# iprc climate

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**Newsletter of the International Pacific Research Center — a center for the study of climate in Asia and the Pacific**

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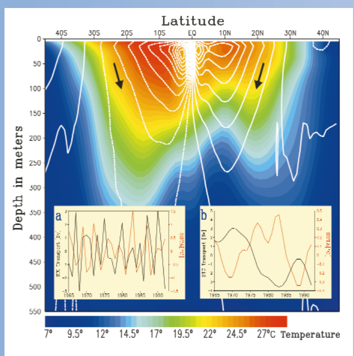


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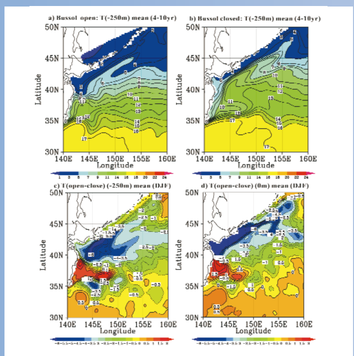


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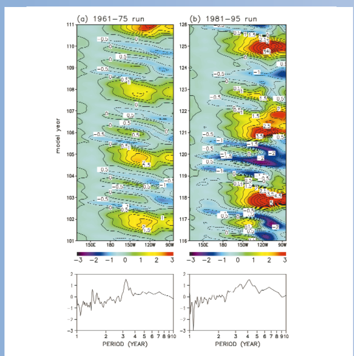


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University of Hawai'i at Mānoa
School of Ocean and
Earth Science and Technology

# Introducing the *IPRC Climate* Newsletter

This first issue of ***IPRC Climate*** introduces the newsletter of the International Pacific Research Center (IPRC) at the School of Ocean and Earth Science and Technology (SOEST), University of Hawai‘i at Mānoa. The center's mission is "to provide an international, state-of-the art research environment to improve understanding of the nature and predictability of climate variability in the Asia-Pacific sector, including regional aspects of global environmental change." Founded in October 1997, under the U.S.-Japan Common Agenda for Cooperation in Global Perspective, the IPRC is a collaborative effort between Japan and the United States.

***IPRC Climate*** will report ongoing research at the IPRC as well as summaries of IPRC-sponsored workshops and events. Our goal is to inform fellow climate researchers and the general public of IPRC activities. We welcome comments on our articles, which readers can send directly to authors (whose email addresses can be found at the IPRC website, http://iprc.soest.hawaii.edu) or to the editor, Gisela Speidel (speidel@soest.hawaii.edu).

Julian P. McCreary, Jr.
Director
International Pacific Research Center

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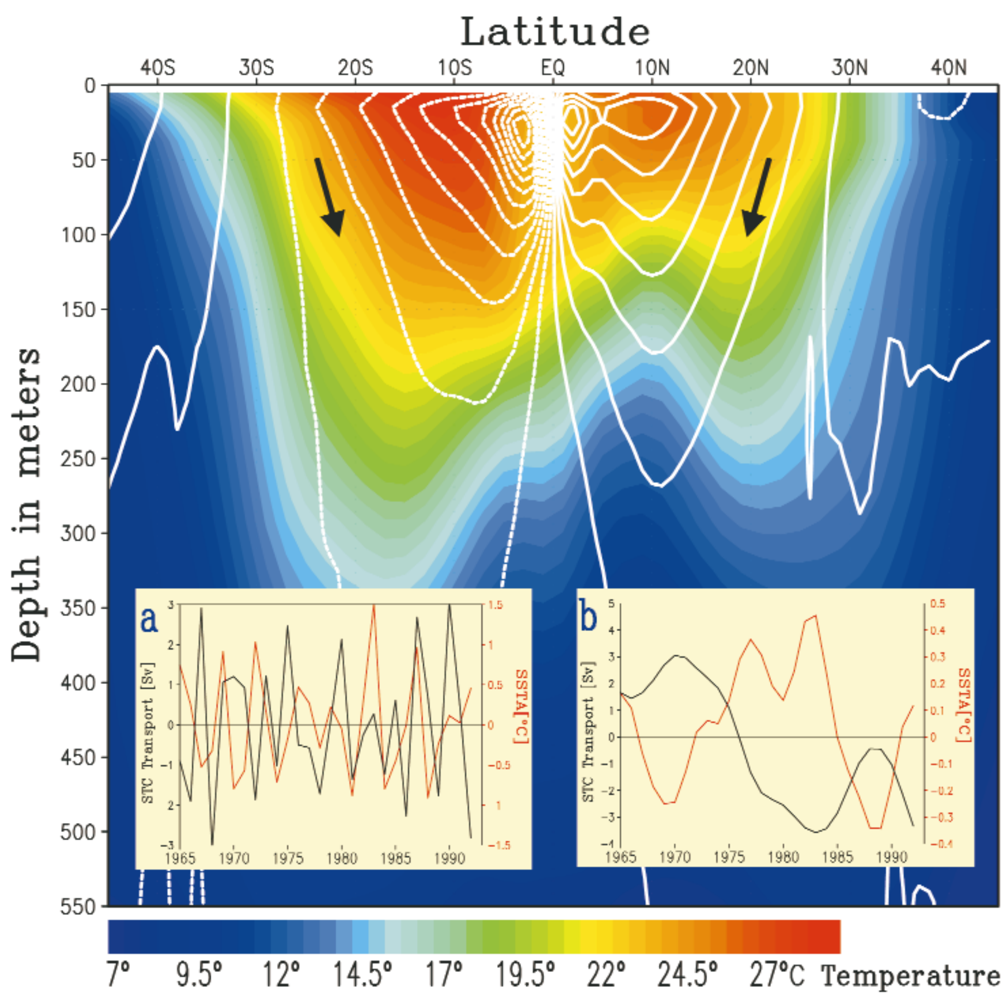


**Figure 1.** *Central Pacific meridional section of ocean temperature (color) and zonally averaged meridional streamfunction (white contours). Sea surface temperature and Subtropical Cell anomalies at interannual (panel a) and decadal (panel b) timescales.*

# Searching for the Cause of Slow Changes in the Equatorial Pacific Ocean

Sea surface temperature (SST) variations in the equatorial Pacific affect global climate. An increase in SST in this region appears to be linked to an increase in global-mean surface temperature since the 1970s and to slow changes in the temporal development of El Niño. (See *A Mechanism for Long-Term Changes in El Niño and the Southern Oscillation*, p. 7.) The cause of these slow variations has been puzzling scientists. **Masami Nonaka**, **Shang-Ping Xie**, and **Jay McCreary**, using an ocean general circulation model (GCM) driven by observed wind stress, have found that on decadal timescales, off-equatorial as well as equatorial wind variations contribute to SST variability (midlatitude winds contribute little). In contrast, the SST variability on interannual timescales (including El Niño) is driven largely by only equatorial winds. Different ocean dynamics must, therefore, govern equatorial Pacific SST variability on these two timescales.

A scenario suggested for the decadal SST variations is as follows: Variations in the off-equatorial trade winds cause variations in the strength (velocity) of the subtropical shallow overturning circulation, or subtropical cells (STCs). Depending upon the strength of the circulation, more or less cold water is transported toward the equator, where the surface water then becomes accordingly warmer or colder. This hypothesized sequence of events is consistent with the velocity anomaly mechanism suggested by Kleeman et al. (1999). The mechanism has received support by McPhaden and Zhang (2001), who used historical hydrographic data to show that the gradual increase in equatorial Pacific SST over recent decades is associated with a decrease in STC transport.

Using a realistic Pacific Ocean GCM that they have developed at the IPRC, Nonaka et al. provide evidence that also supports this mechanism. For details of their findings, see Figure 1 on the opposite page.

This figure shows a meridional section of the central Pacific. Temperatures are in color: thus, warm (red) water is shown floating over the cold (blue-purple) abyssal ocean. The white lines represent the meridional streamfunction along which the zonally averaged ocean current flows in the direction of the black arrows. As indicated by the lines, part of the water subducted below the surface in the subtropics moves to the equator, upwells there, and then returns to the subtropics in the surface layer, creating meridional cells or STCs that connect the subtropics and the equatorial region. The STCs are thought to maintain the tropical thermocline by transporting subtropical cold water (shown by colors from yellow to green) through the subsurface layer.

The lower panels show anomalies in STC strength (black) and equatorial SST (red) for interannual (a) and decadal (b) timescales. At decadal timescales, variations in STC strength are closely related to the SST variations, that is, strong STCs are associated with cold SST anomalies, consistent with the velocity anomaly hypothesis. This relation is not found on interannual timescales, because SST variations over this short time span are determined primarily by equatorial winds.

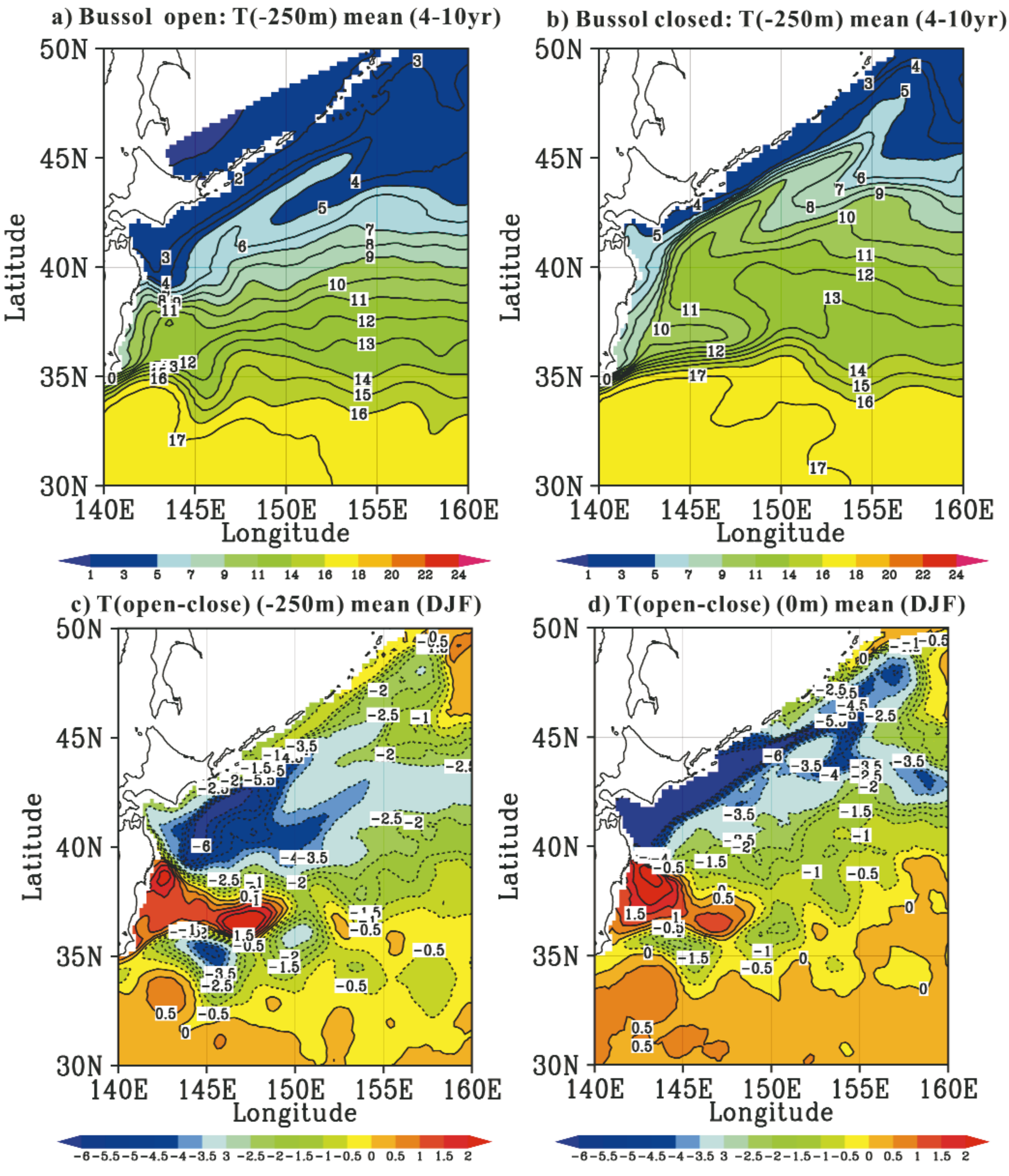


**Figure 2.** *Model simulations of ocean temperatures (ºC) at 250 m under open (a) and closed (b) Bussol Strait conditions. Winter-time temperature differences for solutions with open and closed Bussol Strait at depths of 250 m (c) and at the ocean surface (d).*

# Modeling North Pacific Ocean Climate Realistically

The climate of the North Pacific Ocean varies over decades; it influences weather systems in both Asia and North America and affects marine ecosystems and fisheries. Prediction of such climate variations is therefore useful but only possible if we understand what causes them. The main tool for understanding the ocean is the study of its variability in numerical modeling.

The region with one of the largest variations in SST, the coast off northeastern Japan, has not been simulated accurately until now; generally, models have produced SSTs in the region that are too warm. Recently, **Humio Mitsudera** at the IPRC and his Japanese colleagues **Yasushi Yoshikawa**, **Bunmei Taguchi**, and **Hirohiko Nakamura** have successfully simulated the temperature and salinity fields of this region. In particular, they have found striking impacts of including the outflow from the Sea of Okhotsk through the Bussol Strait, which lowered the simulated ocean temperature to realistic levels. The outflow first flows along the Kuril Islands and the Japanese coast as a density current that carries the very cold, low salinity and low potential vorticity Okhotsk water southward. It is then transported by mesoscale eddies into the ocean interior, where it occupies the intermediate levels.

Figure 2 on the opposite page shows the effects of two numerical modeling experiments on ocean temperature at 250-m depth (the depth at which air no longer affects water temperature): in (a) the Okhotsk Sea outflow is present; whereas in (b) it is absent. Water temperature is represented by the color bands, ranging from purple (1ºC water) to red (24ºC). It can be seen that in the region of interest the ocean is much colder in the open Bussol Strait case than in the closed case. This is shown even more clearly in (c), which represents the mean temperature differences in winter (December, January, and February or DJF) between the open and the closed conditions. The numbers in white rectangles show that between 35ºN and 45ºN the water is between 0.5ºC and 6ºC colder for the open condition. The final panel shows how SST is modified by the Sea of Okhotsk outflow. During the three winter months, SST is colder with outflow than without outflow by the amounts shown, a consequence of the colder subsurface temperature appearing at the surface owing to the formation of a deep mixed layer.

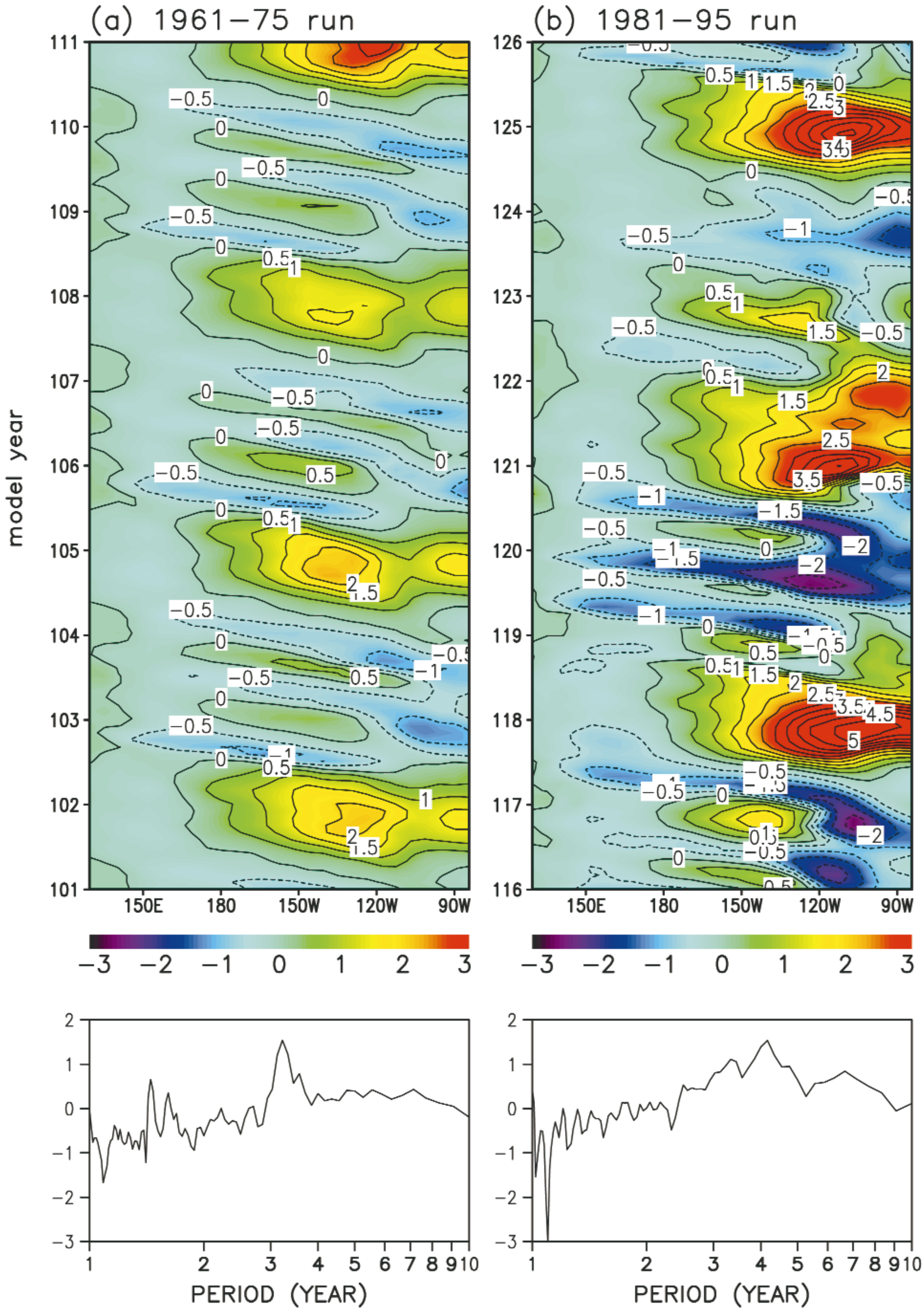


**Figure 3.** *Time series of SST anomalies averaged from 5ºS to 5ºN for solutions to the Cane-Zebiak model using two background states of the Pacific Ocean. Power spectra of NINO3 SST anomalies in log units (averaged over 5ºS to 5ºN; 150º to 90ºW) corresponding to the solutions shown directly above.*

# A Mechanism for Long-Term Changes in El Niño and the Southern Oscillation

In the 1970s, properties of the El Niño-Southern Oscillation (ENSO) changed notably: periods between warm and cold SST states grew longer, the SST differences between these two states grew larger, and the region of maximum variability shifted eastward. The research team of **Soon-Il An** and **Bin Wang** at the IPRC undertook to understand the causes of this change. Observations had shown that the most significant changes in the tropical Pacific from the pre-shift (1961-1975) to the post-shift (1981-1995) period had occurred in the surface winds and SST (See *Searching for the Cause of Slow Changes in the Equatorial Pacific Ocean*, p. 3), whereas changes in thermocline structure remained uncertain.

Using the coupled atmosphere-ocean model of Cane and Zebiak, An and Wang demonstrated that the observed changes in the surface winds associated with the Pacific climate shift can reproduce qualitatively the observed changes in the ENSO properties mentioned above (See Figure 3). The fundamental factor that altered the modeled ENSO's properties was a change in the background equatorial winds (i.e., an eastward shift in the wind stress anomalies) and associated upwelling. Observations had shown that the mean SST gradient from west to east across the Pacific was smaller during the post-shift than the pre-shift period, whereas the mean upwelling in the eastern Pacific was stronger. The stronger upwelling increased vertical heat transfer and reduced horizontal transfer. As a result, the prevailing westward propagation of the SST anomaly was replaced by a stationary oscillation or eastward propagation. Changes in the mean winds also affected ENSO properties by shifting the region of anomalous atmospheric heating and the zonal SST gradient eastward along the equator. An and Wang demonstrated with a conceptual model how such an eastward displacement will prolong the oscillation period and amplify the ENSO cycle by enhancing the growth rate of the unusual cold or warm ocean-atmosphere state and by delaying the transition from one state to the other.

Panels (a) and (b) of Figure 3 show the model's simulations of ENSO properties for the pre- and the post-shift periods respectively. A comparison of the panels shows that, during 10 years of a model run simulating the pre-shift state, there are four anomalous warm SST events, which usually reach a maximum of about 2ºC and occur around 130ºW. On the other hand, the post-shift state simulation shows for the same time span only three anomalous warm SST events, which range from 3.5ºC to 5ºC and occur about 105ºW.

# Observational Needs for Climate Research

## *NASA-IPRC-CLIVAR Decadal Climate Variability Workshop*

What should climate-observation systems be like in 5, 10, or 50 years from now to help scientists unravel the forces of climate and make predictions about climate variability and change? What instruments should be developed? How precise do they need to be? Where do they need to be deployed? These were the sort of questions that NASA asked researchers of decadal climate variability to consider at the NASA-IPRC-CLIVAR Decadal Climate Variability Workshop in Honolulu. Present global weather observation systems have been developed for short-term weather forecasting, not for recording climate variability over long periods of time. Knowing what events need to be measured and at what levels of space and timescales is essential to the development of an observation system that will be useful for climate research.

Over 80 scientists spoke on topics such as climate variations in paleoclimatic records, observations of decadal climate variations, interactions between decadal climate variability and modern society's activities, the modeling of decadal climate variation, ocean-ice-atmosphere processes, and ongoing and planned global observation systems.

The reports showed that, for understanding long-term climate variations, measurements are needed that will yield a better understanding of the vertical structure of the ocean, of salinity, of the thickness and extent of sea ice, and how variations in these interact with the atmosphere. The value of paleoclimatic records for reconstructing past climatic changes was affirmed, together with the need for getting such data quickly from the disappearing paleoclimatic records; other recommendations were to broaden the types of paleoclimatic records and their sampling regions. Further measurement issues raised dealt with precision (repeatability), drift over time (accuracy), and the cross-calibration of the constantly changing observation systems and instruments. Convincing other countries of the importance of maintaining their observation systems and giving free and open access to the data is an essential part of the global observing-measuring endeavor.

The scientists underscored, furthermore, the need for more data on the oceans in the Southern Hemisphere, and for modeling studies to accurately capture such processes as subduction, air-sea heat fluxes, transport, upwelling, and the melting of sea ice. Included in such studies should be the processes upon which paleoclimatic data relies: for example, studies of the effect of salinity and temperature on coral growth in order to validate the paleoclimatic coral data. The many complicated mathematical models presented at the meeting, moreover, highlighted the need for closely comparing their representation of processes. Finally, questions were raised as to whether such climate signals as the North Atlantic Oscillation and the Pacific Decadal Oscillation (PDO) really are distinct modes of ocean-atmosphere interaction, and whether they are predictable.

The very productive workshop was organized by **Vikram Mehta** on behalf of NASA. Mehta is a research scientist at the Earth System Science Interdisciplinary Center, University of Maryland, and the Climate and Radiation Branch, NASA/Goddard Space Flight Center. Participating in the organization were **Eric Lindstrom**, Oceanography Program Scientist at NASA Headquarters; **Antonio Busalacchi**, CLIVAR Co-Chair; **David Battisti**, U.S. CLIVAR Chair; and **Julian McCreary**, Director of the IPRC.

*continued on page 9*

*Workshop organizers (left to right): David Battisti, Vikram Mehta, Eric Lindstrom, Antonio Busalacchi, and Julian McCreary.*

# Coherent Measures on the Pacific Soon to Come

## *CLIVAR Pacific International Implementation Workshop*

Experts on Pacific oceanography, meteorology, and climate variability came from around the world to attend the Pacific CLIVAR International Implementation Workshop hosted by the IPRC at the East-West Center in Honolulu from February 5 to 8, 2001. CLIVAR Pacific's goal is to get a better handle on how the atmosphere and ocean work together and to create a scientific base for predicting Pacific climate changes on seasonal-to-centennial timescales. The discussions and planning done at the workshop form the basis for a draft implementation plan and for recommending to the International CLIVAR Scientific Steering Group the formation of an International Pacific Panel. The role of the Panel will be to coordinate regional and basinwide measurements taken by different countries with the various oceanographic and atmospheric observing systems (e.g., moorings, Argo Floats, radiosondes, satellites) in and over the Pacific and to determine gaps in this network. The Panel is also to coordinate observational studies, especially on the sparsely sampled Southern Hemisphere, as well as diagnostic, empirical, and modeling studies on such themes as the role of boundary currents, air-sea fluxes, and subtropical cells.

Among CLIVAR's interests in the Pacific are better prediction of ENSO and better understanding of other Pacific climate variations, such as the PDO, and of the interaction among different timescales. A focus will be on better understanding the ocean's role in climate beyond the tropics and on developing programs to study how much and by what processes heat is exchanged between the tropics and the mid- and high-latitudes.

Like CLIVAR, its parent organization, CLIVAR Pacific's intent is to leave as a legacy the long-term sampling of the Pacific and improved understanding of the Pacific climate system that will provide information of use to operational meteorological, oceanographic, and climate agencies in helping countries plan their agriculture, fisheries, energy, and water supplies.

**Robert Weller**, Director of the Cooperative Institute for Climate and Ocean Research, Woods Hole Oceanographic Institution, chaired the workshop and the organizing committee. Support came from the International CLIVAR Project Office, national CLIVAR programs, and the IPRC.

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The workshop, held at the East-West Center in Honolulu from January 8-12, 2001, was hosted by the IPRC and sponsored by NASA, CLIVAR, and the IPRC. Several IPRC scientists presented their research at the meeting. They were

**Shang-Ping Xie** (with coauthors Y. Okumura, A. Numaguti, and Y. Tanimoto), *Atmospheric response to changes in Atlantic cross-equatorial SST gradient: Tropical feed back and extratropical teleconnection*

**Masami Nonaka** (with coauthors Shang-Ping Xie and Julian P. McCreary), *Decadal variations of the strength of the Pacific Subtropical Cells and their effect on the tropical heat balance*

**Amy Solomon** (with coauthors Julian P. McCreary, Axel Timmermann, Barry Klinger, and Richard Kleeman), *Feedbacks between interannual tropical oscillations and decadal extratropical oscillations in an intermediate coupled model of the Pacific basin*

**Axel Timmermann** (with Fei-Fei Jin), *Decadal amplitude modulations of ENSO: Physical mechanism and predictability*

**Julian McCreary** was a speaker for the discussion session, *The role of ocean circulations.*

# A Database for North Pacific Climate and Ecosystems

## *PICES-CoML-IPRC Workshop*

A census of what once lived and what now lives in the ocean will give scientists a picture of past and present conditions of marine ecosystems. From this census they can then get a handle on how these ecosystems will respond to climate changes. The compilation of a report on North Pacific climate and its ecosystems brought the North Pacific Marine Science Organization (PICES) and the Census of Marine Life (CoML) together for the workshop "Impact of Climate Variability on Observation and Prediction of Ecosystem and Biodiversity Changes in the North Pacific." Times are right for creating such an inventory, as the ocean environment has become much more accessible. Technologies such as remotely operated vehicles, acoustic and optical sensors on moorings and buoys, and satellite observations make data collection much easier.

Atmospheric scientists, physical oceanographers, marine chemists, and marine biologists came from Canada, China, Japan, Korea, Russia, and the United States to join in this venture. They brought with them a gold mine of knowledge about databases from their regions. From the Bering Sea alone, US researchers have compiled a meta-database of 1,500 records. There are a number of data gaps, however. For example, there are few measurements of the open North Pacific, and little is known of certain species, especially those without any commercial value.

PICES will use the information to develop an integrated inventory of data sources—organized by regions—on the following topics: physical and chemical ocean measurements; phytoplankton, zooplankton, micronekton, and the benthos; fish, squid crabs, shrimps, and migratory fish; birds and mammals. This report, which is to be put together by representatives of the participating nations, will not only describe current ecosystems, but also models for understanding patterns and making predictions. The completed report will be made public and is expected to be used by marine policymakers of the participating nations.

Workshop members recommended that PICES expand the Bering Sea meta-database into a North Pacific ecosystem metadatabase listing all the database sources. The use of keywords will ensure uniform terminology, facilitating searches. The integrated data system will be a great step forward in detecting bas-

*Workshop organizers (left to right): Vera Alexander, Patricia Livingston, Cynthia Decker*

inwide patterns of change and seeing the effects of oceanic climate variations (such as the PDO) on ecosystems.

The workshop has already given scientists at the meeting a broad view of what is happening now in the North Pacific. Reports at the workshop point to a large-scale change—perhaps even a regime shift—in the past two years. Along the northeast Pacific Coast, for example, certain species of salmon and sea birds, that had declined in previous years, have shown a dramatic increase in juveniles. The Cassin's auklets, studied by **Douglas Bertram** with the Canadian Wildlife Service at Simon Fraser University, illustrate this change. Because they feed mainly on zooplankton, they have greater feeding difficulties when their production cycle is out of phase with the zooplankton bloom and they then tend to abandon their eggs. During '96 and '98, the North Pacific was warmer than usual, the plankton bloomed too early, and the number of young plummeted. In the following years, the sea surface cooled, the plankton bloomed later, and the number of young is now again on the upswing. Such a broadbrush view would previously have taken years to piece together from many separate data records.

The workshop, hosted by the IPRC from March 7—9 at the East-West Center in Honolulu, was organized by **Patricia Livingston**, Alaska Fisheries Science Center, National Marine Fisheries Service, and **Vera Alexander**, Dean, School of Fisheries and Ocean Sciences, University of Alaska. **Cynthia Decker** represented CoML. Sponsors were PICES, CoML (through the Alfred P. Sloan Foundation), and the IPRC. The workshop topic is consistent with the United Nations Convention on Biodiversity, adopted by major governments of the world at the Rio de Janeiro Earth Summit Convention in 1992. The agreement includes identifying and monitoring "the important components of biological diversity that need to be conserved and used sustainably."

# Asia-Pacific Network for Climate Information

## *Training Institute on Climate and Society in the Asia-Pacific Region*

The three-week-long Training Institute on Climate and Society in the Asia-Pacific Region drew 20 weather forecasters, agricultural specialists, and climate scientists to the East-West Center in February. The participants, who had been selected through competition, came from 14 Asia-Pacific nations and from Ethiopia. Organized and directed by **Eileen Shea**, Climate Project Coordinator at the East-West Center, the IPRC was one of the co-sponsors together with the East-West Center, the Asia-Pacific Network for Global Change Research (APN), the International START (System for Analysis, Research and Training) Secretariat, and NOAA-Office of Global Programs. The training institute was set up to strengthen the Asia-Pacific network of individuals skilled in using climate information to make decisions about climate variations and extreme weather events – decisions that could yield economic and social benefits.

The first week provided overviews of key climate processes in the Asia-Pacific region and their societal effects. IPRC scientists were invited to take part: **H. Annamalai** spoke on the Australian-Asian monsoon system, **Johannes Loschnigg** on emerging insights into monsoon predictability, **Axel Timmermann** on the ENSO Cycle, and **Shang-Ping Xie** on decadal variability.

Speakers came also from SOEST and the College of Social Science at the University of Hawai‘i at Mānoa; the Earth System Science Interdisciplinary Center at the University of Maryland; and the International Research Institute (IRI) at Columbia. **Michael Glantz** from the University of Colorado-National Center for Atmospheric Research spoke on “Societal Applications of Climate Forecasts,” drawing in detail upon his case studies of what worked and didn’t work to mitigate impacts by forecasting the 1997-98 El Niño. He also explored his idea of setting up a “climate affairs” university study program.

*Using those climate and agricultural forecasting tools!*

The lectures were supplemented with hands-on, learn-by-doing exercises; informal discussions with lecturers, institute sponsors; role-playing, and more. Scientists from IRI gave hands-on training in strategies and challenges of seasonal forecasting opportunities. A team from the International Global Change Institute, University of Waikato in New Zealand, trained the participants in using their climate vulnerability and adaptation integrated assessment modeling tool (VANDACLIM and its clones like FIJICLIM), which focuses on climate-agriculture interactions.

Sessions with scientists from the Agricultural Production Research Unit (CSIRO and the Queensland Department of Primary Industries), Australia, provided hands-on experiences on managing the mixed cropping systems of South Asia’s semi-arid tropics in response to seasonal climate forecasts. Participants also learned to use climate and agriculture forecasting and analytical tools being demonstrated in a Climate and Agriculture (CLIMAG) project supported by APN and START.

At the end, participants each gave a PowerPoint talk describing what they had gained and how they plan to use this experience in their countries. Many had already begun to discuss joint research projects with each other during the institute. An electronic bulletin board is being set up to continue the discussions and collaborations in the development and use of climate information. This is a significant step towards the Asia-Pacific climate information network, proposed by the participants.

# IPRC Moves into New Offices with Style

On December 14, the IPRC celebrated its move into spacious new offices on the campus of the University of Hawai‘i at Mānoa in Honolulu. The offices are on the fourth floor of the Pacific Ocean Science and Technology (POST) building, only a few yards away from the former offices in the Marine Sciences Building.

The President of the University of Hawai‘i, **Kenneth P. Mortimer**, and the Dean of SOEST, **C. Barry Raleigh**, hosted the dedication ceremony with IPRC Director, **Julian P. McCreary**, as Master of Ceremony. The ceremony, which was attended by over 70 guests opened with an ancient Hawaiian tradition, the blowing of a conch to call people together. **Axel Timmermann**, a postdoctoral fellow from Germany, mastered conch-blowing just in time for the dedication.

*Hawaiian blessing…*

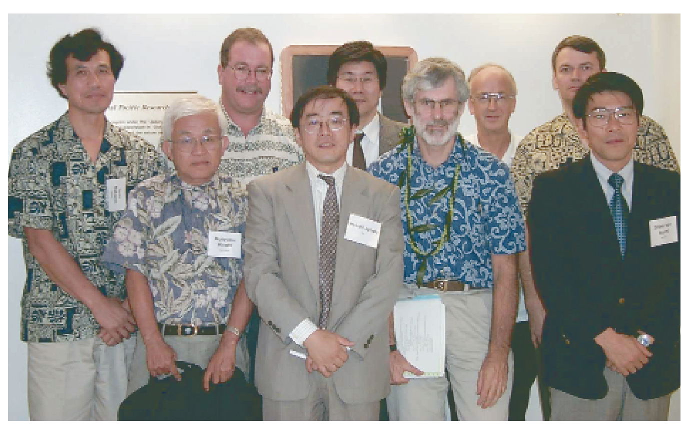

*Untying the maile…*

US Senators **Daniel Inouye** and **Daniel Akaka**, and US Representative **Neil Abercrombie** sent greetings and congratulations. Dean Raleigh spoke of the beginnings of the IPRC, only 3 years ago, of its rapid growth into a staff of nearly 40 people who come from all parts of the globe, and of plans for further growth.

President Mortimer portrayed the IPRC as a unique international, collaborative climate research program. “Since more than half of the world’s population lives in the Asian-Pacific region, the Center’s research to understand the forces that affect Asia-Pacific’s climate and its predictability is of great value. Predicting climate variation,” he said, “is particularly relevant because of the available scientific evidence on global warming. The new IPRC offices,” Mortimer said, “symbolize the close partnership we have with the various Japanese agencies that help fund this Center and the University of Hawai‘i’s total commitment to, and enduring support of, the Center’s research efforts.”

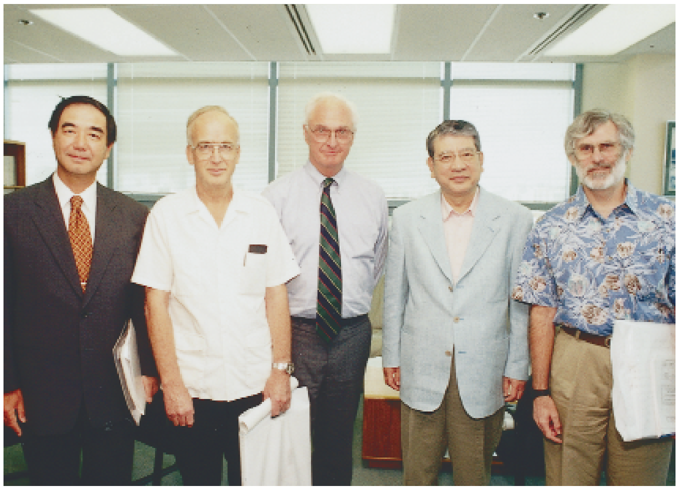
Japanese Senior Consul to Hawai‘i, **Masae Kunou**, brought greetings from Consul General **Minoru Shibuya** and commended “the IPRC on its outstanding efforts toward improving the understanding of the nature and predictability of climate variability in the Asia-Pacific region.” Consul Kunou stated, “the US-Japan Common Agenda has become one of the world’s most successful examples of cooperation between two countries, and I envision that this partnership will flourish for years to come.”

A traditional Hawaiian dedication ceremony followed the speeches. The Reverend Dr. **James Fung** from Kawaiaha‘o Church held the service. In Hawaiian tradition, the Reverend blessed the offices with three ti leaves dipped into waters from Kawaiaha‘o Spring and with salt of the sea. Senior Consul Kunou and President Mortimer untied the maile leis to symbolize the opening of the IPRC offices. The festivities ended with a reception.



*IPRC Implementation Committee at the opening ceremony with Co-chairs Hiroshi Jyodo (front, second from left) and Eric Lindstrom (back, second from left).*

# Japan's Minister of State for Science and Technology Policy Visits IPRC



(Left to right) Minoru Shibuya, Lorenz Magaard, C. Barry Raleigh, Takashi Sasagawa, Julian McCreary

Japan's Minister of State for Science and Technology Policy, **Takashi Sasagawa**, accompanied by the Consul General of Japan, **Minoru Shibuya**, visited the IPRC on January 12, 2001. He met at length with IPRC scientists from the Frontier Research System for Global Change. **Motoyasu Miyata**, IPRC Liaison Officer, described the mission, functions, staffing, and funding of the IPRC. **Humio Mitsudera**, Co-Teamleader of Theme 2, elaborated upon his team's research on the Kuroshio Current and its extension region and this region's possible impact on climate. **Shang-Ping Xie**, Theme-1 Co-Teamleader, briefed the Minister and his group on IPRC's current research on the El Niño/Southern Oscillation, decadal climate variability, and their effects on Japan and global warming. **Takuji Waseda** showcased the IPRC plans for the Asia-Pacific Data Research Center.

Minister Sasagawa and his accompanying staff asked about such climate-related topics as the Kuroshio Current, El Niño, global warming, and ARGO buoys, an indication of their interest in this area of research. The minister affirmed the importance of the IPRC as a bridge between the Japanese, U.S., and other international climate research communities. After the 50-minute meeting, the Minister toured the IPRC offices and facilities.

Offering a gift…

The Minister and the Consul General then met with **Barry Raleigh**, Dean of SOEST, **Julian P. McCreary**, IPRC Director, and **Lorenz Magaard**, Executive Associate IPRC Director. The Minister expressed to Raleigh his support of Japan-U.S. scientific cooperation, represented by such programs within SOEST as the IPRC, the Coral Reef Project, and the Marine Bioproducts Engineering Center. "In this highly technological world, a country cannot accomplish much on its own," said Minister Sasagawa. Raleigh and Sasagawa exchanged news about the construction of high-tech research vessels: Japan's ocean drilling vessel for the Ocean Drilling Project, which is an international research effort for the study of ocean-bottom sediments; and SOEST's research vessel to be completed in 2001, the *Kilo Moana*, which will collect atmospheric as well as surface, midwater, and sea-floor data, and conduct full ocean-depth surveys. Minister Sasagawa ended the meeting on a personal note, when he said, "I have often visited Hawai‘i privately, and Hawai‘i is like a second home."

Minister Sasagawa is the first Minister of State for Science and Technology, a position that was newly created within the Japanese Cabinet as part of the major government reform that took effect on January 6, 2001. The reform consolidated Monbusho (Ministry of Education, Culture, Science and Sports) and the Science and Technology Agency, which had been for many years the major funding agencies of scientific research in Japan.

# Global Warming Predictions

Professor **Akimasa Sumi**, who visited the IPRC from February 19 through March 3, 2001, is the director of the Center for Climate System Research (CCSR) at the University of Tokyo. The center develops coupled ocean-atmosphere GCMs and does research on climate change and variability. At an IPRC seminar, Sumi described his institute's climate modeling research with the CCSR model developed by A. Abe-Ouchi, Y. Yamanaka, M. Kimoto, A. Numaguti, and T. Nakajima. This model has a standard dynamical structure, but an advanced radiation component. In a series of experiments since 1995, the research team has simulated aerosol effects more and more realistically. Both direct and indirect effects of sulfate, carbon, sea-salt, and soil-salt were included in the latest simulations.

*Professor Akimasa Sumi*

The global warming experiments are conducted with projected greenhouse and aerosol emissions of four different possible scenarios for the future developed by the Intergovernmental Panel on Climate Change. The greatest temperature increase over the next century, according to the CCSR simulations, is seen in a heterogeneous world in which people are just interested in maintaining their life style without any concern for the environment, "a tiger world" according to Sumi. In this world, $CO_2$ would increase three-fold over the next century, and the latest version of the CCSR model predicts that the global temperature would rise about 4.5ºC or 8ºF. The best scenario for the environment, according to CCSR research is "a world of 'dematerialization' combined with clean technologies," a "spiritual world" that values material things less than many of today's societies. But even for this world, the CCSR simulation projects a 3.2ºC increase over the next century.

*The temperature is rising…*

CCSR simulation projections of temperature increases are higher than projections from other climate models. Yet, the simulations all agree that the "tiger world" will result in the largest increase and the "spiritual" world in the least. It is noteworthy that the CCSR simulations predict a more rapid increase in warming after 2050 because sulphur aerosol emissions, which lower incoming solar radiation, are projected to decrease.

"Society is asking for clear answers to the question of climate change," says Sumi. "Assessment of future climate is crucial to designing future society. Informing people about these scenario predictions is a good way to get people to see what will happen. We have to do something, and prediction is the key to designing our society and preparing our actions…it takes 5 to 10 years to prepare for this kind of change. The better our climate change prediction models become, the more we will know how to prepare ourselves." Dr. Sumi has voiced his concern about climate change by writing a book in Japanese about global warming. The English title of the book is *Truth of Global Warming*.

# On the Predictability of El Niño

The El Niño-Southern Oscillation (ENSO) phenomenon is fascinating climate researchers and the general public alike. For **Paul Schopf** – Professor of Oceanography at George Mason University, Fairfax, Virginia, and Senior Adjunct Scientist at the Center for Ocean, Land, and Atmosphere Studies – understanding ENSO has been a longtime quest. Why does Nature have this ENSO phenomenon? What is its purpose? What is the duration of an ENSO cycle? In 1983, Schopf, together with Max Suarez, published his well-known Delayed Oscillator Theory that mathematically describes the evolution of the ENSO cycle:

$$dT/dt = T(t) - AT(t - d) - T(t)^3$$

The character of the system is defined by the amount ($A$) of the delayed effect coming from the earlier time ($t - d$). While $T$ is usually thought of as temperature, the equation also describes the winds or ocean heat content.

More recently, Schopf has developed a global, quasi-isopycnal circulation model, namely, the Poseidon Ocean Model. He visited the IPRC during February 2001 to install this model for associate researcher **Zuojun Yu**, who will be using the model for comparative work.

Schopf has been exploring how atmospheric events affect the variability and modulation of ENSO by coupling the model with atmospheric GCMs that range from simple to complex. To see how energy in high-frequency, tropical atmospheric phenomena transfers to the less frequent ENSO events, he has been studying connections between high-frequency stochastic processes – such as the Madden-Julian Oscillation (MJO) and westerly wind burst – and SST variability in the Kuroshio and its Extension region, as well as in the PDO, and El Niño events. Model runs that include “atmospheric noise,” says Schopf, replicate the general state of the Pacific, such as the climate shift in the ’70s and decadal variations observed in ENSO; they also show that features such as the MJO could cause the PDO. Without the atmospheric noise, however, ENSO frequency and amplitude do not change over time and depend solely upon the $A$ and the $d$ coefficients appropriate for the model.

Though these results seem to explain the variability observed in ENSO over decades, they are only part of the picture: the model output's decadal SST differences in the Kuroshio and its Extension region, for example, are less than actually observed. This means feedback must come from some other part of the climate system. Possible mechanisms, according to Schopf, are the gyre circulation suggested by Latif and Barnett (1994) or a subtropical-tropical water pathway hypothesized by McCreary and Lu (1994) and Gu and Philander (1997). See also page 3 of this issue.

Is ENSO predictable? The answer, says Schopf, depends on whether ENSO has a preferred time scale on which it varies, that is, on whether one can predict how the coefficients $A$ and $d$ change over time. He has run his model now for 1,000 years (eight model-years can be run in one day) and has found that even after an absence of a decade (and a flat thermocline across the region), oscillations will eventually “kick in” again. He cannot yet tell, however, whether there is a longer periodicity to $A$ and $d$: if there is, then their evolution may be predictable and decadal changes in ENSO predictable; if not, then predictions of long-term changes in ENSO may not be possible but a “random walk.”

Regarding the hot topic of global warming, Schopf says there are several studies from NCAR and GFDL that are attempting to recreate 20th-century climate. Although many recreations show remarkable agreement, there are decades in which they do not agree, questioning their validity. These differences, according to Schopf, may be accounted for by the decadal variability seen in simulations with his simpler model. Moreover, the effect of simulated global temperature increases can be explored using his model’s heat flux parameterization. He is thinking of running his model with inputs based on recent climate changes in order to see what happens to global SSTs and to ENSO. How will the oscillations change? Will they disappear?

# Coming...

**Gary Tarver** joined the IPRC in February 2001 as a computer systems engineer. He hails from Texas, where he earned a B.S. in chemistry from Texas Tech University in 1981. Having worked part-time in the electrical construction industry while pursuing his undergraduate degree, he continued in the trades as a journeyman wireman after graduation. In 1990 he returned to Texas Tech just to take a few chemistry courses and brush up on recent developments. He enjoyed the study so much that he stayed and earned a Ph.D. in analytical chemistry in 1995. His dissertation, titled "Mapping Fugitive Sulfur Emissions from Texas Oil and Natural Gas Productions Fields," was a study of the physical and chemical processes in sulfur gases that are emitted into the atmosphere during the mining of oil and gas reserves. While working toward his Ph.D., Gary maintained the computers in the chemistry laboratories of Texas Tech, a pursuit he has enjoyed ever since.

Gary still has his hand in chemistry and computers. He writes computer software that controls and automates chemical instruments being designed at Texas Tech. One of his hobbies is process automation, which is a common use of computers.

Before coming to the IPRC, Gary was systems administrator and facilities coordinator at LavaNet, a Honolulu-based Internet service provider. Now at the IPRC, Gary is working with **Ronald Merrill** in computer system administration and assists in the planning and purchasing of computers and related equipment, the configuration of new equipment for end use, and the maintenance and upgrading of the installed hardware and the various other software at the IPRC.

**Jan Hafner** joined the IPRC as a scientific computer programmer in February 2001. He hails originally from Czechoslovakia, where, in 1990, he obtained his Rerum Naturalium Doctoris in Meteorology, which corresponds to the U.S. Master of Science degree. Shortly thereafter, he came to the United States as a graduate student in the department of Atmospheric Science at the University of Alabama, Huntsville, Alabama. After receiving his M.S. in atmospheric science in 1995 and his Ph.D. in 1996 from the University of Alabama, he moved on to become a postdoctoral fellow at Colorado State University's Cooperative Institute for Research in the Atmosphere (1997-1999) and then a research associate at Jackson State University (1999-2001). His research interests are in mesoscale numerical modeling, boundary layer processes, and surface-air interaction. He has published on modeling the urban heat-island phenomenon using satellite derived surface-soil parameters.

Jan will be working at the IPRC with **Shang-Ping Xie**, Co-Leader of Theme 1, on problems of ocean-atmosphere interactions and the role of ocean-atmosphere exchange in climate models. Currently, he is numerically modeling the wind wake triggered by the Hawaiian Islands. This is an interesting problem as the effect of the Islands on the atmosphere is observed to extend several thousands miles – many times longer than aerodynamic theory would predict.

**Tomohiko Tomita** is an atmospheric scientist who has been on the move professionally a fair deal for one so young. After obtaining his Ph.D. in geoscience from the University of Tsukuba, Japan, in 1994, he worked as a scientist with NOAA's Climate and Global Change Program at the University of California-Los Angeles' Atmospheric Sciences Department. In Fall 1997 he joined the Frontier Research System for Global Change and came to the IPRC. His research interests in ENSO and the monsoon, global climate change, and intraseasonal-to-interdecadal climate variability made his stay at the IPRC a good match.

Tomohiko came to the IPRC with the wish to build a communication bridge between the Japanese and U.S. researchers working on climate variation in the Asia-Pacific region. "With communication I mean informal discussion and exchange of ideas among scientists," he explains. He was successful in building this bridge – now the IPRC has a state-of-the-art video conferencing system. He, himself, will reap the benefits of this system back in Japan when he wants to talk with his colleagues at the IPRC. Tomohiko also began informal research discussions within the IPRC, when, together with **Bin Wang**, he started the IPRC lunchtime discussions. These discussions have become a major informal setting for exchanging research findings and ideas, giving rise to fruitful, and at times heated, debates on methodology and other scientific issues.

At the IPRC, Tomita was part of Bin Wang's and **Tim Li**'s Theme-3 team that studies the Asian-Australian Monsoon System. Much of his work, though, has been on decadal global variability in SST-atmospheric pressure fields. Recently, he has been working on the relationship between decadal surface and subsurface temperature variability in the midlatitude North Pacific with **Shang-Ping Xie** and **Masami Nonaka** in Theme 1, the Indo-Pacific Ocean Climate Group.

Tomohiko says that, being an atmospheric scientist, he learned much about ocean dynamics and the interaction between the atmosphere and the ocean while at the IPRC. "This knowledge will be useful for the research I plan to do back in Japan--global climate variability and the monsoon." He explains why he wants to focus on the monsoon for his research: "The monsoon is the heat engine of global climate; it's the most important piece, especially the heat and moisture balance. We need more quantitative information about heating in the monsoon and about what causes differences in heating rates." In Japan, Tomohiko will work with **Tetsuzo Yasunari** and **Kooiti Masuda** in the Large-Scale Water Circulation Group of the Frontier Research System for Global Change.

About his move back to Japan, Tomohiko says he will miss Hawai'i's climate, but looks forward to taking advantage of Japan's hot springs.

**Axel Timmermann** came to the IPRC for half a year as a postdoctoral fellow. During this short time, he worked intensely on the predictability issue of the ENSO phenomenon, work that he has done partly in collaboration with **Fei-Fei Jin**, IPRC affiliate with the UH Meteorology Department. ENSO prediction, according to most scientists, is limited to about one year lead-time because of intrinsic system nonlinearities and short-term atmospheric fluctuations, such as westerly wind bursts. According to Axel, however, amplitude changes in the El Niño may be predictable much further in advance.

His line of reasoning begins with model results of centuries of SST anomalies in the NINO3 region. This region shows periods of great variation and periods of little variation in the amplitude of the SST anomalies. The standard deviations of the anomalies have a cycle of about 10 to 20 years, a finding also seen in observations. In the next step of his argument, he applied nonlinear mathematical concepts—developed to describe the changes in behavior of theoretical homoclinic orbits – to a low-dimensional ENSO model. This model, which makes prognoses for SST and thermocline depth, produces variations in the size of SST anomalies with typical decadal cycles. This scenario is robust against the combined effect of stochastic and annual cycle forcing. On the basis of these past cyclical differences in El Niño amplitude, Axel suggests, the timing of SST anomalies of similar amplitude may become predictable.

Axel acquired his master's degree in theoretical physics at the University of Marburg, Germany. These studies soon became too "ivory towerish" for his taste, and he decided upon something more practical – meteorology. He obtained his Ph.D. in meteorology from the University of Hamburg in 1997 and then spent two years in the Netherlands with the Royal Dutch Weather Service.

Now he returns to Germany, to the Institute of Marine Research at the University of Kiel. There he will head a research team that will develop numerical models simulating paleoclimatic changes. The aim of this modeling work is to get a better understanding of the physical processes underlying swings in climate over millennia. Topics he plans to study are the effects of ice sheet instabilities, internal ocean instabilities, and coupled atmosphere-ocean-ice processes. He will also look at the consequences of long-term changes in output of solar radiation on climate and the effects of ocean tides with very long periods, such as the tide that has a period of 1,800 years.

**Igor Zveryaev**, a physical oceanographer and senior research scientist at the P.P. Shirshov Insitute of Oceanology in Moscow, joined the IPRC as associate researcher in 1998. A member of the Theme-3 team, much of his work at the IPRC was on atmospheric moisture in the tropics, using precipitable water (PW) as index. He found the following patterns: In an EOF analysis, the first mode accounts for 1/4 of the variance in annual mean PW and reflects decadal changes. This mode has four action centers: the tropical Pacific/South America, the Indonesian Maritime Continent, the equatorial central Pacific, and North Africa. Variations in the first two regions are in phase with each other, but opposite in the other two. The second mode has a coherent spatial pattern in PW variations over much of the tropics and is associated with ENSO. The third mode shows action centers of various patterns in the central-eastern tropical Pacific, Indonesia/western tropical Pacific, and South America/equatorial Atlantic.

Igor also studied decadal-interdecadal changes in the Asian monsoon system by looking at the intensity of intraseasonal oscillations (ISO) and summer-mean 850-hPa zonal winds, using 51 years of NCEP/NCAR reanalysis data. He noted that decadal-to-interdecadal variations contribute significantly to the variability in summer-mean 850-hPa zonal winds (30-45%) and ISO intensity (20-35%). The variations are associated with low-level westerlies and meridional dynamics of the Tropical Convergence Zone (TCZ). Singular-value-decomposition analysis shows a strong interdecadal correlation among Indian Ocean SST, summer-mean 850-hPa zonal wind, and ISO intensity; decadal correlations, on the other hand, are weak. Regarding the 1970 regime shift, he found that the Indian Ocean SST increased during the post-shift period, lowering the land-sea heat contrast and the strength of low-level westerlies over the northern Indian Ocean, India, and Indochina. In response to sea surface warming and intensification of convection, the 30-60-day ISO grew more intense over the equatorial central and western Indian Ocean and the South China Sea and less over the Indian subcontinent, northern Arabian Sea, and the Bay of Bengal.

Igor is returning now to Moscow and the P.P. Shirshov Institute, where he will continue this research.

# Visiting Scholars

***The IPRC has an active visitor program. Our visiting scholars give seminars and work with IPRC research staff. The IPRC sponsored the following visitors from December 2000 through March 2001:***

**Kaoru Ichikawa**
Kyushu University, Kyushu, Japan

**Kazutoshi Horiuchi**
FRSGC, Tokyo, Japan

**Jerry Meehl**
NCAR, Boulder, Colorado

**NH Saji**
FRSGC, Tokyo, Japan

**Friedrich Schott**
Institute for Marine Science
University of Kiel, Germany

**Kelvin Richards**
Southampton Oceanography Centre
University of Southampton, UK

**Brian Mapes**
NOAA-CIRES, Boulder, Colorado

**George Kiladis**
NOAA-Aeronomy Laboratory
Boulder, Colorado

**Richard Rosen**
Atmospheric and Environmental
Research, Inc., Cambridge, Mass.

**Akimasa Sumi**
Center for Climate System Research
University of Tokyo, Japan

**Dwi Susanto**
Lamont Doherty Earth Observatory
Columbia University, New York

**Jack Katzfey**
CSIRO - Victoria, Australia

**William Kessler**
NOAA-PMEL, Seattle, Washington

**Michael Glantz**
NCAR, Boulder, Colorado

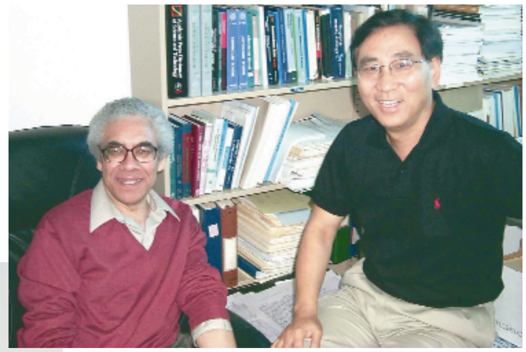
**Vyacheslav Lobanov**
Pacific Oceanological Institute
Vladivostok, Russia

**Kimio Hanawa**
Tohoku University, Tohoku, Japan

**Thomas Jung**
Alfred Wegener Institute of Polar
Research, Bremerhaven, Germany

**Dmitri Nechaev**
Stennis Space Center, Stennis, Miss.

**George Philander**
Princeton University, Princeton
New Jersey



*George Philander (left) and Bin Wang (right): Smiling at El Niño's complexities.*


*Richard Rosen explains the* Earth's Angular Momentum of the 20th and 21st Centuries.

*Vyacheslav Lobanov (left) and Nikolai Maximenko (right): Having fun with the Oyashio Current.*

*Friedrich Schott contemplates* The Three-Dimensional Circulation of the Indian Ocean.

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