New Thrusts, New Field Programs in the Pacific

Pacific Panel of International CLIVAR and their guests.

Surrounded by lush Hawaiian flora, and fighting mosquitoes and centipede attacks, the Pacific Panel of International CLIVAR (Climate Variability and Predictability) and their guests met February 15–17, 2006, in beautiful Manoa Valley in Honolulu. The retreat introduced the new panel (chaired by IPRC's **Axel Timmermann**), identified new scientific thrusts, and discussed new observational programs.

The new panel members are **Magdalena Balmaseda** (ECMWF, UK), **Wenju Cai** (CSIRO, Australia), **Amy Clement** (RSMAS, USA), **Bill Crawford** (IOS, Canada), **Dick Feely** (PMEL, USA), **Alexandre Ganachaud** (IRD, New Caledonia), **Rodney Martinez** (CIIFEN, Ecuador), **David Neelin** (UCLA, USA), **Scott Power** (BoM, Australia), **Bo Qiu** (University of Hawai'i, USA), **Toshio Suga** (Tohoku University, Japan), and **Dongxiao Wang** (SCSIO, China).

With regard to *ENSO dynamics*, the westerly wind bursts and their coupling with sea surface temperature were discussed as triggers of large El Niño events. These disturbances contribute to the wide spread in El Niño-Southern Oscillation (ENSO) forecasts among ensemble members. The challenges still remaining in forecasting El Niño and La Niña were noted in several reports. Recognizing the incomplete understanding of ENSO dynamics and the slow progress in seasonal prediction, the panel is organizing an international ENSO meeting in Australia in 2007.

A report on the *state of coupled general circulation models*, used for example in the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), shows that in most models the tropical mean state of the Pacific is severely biased, with the eastern tropical Pacific being too cold and the southeastern tropical Pacific being too warm (see page 6). Reasons for the biases were discussed. The new field program VOCALS (VAMOS Ocean-Cloud-Atmosphere-Land Study) may provide some answers. VOCALS studies feedbacks between upper-ocean dynamics, sea surface temperature (SST), stratocumulus clouds, and climate in the southeast Pacific. Another new program PUMP (Pacific Upwelling and Mixing Physics), which is looking at the effects of mixing on the mean thermocline temperature and variability in the eastern equatorial Pacific, should also provide answers. The panel plans to have close ties with these two programs.

The *warm pool of the western tropical Pacific* affects the strength of the Walker circulation and the position of the stationary wave patterns in the extratropics. Paleo proxy data reveal that the warm pool was about 4°C colder under glacial conditions than today. This suggests the heat balance of the warm pool is subject to long-term changes. Since climate modeling of this region is still problematical, an accurate assessment of the warm pool's effect on global climate change is not yet possible. Concerned about possible temperature changes in the warm pool, the panel members recommend that more

field programs target the region. The ongoing and planned field campaigns of the South China Sea Institute of Oceanology should improve our understanding of this region.

The *western boundary currents*, which transport heat away from the tropical oceans and release it to the atmosphere at higher latitudes, modulate the climates of Japan, New Caledonia, Australia, and indeed global climate. Changes in wind-stress can shift the fronts of these currents and alter the surface temperature in ways that affect atmospheric circulation. The Kuroshio Extension System Study (KESS) has looked into these front-shifts, and results suggest that long-term prediction of thermocline anomalies in the western North Pacific is feasible. Given this encouraging news, the panel decided to evaluate the hindcast and forecast skills of simple ocean prediction models that are driven by observed wind-stress anomalies and to assess their utility in climate predictions.

The *subtropical-tropical connections of the western boundary currents in the South Pacific* were outlined. SPICE (Southwest Pacific Ocean Circulation and Climate Experiment) is starting to monitor the dynamics and boundary currents in the southwest Pacific. Since the program is conducting experiments in the South Pacific analogous to KESS's North Pacific work, the panel recommended that SPICE establish links with KESS to learn from its experiences, and also with activities conducted by China on monitoring the low-latitude western boundary currents.

The topic *panoceanic connections* included descriptions of the supergyre in the Southern Hemisphere, the oceanic connections between the Pacific and Indian oceans, and results from Coupled Model Intercomparison Project water hosing experiments. The latter suggest that a weaker North Atlantic thermohaline circulation shifts the intertropical convergence zone in the Atlantic and Pacific southward. This shift changes the meridional sea surface temperature gradient, altering the annual cycle and ENSO. These oceanic and atmospheric teleconnections between ocean basins will be a major topic of the CLIVAR Multidecadal-to-Centennial Climate Variability Workshop to be held by the IPRC in Honolulu November 15–17, 2006.

The *climate change* section covered the following topics: a sketch of how our understanding of paleo climates can be used to assess future climate sensitivities; a study of estimates of radiation reduction due to aerosols, which account for 0.6–0.8°C cooling in the central equatorial Pacific and for over 1°C cooling in the subpolar North Pacific. This aerosol effect may be diminishing the greenhouse warming signal in the Pacific Ocean and its polar amplification.

Modeling Pacific climate is still fraught with uncertainties that hamper projections on how global warming will affect the region's climate. The panel debated the possibility of weighting simulations from different models in multi-model runs in accordance with their ability to meet certain standards. No conclusion was reached.

Standards for Ocean Models

The development of high-resolution, large-scale ocean models will help to understand how the ocean state is changing and to predict such changes. The physical processes and space and time scales of such models, however, must be carefully compared against observations, and their thermodynamic and dynamic balances, and such features as eddy sizes and eddy structures must be assessed. The creation of a model-evaluation system that permits comparisons across models is therefore urgent. To help with the development of such a system, the IPRC hosted the "Workshop on Metrics

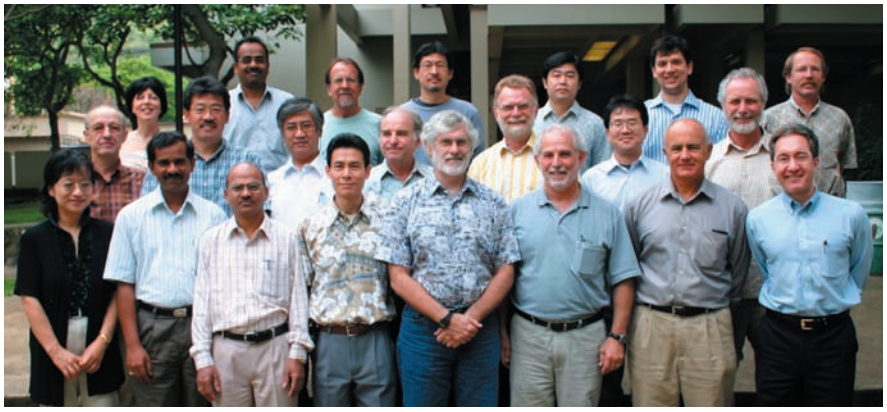
of Ocean Models" at the East-West Center, February 25, 2006. About 60 researchers and scientists from U.S. research funding agencies participated in the workshop.

Data sets derived from various satellite measurements and from direct measurements of the ocean are complex and diverse. The idea is to distill these different sets into a format that is relatively simple to use and allows comparisons among models and between models and observations. Two types of measurements or metrics were discussed: those characterizing the ocean state, and those characterizing the response of the ocean to a forcing imposed upon it. A standard grid for averaging data and clear identification of errors will make ocean observation sets more useful for model evaluation.

Workshop participants suggested creating a website dedicated to the development and use of metrics for ocean-model evaluation. The site would feature, among other things, descriptions and links to observationally derived data sets as well as a comparison between metrics derived from ocean models and from observations.

The workshop was organized by **Julie McClean**, Scripps Institution of Oceanography, and **LuAnne Thompson**, University of Washington, and sponsored by the Office of Naval Research and the International Pacific Research Center.

Plan Completed for Indian Ocean Observing System



Indian Ocean Panel Chair Gary Meyers (front row third from right) with IPRC Director Jay McCreary to his left and members of the Indian Ocean Panel.

The Indian Ocean Panel Workshop was held in early March 2006 at the IPRC in Honolulu instead of, as originally planned, in Reunion, where a mosquito-borne Chikungunya epidemic had broken out. Established in 2004, the panel was charged by the Climate Variability and Predictability (CLIVAR) Program and the Global Ocean Observing System (GOOS) with creating a plan for a comprehensive and continuing observation system to monitor Indian Ocean climate (*IPRC Climate*, Vol. 5, No.1).

At the Honolulu meeting, the panel's accomplishments were reviewed. The most important one is completion of the observation plan. The plan calls for a mixture of moored buoys, Argo floats, Acoustic Doppler Current Profilers, and ships to supplement remote satellite observations. It is published at eprints.soton.ac.uk/20357/. As a result of the panel's work, funding of the observing system by other countries has been forthcoming.

The monitoring system will be invaluable in answering such important climate questions as: Which surface and subsurface conditions in the Indian Ocean affect climate in Africa, Australia, Asia, and beyond? How do ocean conditions affect atmospheric disturbances, particularly the Madden-Julian Oscillation? Sea surface temperature (SST) in the Indian Ocean has increased rapidly in recent decades, while the heat flux into the ocean has decreased. What processes control this rise in SST?

Having published their observing system plan, panel members decided the panel should continue with a new charge. For instance, the panel is well positioned to provide the scientific and technical oversight needed for implementing the system, coordinate the work of participating organizations, ensure the observing system's functioning, recruit new participants, and develop links with the Indian Ocean Tsunami Warming and Mitigation System. The panel is also the appropriate group for coordinating and planning future research on Indian Ocean climate and its effects on the climate system as a whole. The Panel has presented recommendations for its continuation to the International CLIVAR program and GOOS.

High-Resolution Ocean Modeling on the Earth Simulator

The IPRC is participating with scientists from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) in analyses of outputs from high-resolution climate models run on the Earth Simulator (see page 6). IPRC's visiting scientist **Justin Small** hosted a workshop on February 27 on the University of Hawai'i campus for scientists working with OFES, the Ocean General Circulation Model for the Earth Simulator. Scientists from the Earth Simulator Center, the United Kingdom Met Office, and the IPRC discussed technical issues, reviewed recent research outcomes, and looked into possible collaborations. The workshop talks included low-frequency (decadal) variability, zonal jets, throughflows, countercurrents, parameterizations of eddy mixing, and chemical and biological transports. Work with OFES that may spawn further collaboration is summarized below.

OFES simulations on year-to-year and decadal variations in sea surface temperature (SST) and ocean currents were presented for the Oyashio Current, the South Pacific, the Kuroshio Extension, and the Gulf Stream. How these variations come about and how they affect SST, the atmosphere, and storm tracks promise to be fruitful topics for collaborations between IPRC and JAMSTEC. Among the first high-resolution models to have made hindcasts of many decades, OFES is suited for such studies. In particular, its high resolution allows study of the impact of eddies and sharp fronts on decadal variability.

Using QuikSCAT scatterometer wind measurements to force OFES can improve simulations. For instance, the Hawaiian Lee Countercurrent, a zonal jet flowing eastwards towards Hawai'i, was more realistic in the QuikSCAT-forced run than in a run forced with NCEP/NCAR reanalysis winds. In another study, OFES was used together with an offline nitrate-phytoplankton-zooplankton-detritus model to study how strong wintertime winds through the mountain gaps in Central America generate ocean eddies and upwelling that bring nutrients to the surface.

Tracers such as the modal distribution of chlorofluorocarbon (CFC) are being used to study the meridional overturning cell and its seasonal variations and higher frequency variations due to eddies. Also of interest is research on the Indonesian Throughflow, for example OFES simulation of water transports through this complicated network of channels.

Aside from the boundary currents and equatorial currents, the ocean was thought to flow in broad, graceful gyres. **Nikolai Maximenko** and **Kelvin Richards** at the IPRC recently found in both satellite images and high-resolution models that long, narrow zonal jets are almost ubiquitous in the ocean (*IPRC Climate*, Vol. 5, No. 1). These jets, which extend over tens of degrees longitude and a few degrees latitude, may have a similar origin to the banded structure seen on large planets such as Jupiter and Saturn. OFES is helping to understand the dynamics of these deep ocean jets.

Future research plans at the Earth Simulator Center include the development of an extremely high-resolution model (1/30 degree) of the North Pacific. The model will be nested into OFES. At present OFES does not simulate well the SST off the coast of Japan; this nesting may improve the situation. Another possible improvement to OFES is inclusion of the tides or parameterization of their effects on ocean circulation. Tides over shallow water and internal waves generated by tides give rise to patchy ocean mixing. At present OFES does not include these effects, and mixing coefficients, aside from those used in the mixed layer, are unrealistically uniform.

And there is good news for the climate research community. The OFES climatological run will soon become accessible to everyone on the servers of IPRC's Asia-Pacific Data-Research Center!

From left to right: Y. Sasaki, K. Richards, N. Schneider, R. Furoe, T. Jensen, Y. Sasai, M. Nonaka, S.-P. Xie, A. Ishida, Z. Yu, H. Sasaki, J. Potemra, B. Taguchi, R. J .Small. *Not pictured:* P. Hyder, H. Aiki, N. Maximenko, Y. Jia.