FY2005 - Climate Variability and Predictability (CLIVAR)

Preface

The U.S. CLIVAR program seeks to observe, model and understand patterns of climate variability on seasonal to decadal time scales and to assess the predictability of such climate variability. The ultimate goal of NOAA's participation in CLIVAR is to develop skilful predictions of climate variability and change on seasonal to multi-decadal time scales and regional spatial scales for optimal use in resource planning and policy decision making. The program is designed to understand global climate variability; to determine the spatial and temporal extent to which this variability is predictable; to develop the observational, theoretical, and computational means to predict variability; and to make enhanced predictions, where feasible.

CLIVAR Atlantic

The tropical Atlantic marine ITCZ (hereafter AMI) is a dominant feature of the regional climate system. It is a relatively narrow region of convection that connects the two large continental convection centers over Africa and South America. The AMI resides close to the maximum in regional sea surface temperature (SST) in a region of low surface pressure (equatorial trough) that separates between the northeasterly and southeasterly tradewind belts [1-3]. The importance of AMI is in its role in processes that control precipitation along the seaboards of West Africa to the east and northeastern South America to the west. In particular, interannual variations in AMI location and intensity are directly linked to climate anomalies in the Sahel, the Gulf of Guinea region and Northeast Brazil. These are semi-arid, densely populated, and relatively poor regions, in which AMI related rainfall variability can inflict considerable social and economical difficulties [4-8].

Interannual variability of AMI position and intensity is closely linked with interannual variability of tropical Atlantic SST [9-12] to the extent that knowledge of the SST can be used to describe with good accuracy, simultaneous AMI precipitation anomalies [13,14]. In addition, AMI variability is linked with climate variability in adjacent regions, particularly the tropical Pacific (El Niño/Southern Oscillation - ENSO) and North Atlantic (the North Atlantic Oscillation - NAO) [15-18]. These external variations are thought to force the AMI variability, either through their effect on regional SST or directly through the atmosphere [19]. Both internal and external interactions display a strong seasonal dependence, with clear implications for predictability [20].

Despite all these diagnostic relationships, seasonal-to-interannual prediction of AMI-related rainfall anomalies remains an elusive task [21]. Moreover, coupled models display serious biases in the simulation of the annual cycle of SST and atmospheric variables in the tropical Atlantic region [22]. The need to address the reasons for these hindrances and to lay out a course of action to achieving higher skills in predicting tropical Atlantic climate variability, motivated US CLIVAR to sponsor a “Workshop on the Dynamics and Predictability of the Atlantic ITCZ and its Regional Climatic Influences”, which convened at the International Research Institute for Climate Prediction, Palisades, NY in September 2002 (for summary see:

http://www.usclivar.org/Meeting_Files/ITCZ_workshopreport.pdf).

In the course of action for achieving better climate prediction in the tropical Atlantic, particular attention was devoted to discussions of the gaps in understanding atmospheric process governing AMI and its interaction with the surrounding atmosphere and underlying ocean. The prevailing notion is that much of the difficulty in prediction lies in the incomplete understanding of regional ocean-atmosphere interaction, which colors the nature of the regions response to external influences and may also give rise to internal variability [14,23,24]. Another source of difficulty may be the interaction between the surrounding land convection and circulation systems and AMI [25-27]. But above all, it is the lack of in situ, surface and upper level data from the tropical Atlantic marine and land regions, that fully captures the three dimensional structure of the atmospheric circulation in the vicinity of AMI, its relationship to the convection and the SST as well as the circulation over land.

In a recent briefing to the CLIVAR Science Steering Committee (SSC), a tentative plan for an intensive field campaign in the tropical Atlantic was discussed. The campaign was justified by the need to provide data for improving the understanding of the physical and dynamic processes key to the determination of the predictability of AMI and its limits, improving their representation in climate models, and assessing their depiction in global analyses (see: http://www.usclivar.org/Meeting_Files/SSC-11/AMI-procstudybrief.pdf). The SSC endorsed the idea and recommended further development of the research and implementation plan.

In FY2005, NOAA's CLIVAR program will provide funding for a limited number of modeling and diagnostic studies that will address the AMI research goals (see documents above) and will help in the further development of an implementation plan for the field program.

References:

1. Hastenrath, S. & Lamb, P. Some aspects of circulation and climate over eastern equatorial Atlantic. *Mon. Wea. Rev.* **105**, 1019-1023 (1977).
2. Mitchell, T. P. & Wallace, J. M. The Annual Cycle in Equatorial Convection and Sea-Surface Temperature. *J. Climate* **5**, 1140-1156 (1992).
3. Waliser, D. E. & Gautier, C. H. A satellite-derived climatology of the ITCZ. *J. Climate* **6**, 2162–2174 (1993).
4. Hastenrath, S. & Heller, L. Dynamics of climatic hazards in Northeast Brazil. *Quart. J. Roy. Meteor. Soc.* **103**, 77-92 (1977).
5. Hastenrath, S. Interannual variability and annual cycle - mechanisms of circulation and climate in the tropical Atlantic sector. *Mon. Wea. Rev.* **112**, 1097-1107 (1984).
6. Ruiz-Barradas, A., Carton, J. A. & Nigam, S. Structure of interannual-to-decadal climate variability in the tropical Atlantic sector. *J. Climate* **12**, 1-43 (1999).

7. Nicholson, S. E. & Grist, J. P. A conceptual model for understanding rainfall variability in the West African Sahel on interannual and interdecadal timescales. *Int. J. Climatol.* **21**, 1733-1757 (2001).
8. Chiang, J. C. H., Kushnir, Y. & Giannini, A. Deconstructing Atlantic ITCZ variability: Influence of the local cross-equatorial SST gradient, and remote forcing from the eastern equatorial Pacific. *J. Geophys. Res.* **107**, 10.1029/2000JD000307 (2002).
9. Lough, J. M. Tropical Atlantic sea surface temperature and rainfall variations in Subsaharan Africa. *Mon. Wea. Rev.* **114**, 561-570 (1986).
10. Hastenrath, S. & Greischar, L. Circulation mechanisms related to Northeast Brazil rainfall anomalies. *J. Geophys. Res.-Atmos.* **98**, 5093-5102 (1993).
11. Nobre, P. & Shukla, J. Variations of sea surface temperature, wind stress, and rainfall over the tropical Atlantic and South America. *J. Climate* **9**, 2464-2479 (1996).
12. Ward, M. N. Diagnosis and short-lead time prediction of summer rainfall in tropical North Africa at interannual and multidecadal timescales. *J. Climate* **11**, 3167-3191 (1998).
13. Moura, A. D. & Shukla, J. On the dynamics of droughts in Northeast Brazil - observations, theory and numerical experiments with a general-circulation model. *J. Atmos. Sci.* **38**, 2653-2675 (1981).
14. Chang, P., Saravanan, R., Ji, L. & Hegerl, G. C. The effect of local sea surface temperatures on the atmospheric circulation over the tropical Atlantic sector. *J. Climate* **13**, 2195–2216 (2000).
15. Hastenrath, S., Castro, L. C. & Acietuno, P. The Southern Oscillation in the tropical Atlantic Sector. *Contrib. Atmos. Phys.* **60**, 447-463 (1987).
16. Uvo, C. B., Repelli, C. A., Zebiak, S. E. & Kushnir, Y. The relationships between tropical Pacific and Atlantic SST and northeast Brazil monthly precipitation. *J. Climate* **11**, 551-562 (1998).
17. Czaja, A., van der Vaart, P. & Marshall, J. A diagnostic study of the role of remote forcing in tropical Atlantic variability. *J. Climate* **15**, 3280-3290 (2002).
18. Giannini, A., Saravanan, R. & Chang, P. Oceanic forcing of Sahel rainfall on interannual to interdecadal time scales. *Science* **302**, 1027-1030 (2003).
19. Chiang, J. C. H., Kushnir, Y. & Zebiak, S. E. Interdecadal changes in eastern Pacific ITCZ variability and its influence on the Atlantic ITCZ. *Geophys. Res. Lett.* **27**, 3687-3690 (2000).
20. Sutton, R. T. & Allen, M. R. Decadal predictability of North Atlantic sea surface temperature and climate. *Nature* **388**, 563-567 (1997).
21. Goddard, L. & Mason, S. J. Sensitivity of seasonal climate forecasts to persisted SST anomalies. *Clim. Dyn.* **19**, 619-631 (2002).
22. Davey, M. K. et al. STOIC: a study of coupled model climatology and variability in tropical ocean regions. *Clim. Dyn.* **18**, 403-420 (2002).
23. Xie, S.-P. A dynamic ocean-atmosphere model of the tropical Atlantic decadal variability. *J. Climate* **12**, 64-70 (1999).
24. Kushnir, Y., Seager, R., Miller, J. & Chiang, J. C. H. A simple coupled model of tropical Atlantic decadal climate variability. *Geophys. Res. Lett.* **29**, 2133, doi:10.1029/2002GL015874 (2002).

25. Li, T. M. & Philander, S. G. H. On the seasonal cycle of the equatorial Atlantic Ocean. *J. Climate* **10**, 813-817 (1997).
26. Zhang, C. & Pennington, J. African dry-air outbreaks. *J. Geophys. Res.*, submitted (2004).
27. Biasutti, M., Battisti, D. S. & Sarachik, E. S. Terrestrial influence on the annual cycle of the Atlantic ITCZ in an AGCM coupled to a slab ocean. *J. Climate*, submitted (2004).

CLIVAR Pacific

The long-term objective of NOAA CLIVAR program is to enhance NOAA operational climate forecasts and to improve climate change projections and assessments.

In FY2005, CLIVAR Pacific invites proposals to investigate intraseasonal-to-decadal coupled ocean-atmosphere variability and their potential changes on decadal-to-centennial time scales including their linkage with anthropogenic-induced climate change.