

# IPRC Scores High!

## A report on the FRSGC Interim Evaluation

Takuji Waseda

Japan's Frontier Research System for Global Change (FRSGC), established in October 1997 by the National Space Development Agency of Japan (NASDA) and the Japan Marine Science and Technology Center (JAMSTEC) to improve prediction of global climate change, held an *Interim Evaluation* of its research programs: the IPRC in Honolulu, the International Arctic Research Center in Alaska, and the six programs at the Institute for Global Change Research (IGCR) in Japan. The evaluation, held May 23–26, 2001, took place at the IGCR, which recently moved to the Yokohama Institute for Earth Science, home of the Earth Simulator supercomputer. Eight distinguished researchers from Australia, Germany, Japan, and USA made up the Evaluation Committee.

**Shuichiro Yamanouchi**, president of NASDA, and **Takuya Hirano**, president of JAMSTEC, opened the meeting. The FRSGC Director-General **Dr. Matsuno** and the co-chairs of the Evaluation Committee, **Dr. Nitta**, former director general of Japan Meteorological Agency, and **Dr. Brasseur**, Max Plank Institute for Meteorology, spoke about the evaluation's goals. This was followed by the directors' reports on their research programs. These reports were supplemented by private interviews with junior researchers from the various programs.

The Committee praised the FRSGC for its high quality research. Recommendations included contract renewal for young scientists beyond the current five-year limit; active recruitment of young women scientists; broader participation in international projects such as IPCC, IGBP and WCRP; creation of a strategy for developing model components for the Earth Simulator; and an enhanced visitor program.



Director Julian P. McCreary discussing IPRC research.

Regarding the IPRC, the Committee found that its research strategies—theoretical analysis, numerical modeling, and data analysis of physical climate processes—were “fitting” and “powerful tools” for research on IPRC scientific themes. They applauded the matrix organization, in which researchers with different research backgrounds and interests are mapped on to research projects under the four IPRC research themes, and concluded that this research structure combined with the research strategies has produced many excellent studies of scientific merit and a series of papers on North Pacific decadal variation that “forms the basis for an attractive new hypothesis on this important mode of climate variation.”

The Committee also evaluated favorably the recently established Asia-Pacific Data-Research Center at the IPRC—a center that is to provide easy access to climate data for scientists and the public—as well as the research on Theme 4, the environmental impact of global and regional change. They suggested adding a new theme, biogeochemical/physical modeling, and recommended that the IPRC 1) solve its computer resources problem, particularly in view of the Earth Simulator operation soon to begin, and 2) enhance information exchange and cooperation between young scientists at the IPRC and FRSGC.

According to the report, “The strong and experienced leaderships of Professor **J. P. McCreary** (Director of IPRC) and Professor **T. Yamagata** (Director of FRSGC's IPRC Program) ....are contributing significantly to capacity building. Young scientists coming from various countries are conducting excellent works and becoming world-class scientists in the active and well-organized research environment of the IPRC.” The reports summarizes, “The science program in IPRC is evaluated to be excellent, because it has contributed significantly to understanding of climate variations in Indo-Pacific Ocean, regional ocean influences on Asia-Pacific climate and Asian-Australian Monsoon System. ....The activity level of the IPRC is very high, showing one of the best examples of international cooperation. The IPRC receives high marks from the Evaluation Committee for its concerted efforts, progress and accomplishments up to date and its research plans for the next five years.”

# IPRC Holds First Annual Symposium

On June 5 and 6, 2001, the IPRC held its first of a planned annual series of symposia to review highlights of research conducted over the previous year. Held at the East-West Center, Honolulu, the symposium featured talks by IPRC scientists and several IPRC affiliates.

On Pacific Ocean circulation, ten talks were given. **Jay McCreary** presented a new theory on the equatorial subsurface Tsuchiya jets, in which ocean upwelling causes subsurface characteristics to converge and generate potential-vorticity fronts. **Tangdong Qu** analyzed results from a JAMSTEC high-resolution ocean model simulation, showing that mesoscale eddies enhance subduction rates by up to  $100 \text{ m yr}^{-1}$  in the formation region of the Subtropical and Central Mode Waters (STMW and CMW), a 44% increase over the regional average process; **Roger Lukas** (SOEST) linked Hawaii Ocean Timeseries data on interannual temperature and salinity variations to precipitation to the north, where subsurface water is subducted. **Konstantin Lebedev**, using 4-D variational assimilation, conducted an inverse-modeling study of the North Pacific Mode Water formation and transport, revealing two distinct sites of water mass production corresponding to STMW and CMW. In conducting large-eddy simulations of turbulent mixing and comparing them to existing 1-D surface mixed-layer models, **Dailin Wang** found that mixing is often poorly represented and guidelines are needed to describe conditions and purposes for which different models are appropriate. Pacific decadal variability was the subject of three talks: **Masami Nonaka** showed in a series of ocean GCM experiments that equatorial and off-equatorial wind forcing contributes about equally to decadal SST anomalies on the equator; using both observations and an intermediate coupled model, **Soon-Il An** suggested that decadal changes in the equatorial zonal wind and SST can cause changes in the interannual space-time structure of ENSO; and **Fei-Fei Jin** (SOEST) presented a theory in which tropical air-sea interaction generates interannual and decadal variability. Two talks were on satellite measurement application: **Zuojun Yu**, using wind forcing that properly resolves the aerodynamic effects of Hawaiian mountains, showed her ocean model can reproduce the eastward Hawaii Lee Countercurrent (HLCC) and that mesoscale eddies strongly affect HLCC's western extent; analyzing QuikSCAT and TRMM measurements, **Shang-Ping Xie** showed strong co-variability of surface wind, water vapor and clouds with tropical instability waves on the Pacific and Atlantic equatorial fronts.

For Indian Ocean circulation, **Bohyun Bang** presented preliminary results with an Indo-Pacific Ocean model; **Toru Miyama** described the cross-equatorial flows of the shallow overturning Indian Ocean circulation; and **Tommy Jensen** used passive tracers to illustrate the water exchange between Bay of Bengal and the Arabian Sea.

On the Kuroshio/Oyashio currents, **Takuji Waseda** presented numerical experiments revealing a mechanism for

Kuroshio-meander formation involving *anticyclonic* eddies; **Nikolai Maximenko** introduced a new index for the Kuroshio path that uses a bimodal decomposition of the temperature field at 400-m depth south of Japan and indicates the importance of deep circulation in creating and maintaining the large-meander state.

Regarding the Kuroshio and Oyashio Extensions (KOE), **Humio Mitsudera** presented a successful simulation of the Kuroshio and Oyashio confluence, revealing an Oyashio water pathway from the subarctic to the subtropics and the influence of low-potential vorticity Oyashio water on the stratification in the Kuroshio Extension; **Gang Yuan**, based on his analysis of acoustic tomography data from the 1997 KOE experiment and satellite data, concluded that during summer 1997 the recirculation grew stronger, making the Kuroshio Extension migrate northward; **Max Yaremchuk**, applying 4-D variational assimilation, showed that acoustic tomography is an efficient way to constrain the ocean state in the Kuroshio Extension.

The Asian-Australian monsoon session included monsoon climatology simulations with three different coupled



T. Li and H. Annamalai debating monsoon issues.

GCMs: **Tim Li's** newly developed IPRC ECHAM-MOM coupled GCM; **Johannes Loschnigg's** NCAR-C5M; and **Xiouhua Fu's** hybrid coupled model with ECHAM4 as the atmospheric component and the Wang-Li-Fu, 2.5-layer intermediate model as the ocean component. The simulations show that air-sea interaction enhances northward propagation of the intraseasonal oscillation over the Indian Ocean and impacts the monsoon by connecting two convective bands, namely, the monsoon trough and the equatorial Indian Ocean convective zone. Two studies analyzed observations on monsoon interannual variability: **Randy Wu** showed that the relationship between the East Asian summer monsoon and ENSO changes over decades; **H. Annamalai** showed that low-frequency circulation patterns derived from summer-mean composites affect high-frequency oscillations over the Asian Monsoon region during boreal summer. **Yuqing Wang** and **Omer Sen** presented their new IPRC Regional Climate Model (see p. 7). Finally, **Peter Hacker**, manager of the Asia-Pacific Data-Research Center, described the evolving Center.

# Plans for Ongoing, Real-Time Assimilated Ocean Data

## The International Workshop on GODAE with Focus on the Pacific

*Humio Mitsudera*

To advance climate research, a permanent system of measuring instruments that produces reliable data over the world's oceans and lands must be in place, as well as techniques for assimilating in the best way the many different measures into climate models. To date such measuring instruments are temporary and geared toward specific research projects rather than part of a coordinated, broad-based, permanent system. The Global Ocean Observing Panel for Climate has recognized this problem and is conducting the Global Ocean Data Assimilation Experiment (GODAE) to demonstrate that it is feasible to provide real-time global ocean data assimilation that gives regular and realistic descriptions of such ocean fields as temperature, salinity, and currents at high temporal and spatial resolution. The experiment, planned for 2003–2005 (2003–2007 in the U.S.), is intended to produce a synthesis of satellite and direct measurements consistent with dynamical and physical constraints, and error estimates for both observations and models.

The International Workshop on GODAE with Focus on the Pacific, hosted by the IPRC at the East-West Center July 23–25, 2001, was held to determine what still needs to be done over the next two to three years in the northern and tropical Pacific to conduct the experiment. About 50 scientists from Australia, China, Japan, Korea, and US attended to discuss present observing systems and data assimilation schemes, ways to conduct global and coastal (mesoscale) ocean data assimilation, ways to connect large- and meso-scale assimilation products, identification of data and model products to be used for the experiments, and the development of metrics to assess the quality of model assimilation products for the North Pacific and adjacent seas.

The ocean-data assimilation discussion focused on determining the best ways to assimilate global and Pacific Basin data ranging from seasonal to interannual timescales. In this context, IPRC associate researcher **Max Yaremchuk** showed how a 4-D variation method applied to the oceanic mixed layer can be used to obtain production-rate estimates of the Mode Waters in the North Pacific Ocean and how acoustic measurements can be assimilated into simple models.

Another session focused on Pacific boundary currents and North Pacific mesoscale eddies. Methods for assimilating mesoscale data in the western Pacific, for nesting mesoscale models within large-scale models, and for coupling ocean models with biological models were presented. **Takuji Waseda**, IPRC-FRSGC researcher, showed how *anti-cyclonic* eddies can generate short-term Kuroshio meanders



*Peter Hacker describing the APDRC.*

and stressed that prediction of Kuroshio pathways requires an understanding of the region's physical ocean processes.

The quality of various existing data products—satellite-based, numerical weather prediction, and direct measurements—and data assimilation products, together with comparisons among different types of measurements of the same variables, were also discussed. The GODAE real-time data server at Monterey was showcased, and **Peter Hacker**, manager of IPRC's Asia-Pacific Data-Research Center (APDRC), described the delayed climate data sets (including ocean assimilation products) that are, and will be, available on the APDRC server.

The scientists repeatedly raised the need for systems that serve quality-controlled, standardized, real-time and delayed ocean data sets and assimilated data-products. At present, climate data are distributed on many different servers with little standardization among the various sets, and much time is wasted in getting and formatting data to make it usable. The development of assimilation products for the western North Pacific is so important that participants discussed the possibility of GODAE conducting a pilot project to compare various products and assimilation methods.

Workshop conveners: **Toshiyuki Awaji** (Kyoto University), **Ming Ji** (NOAA–National Center for Environmental Protection), and **Humio Mitsudera** (IPRC). Steering Committee: **Ichiro Fukumori** (NASA–Jet Propulsion Laboratory), **Peter Hacker** (APDRC, IPRC), **Masafumi Kamachi** (Japan Meteorology Agency), **Michele Rienecker** (NASA–Goddard Space Flight Center) and **Max Yaremchuk** (IPRC). Workshop sponsors: NOAA–Office of Global Programs, Office of Oceanic and Atmospheric Research, and the Joint Institute of Marine and Atmospheric Research; NASA–Jet Propulsion Laboratory; Japan's Ministry of Education, Culture, Sports, Science and Technology; and IPRC.



## Monsoon Issues

IPRC Theme 3 is dedicated to improving the understanding of the Asian-Australian monsoon circulations. **Tim Li**, Theme-3 Co-Leader, held a mini-symposium to take advantage of the visit by monsoon specialist **Bill Lau**. The current prevailing view is that Indian summer-monsoon rainfall can be predicted from the equatorial eastern Pacific SST (NINO3 region), with a dry monsoon being simultaneously correlated with high NINO3 SST anomalies. Tim Li, however, showed that on a timescale of 2 to 3 years, the Indian Ocean (IO) SST pattern in preceding winter and spring is more closely related to monsoon rainfall. He stressed that the monsoon-ENSO relationship during developing and decaying phases of an El Niño is different. During the decay phase of El Niño, NINO3 SST anomalies have little influence on the following summer monsoon, which can be dry, wet, or normal, depending upon the IO SST anomaly sign. For instance, the three strongest El Niños of the last century (1972, 1982, and 1997) were followed by wet monsoons because they were all accompanied by uniformly warm SST anomalies in the Indian Ocean in the preceding winter. According to Li, these Indian Ocean SST anomalies may impact the Indian summer monsoon rainfall through enhanced moisture supply.

Lau believes most current theories are “ENSO-centric” because the GCMs used to predict rainfall over India during the monsoon capture only ENSO physics. “Since their simulation of subsidence over the monsoon region is too strong during El Niño years, they predict a weak monsoon regardless of conditions over the Indian Ocean and produce wrong predictions. Then, after running into trouble, they try to fix the monsoon physics. First, the monsoon physics, however, must be developed, then these equations must be built into the GCMs,” says Lau. “Another possibility is to improve predictions by coupling the GCM to an ocean model.”

Several IPRC scientists are using coupled models to understand monsoon dynamics better: **Johannes Loschnigg’s** work with the NCAR Climate System Model shows that composites of strong and weak monsoon years and north-south heat transport in the Indian Ocean support the idea that the IO SST dipole is part of a biennial cycle with monsoon circulation and NINO3-SST. **Xiouhua Fu** has coupled the ECHAM4

atmospheric GCM with the Wang-Li-Fu ocean model. Coupling resulted in more realistic monsoon precipitation than solutions with the ECHAM4 alone, showing, as in observations, a stronger rain belt near 15°N and a weaker one in the equatorial Indian Ocean. Improved results come from both local and remote air-sea interactions. Tim Li has coupled the ECHAM4 model to the Modular Ocean Model 2.0. With this model, Li is able to simulate ENSO-like variability in the tropical Pacific and a dipole SST in the equatorial Indian Ocean, which appears independent of eastern Pacific SST anomalies. Research conducted by **H. Annamalai**, however, suggests that in 1997, the ENSO events triggered the strong IO dipole.

More precise definitions of weak or strong monsoon are needed to improve research in this area, according to Lau. “Since rainfall is of great societal importance, it is usually used as a monsoon index rather than atmospheric circulation patterns. Scientists, however, are often unclear about what they mean by a strong or weak monsoon. The patterns of weak or strong monsoon differ from one region to the next, and even over China such indices may vary.” Lau, therefore, believes that a single monsoon index is not useful, but rather the region being discussed and the nature of the index being used, must be clearly stated. Moreover, he feels, there should be a distinction between indices used for prediction and those used for diagnostic purposes—indices for diagnostics should capture monsoon dynamics, such as vorticity.



# Forecasting Regional Climate

## The First IPRC Regional Climate Modeling Workshop

Regional climate models (RCMs) are useful tools for understanding and predicting regional climate. These models use more sophisticated physical parameterization schemes than general circulation models, and they represent more realistically and in finer detail the regional atmospheric circulation and surface forcings—such as topography, lakes, coastlines, and vegetation—and their effects on regional climate.

To facilitate RCM development, the IPRC held its first regional climate-modeling workshop at the East-West Center, October 10–12, 2001. On the first day, IPRC associate researcher **Yuqing Wang** gave an overview of regional climate modeling and the issues that must be resolved to improve the ability to simulate and predict local climates. Scientists then shared their different approaches and successes in modeling regional climate. Most of the models presented were developed to simulate the Asian monsoon as this region is climatically the most complicated on Earth, with land-surface characteristics ranging from desert to tropical forest, from immensely long coastlines to the Tibetan Plateau with mountains over 6000 m high, and with the huge Pacific Ocean to the east. Abstracts of the papers are available at <http://iprc.soest.hawaii.edu/announcements.html>.

Difficulties and uncertainties surrounding RCM research, and approaches to overcoming them, were the focus of the second day. Clouds, for instance, have a crucial effect on climate, and ability to model their feedbacks to the climate system is critical. What is the best way to model clouds? Some scientists are working on representing cloud processes explicitly, computationally a very expensive procedure. Others think clouds too complicated to ever get right; it is best, therefore, to deal with them macroscopically and to apply the best empirical cloud schemes from GCMs rather than detailed cloud microphysics. (In the IPRC–RegCM, see p. 7, reasonable simulations are achieved with explicit cloud microphysics when the model is run at a resolution of  $0.25^\circ$ ).

Another discussion dealt with surface boundary-layer processes in regional climate modeling. What level of complexity is needed in land surface models (LSMs) to represent land surface processes adequately? Participants agreed that the standard bucket model was inadequate and that a higher level (“intermediate” or “micrometeorological”) LSM was necessary. How should soil moisture be initialized? Everyone agreed that this was an important issue in land

surface modeling. The different methods, such as climatological and satellite remote-sensing of soil moisture, however, have limitations. The soon-to-be-released NCEP–NCAR reanalysis soil-moisture data was mentioned as an option for future application. In general, there was a consensus that a coupled atmosphere-ocean-land model could be expected to improve climate simulation.

Convective parameterization issues were also discussed. In winter, RCMs tend to be better in predicting temperature and rainfall than in summer. In summer, thermodynamics mainly drive the circulation; whereas during winter, large-scale dynamical forcing dominates. Poorer summer simulations arise from convective schemes that include many uncertainties representing the complexity of subgrid scale cumulus convection. Although cumulus parameterization is a way of incorporating the subgrid scale convective processes, an alternative approach to include their effect in a high-resolution model is to enhance the vertical subgrid scale turbulent mixing in the cloud region.

On the last day, participants discussed topics for collaboration. Possibilities raised were comparisons among the different models regarding their ability to simulate the following: a) the temporal and spatial characteristics of clouds, air-sea-land interaction, and convective activities; b) particular anomalies, for example, rainfall anomalies in East Asia during 1991, 1998, 1999; and c) the effects of such perturbations as deforestation and land-use, aerosols and doubling of  $\text{CO}_2$ . Diagnostic parameters would be cloud optical properties, cloud cover, outgoing long-wave radiation, the amplitude of the diurnal cycle, and pattern comparisons (EOF, for example) for surface air temperature, precipitation and circulations.

Workshop organizers were **C.-W. Wang**, State University of New York at Albany, and **Bin Wang, Yuqing Wang**, and **Lorenz Maggaard** from the IPRC.

