gran interés para los actores políticos y debería profundizarse su estudio en los próximos años, su especificidad sectorial y social dificulta la extracción

[1]*Condensed from the Task Force White Paper on VAMOS & Extremes developed by // // Sintetizado del White Paper del grupo de trabajo sobre VAMOS & Extremos preparado por*
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The strengths of VAMOS are in process-oriented, dynamical understanding of the warm season climate over the Americas. It therefore appears that an appropriate framework for the VAMOS community would be to work on statistical definitions of extreme events relevant to the warm season climate of the Americas for the analysis of interannual variability, decadal variability and climate change. In working towards explicit definitions of extremes, we will consider definitions of extremes that capture specific historical events as well as definitions appropriate to extreme value theory. We will, for example, consider particular years or periods in which the seasonal expression of extreme events was outstanding, whether in the seasonal mean or the weather characteristics. We believe that this will help to further our understanding of mechanisms, predictability and the potential for early warning.

Our definitions of extremes will be cast in terms of seasonal to intra-seasonal departures from multi-decadal climate averages, even if the dynamical understanding of specific types of extreme events requires examination at shorter timescales, such as analyzing the underlying synoptic meteorology. A list of major extreme events being considered for VAMOS is as follows:

* Droughts: Drought is broadly defined as persistent precipitation deficits. For meteorological drought, we propose use of standardized precipitation indices. In other contexts, drought may be defined using other variables, such as soil moisture deficit for agricultural drought or streamflow deficits for hydrological droughts. Where data are available to conduct complimentary analyses for these sectoral contexts, such work could increase greatly the local relevance of the work.

* Fluvial or inundation periods: Wet extremes encompass a wider range of timescales. One example, taken from the GEWEX/CEOP definition, could be “substantial precipitation for 24h to several days that affects basins or regions on scales of at least 105 km2”. In the context of climate variability and change, VAMOS is interested in periods of anomalous frequency of heavy precipitation events, based on daily to weekly characteristics.

* Heat waves: Temperature-based extremes also span a range of time scales. The specific definition(s) will be regionally dependent. Since heat waves are of considerable interest in the context of drought, and since extreme heat waves are often coincident with drought, temperature extremes should be considered also in terms of their covariance with precipitation extremes.

VAMOS plans for the 2009-2013 period

We have drafted a work plan on extremes within VAMOS that considers issues that are coherent across VAMOS program areas, that includes aspects of extremes that are somewhat unique to VAMOS, and that capitalizes on existing and ongoing efforts within the climate community. In addition, we seek creativity in advancing new metrics for anomalous ‘high impact’ or ‘extreme’ behavior such as changes in the seasonal frequency of threshold events (heavy rainfall, hail, high winds), integration of daily departures over a season (e.g., integrated evaporative demand over a season, similar to degree days), and so forth. The unique perspective that VAMOS brings to the study of extremes, is the emphasis on extremes in warm season ‘monsoon’ hydroclimates.

The initial activity will be refinement of the proposed list of extreme events, including more detailed specification of how extremes, events and indices should be defined, and a listing of season(s) of focus for the various VAMOS program areas. This list may be modified as research progresses. The next activity will be to document extremes over the historical record. This is necessary to lay the foundation for guiding observation, modeling and prediction studies on extremes. Particular questions could be: What are the regional characteristics of the defined extremes? What climate variability or change can be deduced in those extremes? Are there particular years that would be important to study more closely? Outcomes from these

de un lineamiento general para las regiones de VAMOS. Para la actividad transversal sobre extremos en VAMOS no definimos eventos extremos sobre la base de sus impactos, sino que reconocemos la necesidad de abordar dichos impactos en el contexto de nuestras definiciones. Se promueve que cada programa regional de VAMOS trabaje en definiciones específicas sectorial y localmente según corresponda, ya que serán de gran importancia para establecer vínculos entre la investigación científica y la sociedad.

Las fortalezas de VAMOS yacen en la comprensión dinámica y orientada de los procesos del clima de la estación cálida en las Américas. Parece entonces que un marco adecuado para la comunidad de VAMOS sería el uso de definiciones estadísticas de eventos extremos pertinentes al clima de la estación cálida de las Américas para analizar la variabilidad interanual, decenal y el cambio climático. Al trabajar para lograr definiciones explícitas de extremos, consideraremos aquellas que capturan eventos históricos específicos así como las que son adecuadas para la teoría de los valores extremos. Por ejemplo, consideraremos años o períodos particulares en los que la manifestación estacional de eventos extremos fue extraordinaria, ya sea en la media estacional como en las características del tiempo. Creemos que esto ayudará a mejorar nuestra comprensión de los mecanismos, la predictabilidad y el potencial de la alerta temprana.

Nuestras definiciones de extremos se asignarán en términos de apartamientos estacionales o intraestacionales de los promedios climáticos multidecenales, aún cuando la comprensión dinámica de tipos específicos de eventos extremos requiera de un análisis en escalas menores, como la meteorología sinóptica asociada a ellos. A continuación presentamos una lista de los eventos extremos que se consideran en VAMOS:

** Sequías: La sequía se define en forma amplia como un déficit persistente de precipitación. Para las sequías meteorológicas proponemos el uso de índices estandarizados de precipitación. En otros contextos, la sequía puede definirse mediante otras variables, como déficit en la humedad del suelo para sequías agrícolas o déficit en los caudales para sequías hidrológicas. Los análisis complementarios para estos contextos sectoriales en los lugares donde se disponga de datos podrían aumentar la relevancia local del trabajo.*

** Extremos fluviales o períodos de inundación: Los extremos húmedos abarcan un rango más amplio de escalas. Un ejemplo tomado de la definición de GEWEX/CEOP podría ser “lluvias considerables de 24 horas a varios días que afectan cuencas o regiones en escalas de al menos 105 km2”. En el contexto de la variabilidad y el cambio del clima, VAMOS se interesa en períodos de frecuencias anómalas de precipitaciones intensas, sobre la base de sus características diarias a semanales.*

** Olas de calor: Los extremos de temperatura también abarcan un amplio rango de escalas. Su(s) definición(es) depende(n) de la región. Como las olas de calor tienen un interés considerable en el contexto de las sequías, y como las olas extremas de calor coinciden a menudo con ellas, los extremos de temperatura deberían considerarse también en términos de su covarianza con los extremos de precipitación.*

Planes de VAMOS para el período 2009-2013

Preparamos un plan de trabajo sobre extremos que toma en cuenta cuestiones que son coherentes entre las áreas del programa de VAMOS, incluye aspectos de los extremos que son de alguna manera únicos para VAMOS y capitaliza los esfuerzos existentes y en curso dentro de la comunidad del clima. Además, buscamos creatividad en el avance de una nueva métrica de comportamientos anómalos ‘de alto impacto’ o ‘extremos’ como los cambios en la frecuencia estacional de eventos umbral (precipitación intensa, granizo, vientos fuertes), la integración de apartamientos diarios en una estación (ej., demanda de evaporación integrada en la estación, similar a los días-grado), y así sucesivamente. La perspectiva única que aporta VAMOS al estudio de extremos consiste en su foco en los first two activities will help to focus further efforts on extremes within VAMOS.

The VAMOS activity on extremes will benefit from numerous on-going efforts, providing the ability to analyze, characterize and/or diagnose extremes. Of these, the provision of observational and model-based data is paramount. Some of the identified sources or coordinated efforts are given here. Information on efforts we may have missed would be welcome.

a) Observational data

One of the most important efforts within the climate community that is absolutely essential to any study of extremes is the provision of a sufficient length of quality controlled observational data.

• Precipitation and surface temperature data:
For most of the regions studied under VAMOS monthly gridded and station data is available back to 1950. For several regions, multi-decade timeseries of daily data is either currently, or soon to be, available.

• Streamflow data:
Within the US this data is available from the United States Geological Survey. In Brazil this data is available from the Brazilian National Water Authority. For other regions, data may be available, from National Meteorological and Hydrological Services.

• Land surface data:
Satellite data is available for global vegetation. Data is also available from land data assimilation systems, although these are model based. Soil moisture observations, which would be required for agricultural definition of extremes, are not widely available.

• Paleo-data:
This type of data extending back hundreds of years, but through proxies such as tree rings or lake sediments, would provide a valuable insight to the historical variability and change in extreme events, particularly in the context of climate change. An extensive tree ring reconstruction project has been conducted for the United States, but there are issues with diagnosing warm season precipitation from tree rings. Some paleo-data studies have been conducted for parts of South America, but the data is not readily available.

b) Model data

In order to determine predictability or sensitivity to changing ocean temperatures, or changing atmospheric composition, data from dynamical models is crucial. Using various model integrations from idealized experiments, simulations of past conditions, and predictions of future conditions, the VAMOS extremes activity will evaluate the quality of current models in predicting specific extreme events. Contributing to those efforts, several activities are underway, some as part of other CLIVAR activities.

i. The NAME Forecast Forum (and previous NAME Model Assessment Project effort) has been focusing on seasonal scale prediction. More information is available at: http://www.cpc.noaa.gov/products/Global_Monsoons/American_Monsoons/NAME/index.shtml.

ii. The CLIVAR Drought Working Group ran atmospheric Global Climate Model experiments forced with a set of idealized sea-surface temperature (SST) forcing patterns deemed to have an impact on drought in the Americas. These include control simulations with climatological SST, and for some models, runs with fixed soil moisture. More information is available at: http://www.usclivar.org/drought.php and http://gmao.gsfc.nasa.gov/research/clivar_drought_wg/index.html

iii. A program has been outlined and endorsed by the CLIVAR Asian-Australian Monsoon Panel for a coordinated project in which climate models are run at high resolution to address weather/climate issues to focus on tropical storm climate connections (e.g., impact of the Madden-Julian Oscillation, SST anomalies). The focus is on tropical storms but the runs/project will also be relevant to VAMOS.

extremos de la estación cálida de los hidroclimas 'monzónicos'.

La primera actividad será el refinamiento de la lista propuesta de eventos extremos, incluyendo especificaciones más detalladas de cómo deberían definirse los extremos, eventos e indices, y una lista de estación(es) de interés para los distintos programas de VAMOS. A medida que la investigación avance la lista podrá sufrir modificaciones. La próxima actividad será la documentación de los extremos a partir del registro histórico. Esto es necesario para sentar las bases que orienten los estudios de observación, modelado y pronóstico de extremos. Algunos interrogantes específicos podrían ser: ¿Cuáles son las características regionales de los extremos definidos? ¿Qué variabilidad o cambio climático puede deducirse de esos extremos? ¿Hay algún año en particular que deba estudiarse con mayor detalle? Los resultados de estas dos primeras actividades contribuirán a concentrar esfuerzos futuros en extremos dentro de VAMOS.

La iniciativa de VAMOS sobre extremos se verá beneficiada con las numerosas actividades en curso, brindando habilidad para analizar, caracterizar y/o diagnosticar extremos. De ellos, la provisión de datos de observaciones y modelos es primordial. Se presentan algunas fuentes o esfuerzos coordinados y agradeceremos información sobre los que no hayamos mencionado.

a) Observaciones

Uno de los más importantes esfuerzos de la comunidad climática que es absolutamente esencial para cualquier estudio de extremos es la provisión de series de datos observados suficientemente largas y sometidas a control de calidad.

• Datos de precipitación y temperatura en superficie

Para la mayoría de las regiones que se estudian en VAMOS se dispone de datos mensuales en grilla y de estaciones desde 1950. Para otras, series de datos diarios de varias décadas están disponibles o lo estarán pronto.

•Datos de caudales

En EE.UU. estos datos pueden obtenerse en el United States Geological Survey; en Brasil, en la Autoridad Nacional del Agua. En otras regiones, los datos podrían obtenerse en los Servicios Meteorológicos e Hidrológicos Nacionales.

• Datos de superficie

Se dispone de datos satelitales para vegetación global. También hay datos de sistemas de asimilación de datos de superficie, aunque son obtenidos de modelos. No hay una disponibilidad amplia de observaciones de la humedad del suelo, que serían necesarios para la definición agrícola de extremos.

• Paleo-datos

Este tipo de datos se remonta a cientos de años, pero se obtienen a través de proxys como los anillos de árboles o los sedimentos lacustres, brindarían elementos valiosos para comprender la variabilidad y cambio históricos de los eventos extremos, especialmente en el contexto del cambio climático. En EE.UU. se ha realizado un gran proyecto de reconstrucciones mediante anillos de árboles, pero hay problemas con el diagnóstico de la precipitación en la estación cálida con este método. En algunas partes de América del Sur se han realizado estudios de paleo-datos, pero estos no son fácilmente accesibles.

b) Datos de modelos

Los datos de modelos dinámicos son fundamentales para determinar la predictabilidad o sensibilidad a los cambios en la temperatura del océano o en la composición de la atmósfera. Usando varias integraciones de modelos de experimentos idealizados, simulaciones de condiciones pasadas, y pronósticos de condiciones futuras, la iniciativa de extremos de VAMOS evaluará la calidad de los modelos actuales para la predicción de eventos extremos específicos. Contribuyendo a dichos esfuerzos, hay en marcha varias actividades, algunas de ellas como parte de las actividades de CLIVAR.

Of course, the interests and efforts of the scientists and their institutions working within the VAMOS region are also central to the success of this activity. We hope to report more on these specific regional studies in future VAMOS! editions. Those interested in participating in the activity on extremes within VAMOS are encouraged to contact Carlos Ereño.

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i. El Foro de Pronóstico de NAME (y el anterior Proyecto de NAME para Evaluación de Modelos) se estuvo concentrando en el pronóstico estacional. Más información en http://www.cpc.noaa.gov/products/Global_Monsoons/American_Monsoons/NAME/index.shtml.

ii. El Grupo de Trabajo de CLIVAR sobre Sequías hizo experimentos atmosféricos con Modelos Climáticos Globales forzados con un conjunto de patrones idealizados de temperatura de la superficie del mar (SST) que se supone tiene impacto en las sequías en las Américas. Entre ellos se cuentan simulaciones de control con SST climatológicas, y para algunos modelos, corridas con humedad del suelo fija. Puede hallarse más información en http://www.usclivar.org/drought.php y http://gmao.gsfc.nasa.gov/research/clivar_drought_wg/index.html

iii. Se delineó un proyecto coordinado que recibió el apoyo del Panel del Monzón de Asia y Australia de CLIVAR. Consiste en hacer corridas de los modelos climáticos en alta resolución para abordar cuestiones del tiempo/clima centradas en las conexiones climáticas de las tormentas tropicales (ej., impacto de la Oscilación de Madden-Julian, anomalías de SST). Si bien el foco está en las tormentas tropicales, las corridas y el proyecto serán también pertinentes a VAMOS.

Por supuesto que los intereses y esfuerzos de los científicos y sus instituciones que trabajan en la región de VAMOS son también fundamentales para el éxito de esta actividad. Esperamos brindar más informes sobre estos estudios regionales específicos en futuros números de VAMOS!. Se invita a aquellos que estén interesados en participar en esta actividad a comunicarse con Carlos Ereño.

VOCALS is VAMOS on the GO!

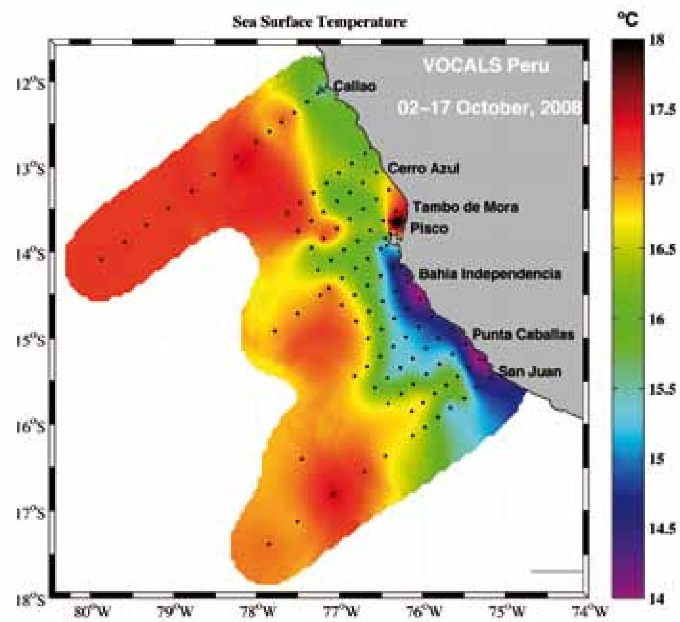
The VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS) program is a component of the international CLIVAR/VAMOS focused on the southeastern Pacific (SEP) climate on diurnal to interannual timescales. The SEP is a region dominated by strong coastal upwelling (Fig. 1), extensive cold SSTs, and home to the largest and most poorly-observed subtropical stratocumulus deck on Earth. VOCALS develops and promotes scientific activities leading to achievement of two major objectives in the SEP 1) elimination of CGCM systematic errors in the region and improved model simulations of the coupled system in the region and global impacts of its variability, and 2) improved understanding and regional/global model representation of aerosol indirect effects over the region. To achieve these goals the program has been organized in three components: 1) a modeling component with a model hierarchy ranging from the local to global scales, 2) a suite of extended observations from regular research cruises, instrumented moorings, and satellites, and 3) an international VOCALS Regional Experiment (REx). VOCALS has been designed for maximum synergy among of intensive field measurements, long-term observations, and modeling.

The operational phase of VOCALS-REx was completed during October and November 2008. During that period approximately 150 scientists from 40 institutions in 8 nations worked in Chile and Peru. A total of five aircraft including the NSF C-130, the DoE G-1, the CIRPAS Twin Otter, and two aircraft from the UK (the FAAM BAe-146 and the NERC Do-228), and two research vessels (the NOAA Ronald H Brown and the Peruvian IMARPE José Olaya) sampled the lower atmosphere and upper-ocean. Specific targets were the processes controlling the optical and structural properties of stratocumulus clouds including continental aerosols from smelters and volcanoes, processes controlling the ocean transport of cold, fresh water offshore, and the chemical and physical interactions between the lower atmosphere and upper-ocean. VOCALS-REx gathered unique, multidisciplinary datasets for studies on the physical and chemical couplings between different components of a regional climate system. Preliminary results

¡VOCALS es VAMOS en movimiento!

El programa Estudio del Océano-Nubes-Atmósfera-Tierra de VAMOS (VOCALS) es un componente del programa internacional CLIVAR/VAMOS concentrado en el clima del Pacífico sudoriental (SEP) en escalas que van desde la diurna a la interanual. El SEP es una región dominada por una fuerte surgencia costera (Fig. 1), con amplias zonas de bajas SSTs, y es la región más grande y menos estudiada de la cubierta subtropical de estratocúmulos de la Tierra. VOCALS desarrolla y promueve actividades científicas en el SEP que persiguen dos objetivos principales 1) eliminar los errores sistemáticos de los CGCM en la región y obtener simulaciones mejoradas del sistema acoplado en la región y de los impactos globales de su variabilidad, y 2) mejorar la comprensión y modelación regional/global de los efectos indirectos de los aerosoles en la región. Para alcanzar estos objetivos el programa fue organizado en tres componentes: 1) un componente de modelado con una jerarquía de modelos que va desde la escala local a la global, 2) un conjunto de observaciones extendidas realizadas mediante campañas oceanográficas regulares, boyas con instrumental ancladas, y satélites, y 3) un experimento regional internacional de VOCALS (REx). VOCALS fue diseñado para lograr una sinergia máxima entre las mediciones intensivas de campo, las observaciones a largo plazo y el modelado.

La fase operativa de VOCALS-REx se llevó a cabo en octubre y noviembre de 2008. Durante ese período cerca de 150 científicos de 40 instituciones de 8 países trabajaron en Chile y Perú. Cinco aeronaves, el NSF C-130, el DoE G-1, el CIRPAS Twin Otter, dos aeronaves del Reino Unido (el FAAM BAe-146 y el NERC Do-228), y dos buques de investigación (el Ronald H Brown de la NOAA y el José Olaya de IMARPE- Perú) observaron la atmósfera baja y la capa superior del océano. Los objetivos específicos fueron los procesos que controlan las propiedades ópticas y estructurales de los estratocúmulos incluyendo los aerosoles continentales de las metalúrgicas y los volcanes, los procesos que controlan el transporte oceánico de



Sea Surface Temperature (shading colors in °C) observed during the VOCALS-Peru cruise experiment. Black dots correspond to CTD station locations" // Temperatura de la superficie del mar (los colores indican temperaturas en °C) medida durante la campaña VOCALS-Perú. Los puntos negros corresponden a estaciones CTD.

were presented at the recent Annual Meeting of the American Meteorological Society in Phoenix, Arizona. The funding for VOCALS has been provided by several sources: In the US, NSF, NOAA, DOE and ONR; in Chile CONICYT (PBCT:ACT19)., DMC, SAEMC, DGF and UV; in Peru, IRD, INSU; NSF and IMARPE, and in the UK NERC and the MetOffice.

Further information on VOCALS can be found on the program website http://www.eol.ucar.edu/projects/vocals/.

agua fría y dulce mar adentro y las interacciones químicas y físicas entre la atmósfera baja y la capa superior del océano. VOCALS-REx recolectó conjuntos de datos únicos y multidisciplinarios para estudiar el acoplamiento físico y químico entre diferentes componentes del sistema climático regional. En la reciente reunión de la Sociedad Meteorológica Americana que tuvo lugar en Phoenix, Arizona se presentaron resultados preliminares. El financiamiento de VOCALS proviene de diversas fuentes: en EE.UU., NSF, NOAA, DOE y ONR; en Chile CONICYT (PBCT:ACT19)., DMC, SAEMC, DGF y UV; en Perú, IRD, INSU; NSF e IMARPE y en el Reino Unido, NERC y el Servicio Meteorológico.

Hay más información sobre VOCALS en http://www.eol.ucar.edu/projects/vocals/

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Philosophical Transactions of the Royal Society A have just published:

The Pliocene: a vision of Earth in the late 21st century?

compiled and edited by Alan M. Haywood, Harry J. Dowsett and Paul J. Valdes - http://publishing.royalsociety.org/pliocene A specially discounted price of £47.50 is available by contacting Debbie Vaughan at the Royal Society direct (debbie.vaughan@royalsociety.org) or by contacting Portland Customer Services (quoting reference TA1886) via the Portland Press website.

For further information on related environmental change and renewable energy issues of Philosophical Transactions A, please visit

http://publishing.royalsociety.org/philtransa/environment

Conference Announcement

The U.S. Atlantic Meridional Overturning Circulation (AMOC) Science Team

is organizing an open science meeting focused on AMOC observations, modeling and prediction. The U.S. Administration's Ocean Research Priorities Plan included the study of the AMOC as a near-term priority and relevant federal agencies are responding with new efforts in this arena. This meeting is designed to facilitate communication between U.S. and international AMOC researchers and will be held 4-6 May 2009 in Annapolis, MD USA.

Please go to **www.AtlanticMOC.org/AMOC2009.php** for a complete description of the meeting including registration, abstract submittal and logistical details.

The abstract deadline is 3 March 2009 and the registration deadline is 3 April 2009. For more information about the U.S. AMOC Science Team, go to www.AtlanticMOC.org.

CLIVAR CALENDAR April, May and June 2009 - see http://www.clivar.org/calendar/calendar_all.

Dates	Place	Country	Title	Status	Contact
2009-04-19 - 2009-04-24	Vienna	Austria	EGU General Assembly	Open	
2009-04-27 - 2009-05-08	Trieste	Italy	Water resources in developing countries: Planning and management in a climate change scenario	Open	
2009-04-27 - 2009-04-28	Pusan	Korea	PACSWIN Submarine cable workshop	Open	you@geosci.usyd.edu.au
2009-04-27 - 2009-04-29	Exeter	United Kingdom	WGOMD Workshop on Ocean Mesoscale Eddies	Open	anna.pirani@noc.soton.ac.uk
2009-04-30 - 2009-05-01	Exeter	United Kingdom	WGOMD Panel Meeting	Limited	anna.pirani@noc.soton.ac.uk
2009-05-04 - 2009-05-08	Lund	Sweden	21st Century Challenges in Regional Climate Modelling	Open	
2009-05-04 - 2009-05-06	Annapolis, MD	U.S.A.	First U.S. Atlantic Meridional Overturning Circulation (AMOC) Annual Meeting	Open	Molly.Baringer@noaa.gov
2009-05-11 - 2009-05-15	Manado, North Sulawesi	Indonesia	World Ocean Conference	Open	info@woc2009.org
2009-05-19 - 2009-05-22	Madrid	Spain	16th Session of the CLIVAR Scientific Steering Group	Invitation	hyc@noc.soton.ac.uk
2009-05-24 - 2009-05-27	Toronto	Canada	AGU Joint Assembly	Open	
2009-05-31 - 2009-06-05	Chandris Conference Centre, Corfu	Greece	2nd International Summit on Hurricanes and Climate Change	Open	jelsner@fsu.edu
2009-06-02 - 2009-06-05	Cologne	Germany	Global Change in Africa: Projections, Mitigation and Adaption	Open	africa-conference@uni-koeln.de
2009-06-03 - 2009-06-05	La Reunion	France	6th Session CLIVAR/GOOS Indian Ocean Panel	Invitation	rbos@iim.csic.es
2009-06-06 - 2009-06-11	Obergurgl, Tyrol	Austria	Mechanisms of Quaternary Climate Change: Stability of Warm Phases in the Past and in the Future	Open	jkelly@esf.org
2009-06-08 - 2009-06-17	Budapest	Hungary	Summer School on "climate Variability & Climate Change: Estimating and reducing uncertainties"	Open	horanyi.a@met.hu, hagel.e@met.hu, szepszo.g@met.hu
2009-06-08 - 2009-06-11	Princeton	USA	Ocean Carbon and Biogeochemistry (OCB) scoping workshop	Open	mzawoysky@whoi.edu

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

UK Met Office Hadley Centre, Exeter, UK, 27–29 April 2009

http://www.metoffice.gov.uk/conference/mesoscale_workshop/ Invitation to apply for travel grants

Funding to support travel is available for young PIs, students and Post-docs that will be presenting a poster at the workshop.
To apply please email Anna Pirani (apirani@princeton.edu) including the following:

- a short cv,
- full contact details of the applicant's institution,
- the abstract with title and authors list of the poster being presented,
- an estimate of the applicant's travel expenses and the support being requested.

Applications will be evaluated according to the quality of the participant's abstract and the potential value and impact of support for the applicant.
The deadline for applications is the 15th March.

CONTENTS

CLIVAR

Editorial 2

The Horn of Africa Regional Climate Model Inter-comparison Project 3

The Snows of Kilimanjaro: A critical comment on Numerical Simulations of the Role of Land Surface Conditions on the Climate of Mt. Kilimanjaro Region 7

Response to: 'The Snows of Kilimanjaro' 9

The third Mediterranean Climate Variability and Predictability - European Science Foundation (MedCLIVAR-ESF) workshop and the first MedCLIVAR-ESF summer School 10

Report of the ninth Session of the Asian-Australian Monsoon Panel 11

Report from the twelfth Session of the Working Group on Coupled Modelling (WGCM) 12

The fifth session of the CLIVAR/GOOS Indian Ocean Panel 14

VAMOS 15

Activities on anthropogenic climate change 16

Actividades relacionadas con el cmbio climático antrópico 16

Modeling issues: an update after 11th panel meeting 19

Cuestiones de modelado: una actualización luego de la 11a reunión del panel 19

Cross-hemispheric interactions between variability of the American monsoon systems regions 23

Interacciones interhemisféricas entre regiones de variabilidad de los sistemas monzónicos americanos 23

Variability of the American monsoon systems and extremes 26

La variabilidad de los sistemas monzónicos americanos y los extremos 26

VOCALS is VAMOS on the GO! 29

VOCALS es VAMOS en movimiento! 29

ANNOUNCEMENTS 31

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