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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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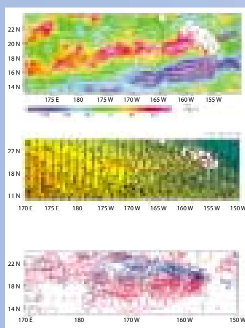

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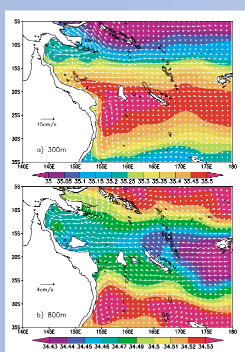

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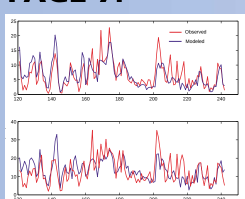

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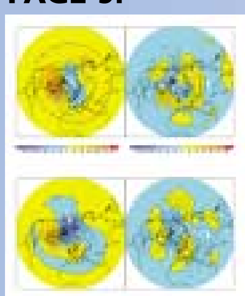

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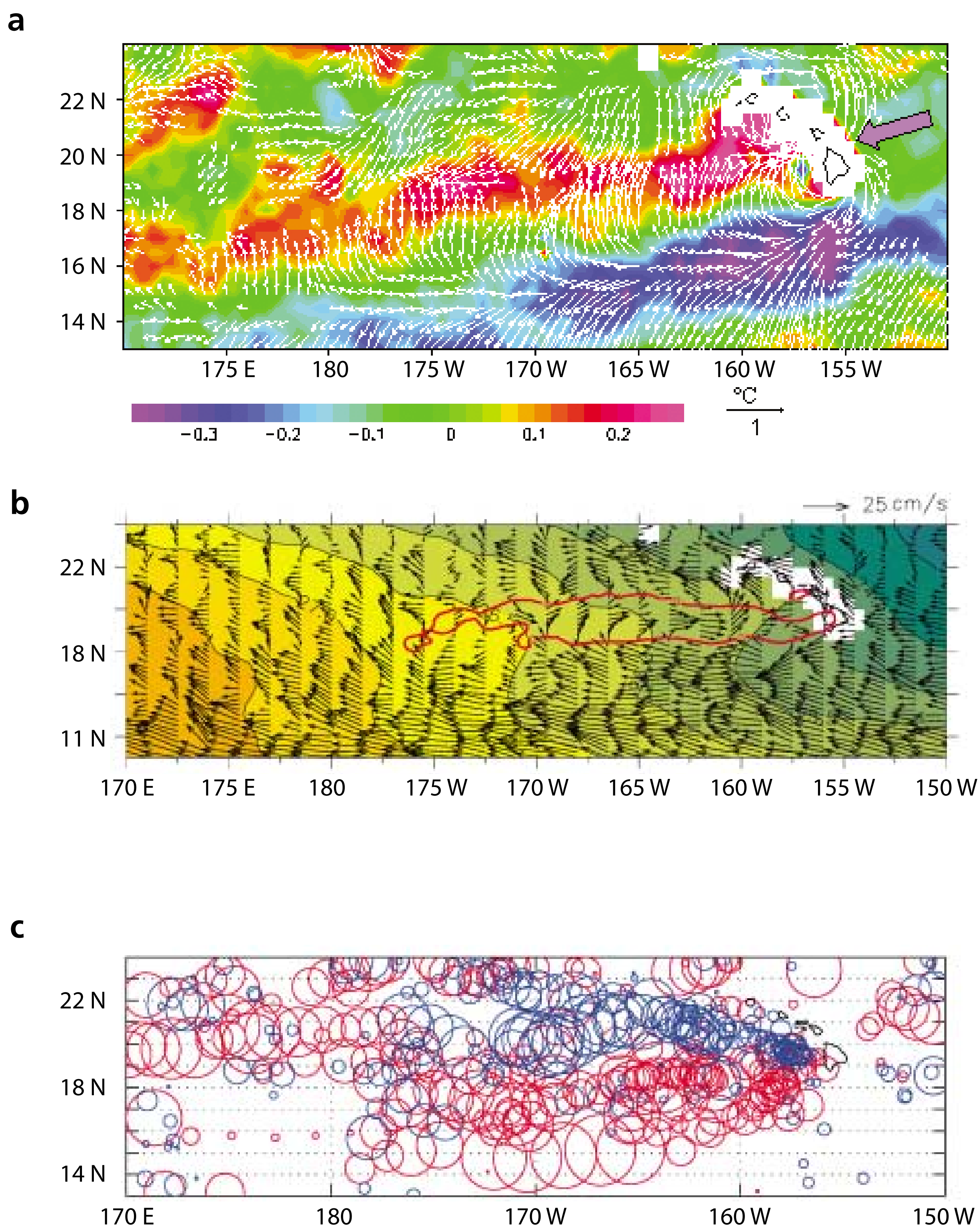


Figure 1. *The wind-wake of the Hawaiian Islands: (a) TRMM SSTs (high-pass filtered in the latitudinal direction to emphasize island effects; color scale in °C) and QuikSCAT wind vectors (m/s; the vector scale is also high-pass filtered and changed to 3 m/s east of 165°W); (b) mean surface currents from drifting buoy-data superimposed on annual mean SSTs based on 1999 TRMM data; and (c) eddy-related features derived from drifting-buoy data. The blue (red) circles indicate the locations and radii of cyclones (anticyclones).*

(Figure 1a is adapted with permission from Xie, Liu, Liu, Nonaka, 2001: Far-Reaching Effects of the Hawaiian Islands on the Pacific Ocean-Atmosphere System. Science, ***292****, 2057-2060. Copyright 2001American Association for the Advancement of Science.)*

The Hawaiian Isles' Remarkable Effect on Atmospheric and Oceanic Circulation

Wind-wakes caused by islands should dissipate within 300 km downstream. The Hawaiian Islands, however, trigger an interaction between the atmosphere and ocean that extends thousands of miles downwind. Using data gathered by advanced satellite technology, **Shang-Ping Xie** (IPRC), **W. Timothy Liu** (Jet Propulsion Laboratory), **Qinyu Liu** (Qingdao University), and **Masami Nonaka** (IPRC and Frontier Research System for Global Change) were able to detect this interaction (Far-Reaching Effects of the Hawaiian Islands on the Pacific Ocean Atmosphere System, *Science*, **292**, 2001). The narrow, long break in the Pacific tradewinds stretches more than 3,000 km from the western side of the Hawaiian Islands to beyond Wake Island and includes an eastward jet imbedded in the westward-flowing North Equatorial Current.

Unraveling the dynamics of the eastward jet, the authors show in their analyses how tiny islands, barely visible on a world map, can affect a long stretch of Earth's largest ocean. When the westward trade winds impinge on the Hawaiian Islands, standing tall in the middle of the Pacific Ocean, the islands force the winds to split, creating areas of weak winds behind the islands and strong winds on the islands' flanks (panel a). Individual wakes form behind the islands, but these merge about 240 km to the west. A dipole wind curl leeward of the Hawaiian Islands spawns the narrow eastward current that draws warm water from west to east. The resulting SST gradient forces the winds from the north and the south to converge, weakening the northeasterly trades to the south of the warm tongue and intensifying them to the north. This feedback loop allows the wake and the wind curl pattern to persist over a great distance. The study suggests that surface winds react to sea-surface temperature variations as small as a few tenths of a degree, indicating a climate sensitivity much higher than has been previously thought.

To study more closely the nature of the eastward flowing current, a team of IPRC researchers—**Zuojun Yu, Nikolai Maximenko**, Shang-Ping Xie, and Masami Nonaka—looked at eddy-related features, as well as at the mean surface flow recorded by drifting buoys near the Islands (panel b). Between 160°W and the Island of Hawaii, the anticyclonic (cyclonic) eddies are generally smaller than 100 km (60 km) in radius, and their rotational velocities can reach 80 cm/s (panel c). The eddies may become larger as they propagate westward, and the rotational velocities of the anticyclonic (cyclonic) eddies are between 20–50 cm/s (20–30 cm/s).

Using this information as a guideline, Yu and her collaborators were able to simulate the eastward jet and to unravel its dynamics with a 2.5-layer model at 0.1° resolution. Reproduction of the observed jet required that vigorous eddies develop west of the islands. The eddies appear very similar to the cyclones and anticyclones in the observation and seem to be dominated by barotropic instabilities. The barotropic instabilities act to limit the westward extent of the jet by weakening the horizontal shear. The team's analysis is summarized in the manuscript "Eddy–mean flow interaction west of Hawaii" (submitted to *Journal of Physical Oceanography*). Together these studies help to understand the fascinating phenomena triggered by the Hawaiian Islands.

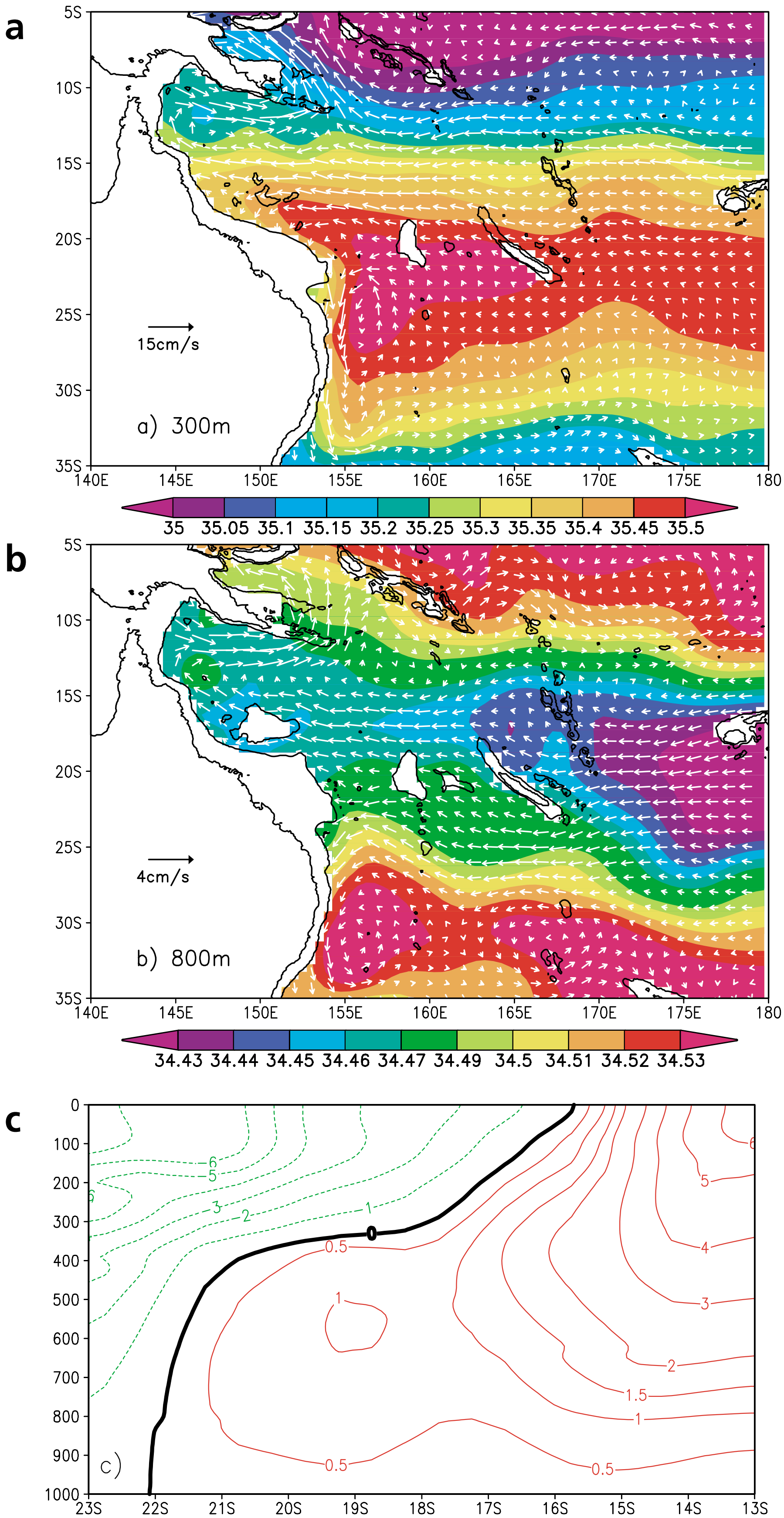


Figure 2. *Geostrophic velocity (relative to 1200 db) and salinity fields at (a) 300 m and (b) 800 m in the western South Pacific, and (c) the alongshore component of the flow (cm^{-1}) averaged within a 2°-longitude band from the coast. Positive values in (c) are northwestward, and the contour of zero velocity indicates the bifurcation of the SEC.*

Currents of the Western South Pacific

The low-latitude western boundary currents (LLWBCs) of the Pacific have been shown to play a very important role in the development of El Niño. They are also a key component of the global thermohaline circulation. These currents are therefore believed to be important in determining the world's climate. In the Northern Hemisphere, the LLWBCs include the Mindanoa Current and the Luzon Undercurrent; in the Southern Hemisphere, the New Queensland Current and the New Guinea Coastal Undercurrent.

A fair amount is known about the Northern Hemisphere LLWBCs, but much less is known about their Southern Hemisphere counterpart. The South Equatorial Current, as it approaches the Australian coast, splits into the southward-flowing East Australian Current and the northward-flowing North Queensland Current. The precise location of this bifurcation determines the amount of subtropical water imported to the tropics via the LLWBCs, and hence is probably significant for Pacific climate variability. The large-scale circulation of the western South Pacific has been broadly described based on various synoptic observations, and there is evidence to suggest the existence of a subsurface countercurrent, i.e., the Great Barrier Reef Undercurrent flowing northward underneath the East Australian Current at about 18°S. The detailed structure of the South Equatorial Current bifurcation, however, has never been carefully examined due to sporadic sampling.

Tangdong Qu, associate researcher at the IPRC, and his collaborator **Eric Lindstrom**, Oceanography Program Scientist at NASA, recently constructed a new data set using all existing hydrographic observations and provided a climatological interpretation of the circulation in the western South Pacific. By averaging the data along isopycnal surfaces in a 0.5°x0.5° grid, with an e-folding smoothing scale of about 100 km, they show many detailed phenomena associated with the narrow western boundary currents along the coast of Australia and Papua New Guinea.

Panels (a) and (b) of Figure 2 show the dynamically calculated (relative to 1200 db) velocity fields at 300 and 800 m, and panel (c) shows the alongshore component of the flow averaged within a 2°-longitude band from the coast. Over a large part of the region studied, say, south of 15°S, the signature of the South Equatorial Current is weak at the sea surface, and the surface flow seems to be predominantly eastward (not shown). At about 300 m (Figure 1a), the current is fully developed, and at deeper levels, it becomes weaker but more widely spread (Figure 1b).

This study reveals two significant features. First, with increasing depth, the bifurcation of the South Equatorial Current shifts southward, from about 15°S near the surface to about 22°S in the intermediate layers (Figure 2c). As a result, the origin of the Great Barrier Reef Undercurrent is at about 22°S, which is somewhat farther south than previously thought. Further north, the Great Barrier Reef Undercurrent intensifies below the East Australian Current and merges with the North Queensland Current at about 15°S, adding to the waters that flow into the New Guinea Coastal Undercurrent through the Louisiade Archipelago. Second, a strong water-property connection exists between the Coral and Solomon Seas. Water of South Pacific origin, such as the South Pacific Tropical Water and the Antarctic Intermediate Water, can be traced from the Great Barrier Reef Undercurrent and the North Queensland Current to the New Guinea Coastal Undercurrent, supporting the hypothesis that the New Guinea Coastal Undercurrent comes from the south via the Coral and Solomon Seas.

This identification of the structure of these Southern Hemisphere LLWBCs provides a background for understanding the circulation, including the thermohaline circulation, in the western South Pacific, as well as a guideline for the design and analysis of future observations and simulations of the region. The findings, thus, are a significant step toward understanding the role of ocean circulation in global climate and climate change.

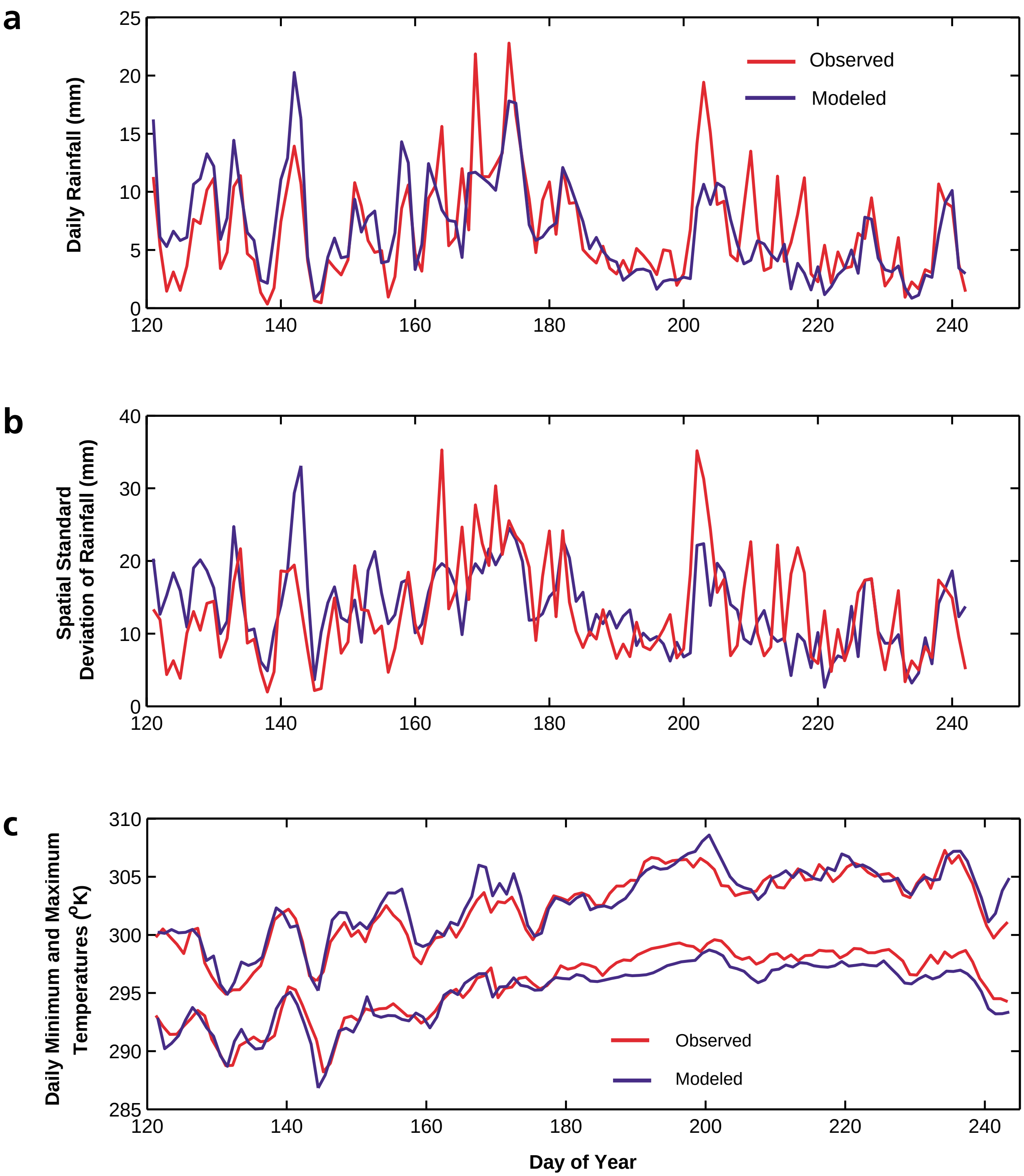


Figure 3. *Results from the IPRC–Regional Climate Model simulation of the 1998 Asian summer monsoon for the region 23-34°N, 105-122°E: (a) observed and modeled daily precipitation; (b) the spatial standard deviations of the observed and modeled daily precipitation; and (c) observed and estimated daily minimum and maximum temperatures.*

The IPRC–Regional Climate Model

Accurate regional climate predictions are important but difficult to make. **Yuqing Wang**, IPRC associate researcher, and **Omer Sen**, IPRC postdoctoral fellow, have developed the IPRC–Regional Climate Model (IPRC–RegCM), designing it for regional climate research and prediction, especially for studies of the Asian-Australian monsoon. To evaluate the model's performance, they have used it to simulate the 1998 summer monsoon, which caused severe flooding in China. The model domain covered the East Asian summer monsoon region with a resolution of 0.25° in both latitude and longitude. The simulation was run from April 28 to August 31, and results were compared to available station observations in the combined Yangtze-Huai River basin and southern China (23-34°N, 105-122°E) region.

Figure 3 shows the observed and modeled daily precipitation (a) and their spatial standard deviations (b) for the area defined above. The model realistically reproduces the trends and fluctuations of precipitation over the region. The spatial patterns of modeled and observed rainfall variability also agree reasonably well. (Note that the precipitation was underestimated between Julian days 200–220.) Table 1 below summarizes monthly statistics related to precipitation. The table shows that the correlation coefficients of the spatial precipitation patterns indicate good simulation skill in all months except July.

Figure 3c shows observed and modeled daily minimum and maximum temperatures. The estimated daily temperatures are in good agreement with the observations, though there is a small cold bias in the daily minimum temperature during the last two months.

Overall, the model captures the unique features of the Meiyu fronts, the associated rainfall, including a severe flood during the period, and land-surface processes. It can thus be used to study regional climate over East Asia, and to make climate predictions by nesting it in a GCM.

The IPRC–RegCM is based on a mesoscale tropical cyclone model developed by Y. Wang (*Mon. Wea. Rev.*, 2001). It incorporates an advanced radiation scheme (Edward and Slingo, 1996) and an advanced land-surface model (BATS; Dickinson et al., 1993), together with high-resolution vegetation and soil classification data to simulate the land-surface processes realistically. Using hydrostatic, primitive equations in longitude/latitude grids with sigma as the vertical coordinate, the model physics include an E-ε turbulence closure scheme for subgrid vertical mixing, a modified Monin-Obukhov scheme for the surface-flux calculations over the ocean, a mass-flux scheme with CAPE (convective available potential energy) closure for subgrid-scale cumulus parameterization, an explicit treatment of mixed-ice phase cloud microphysics for grid-resolved moist processes, and frictionally-induced dissipative heating. For initial and lateral boundary conditions, the model uses NCEP-NCAR reanalysis, and weekly Reynold's SST for lower boundary conditions over the ocean. The soil moisture fields were initialized such that the initial soil moisture was based on the vegetation and soil type defined for each grid cell.

Table 1. Monthly mean statistics of observed and simulated precipitation (mm day^{-1}) over the region.

Month	Observed Mean (mm)	Estimated Mean (mm)	Spatial Correlation	Temporal Correlation	Bias (mm)
May	5.74	7.78	0.49	0.92	2.34
June	9.45	8.90	0.67	0.69	-0.33
July	6.70	5.64	0.05	0.67	-1.07
Aug.	5.04	4.00	0.51	0.56	-1.17

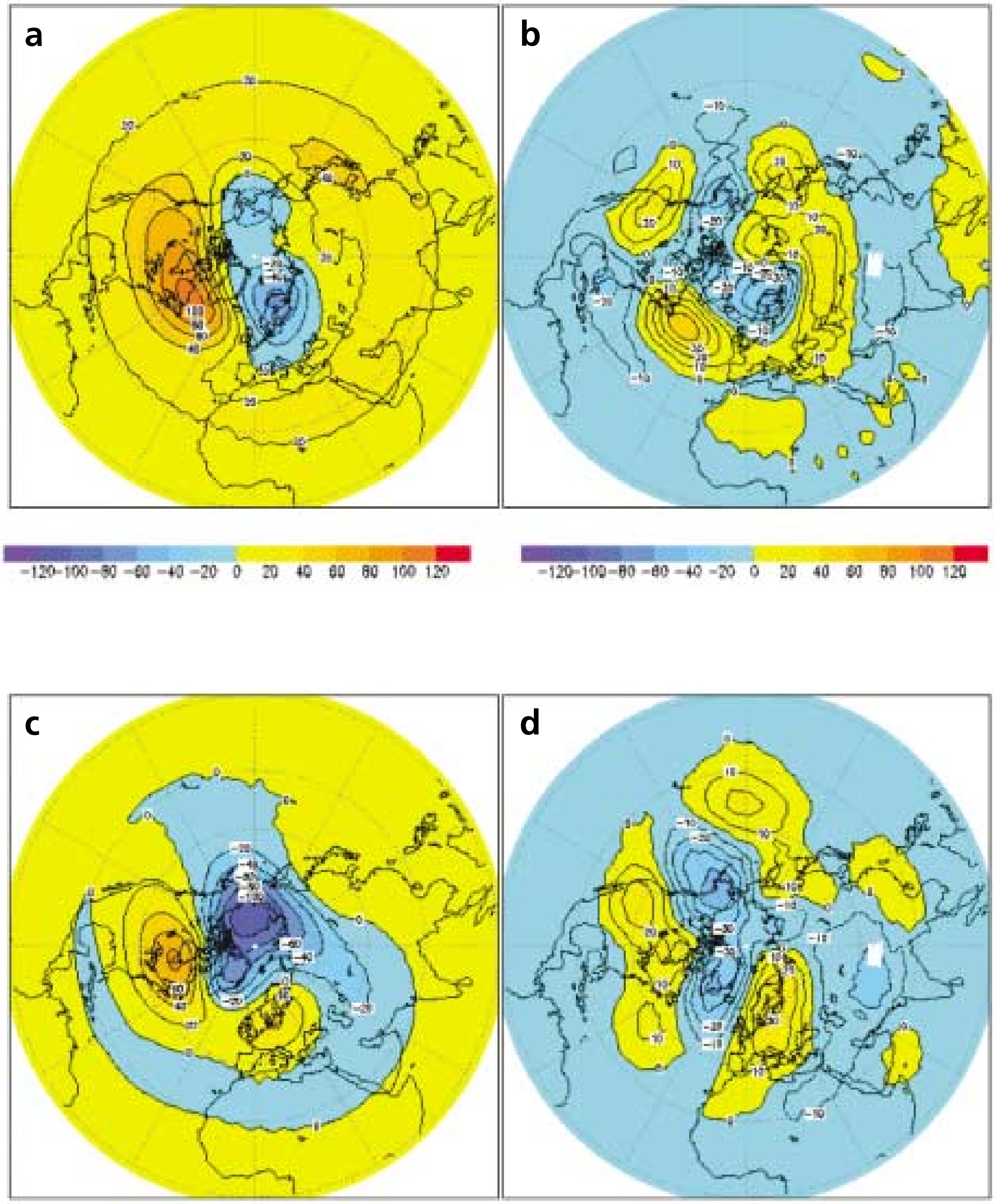


Figure 4. *Aspects of the SKYHI model simulation of aerosol effects from the Pinatubo eruption: (a) 50 hPa and (b) 500 hPa geopotential height anomalies for December to February in the first year after eruption; (c) 50 hPa and (d) 500 hPa geopotential height anomalies for December to February in the second year.*

Effects of Volcanic Eruptions on Large-Scale Atmospheric Circulation

Large explosive volcanic eruptions inject massive amounts of sulfur into the stratosphere. This rapidly forms a significant aerosol layer of sulfuric acid droplets that persists over the next two or three years. In the last decades of the 20th century there were several major explosive eruptions: Mt. Agung, Indonesia, in 1963; El Chichon, Mexico, in 1982; and Mt. Pinatubo, Philippines, in 1991. Following each of these eruptions, the climate in the Northern Hemisphere in the two subsequent years was anomalous. In summer the extratropical surface temperatures were lower than normal, which is an expected consequence of the reduced direct solar heating of the troposphere as more of the solar beam is absorbed in the stratosphere. In winter, however, the situation was more complicated and the most prominent effects observed at the surface were warm anomalies in North America and northern Europe. The observed winter-mean anomalies in the extratropical circulation and surface climate were as large as those that typically accompany the mature phases of large El Niño events. How the volcanic perturbation to the stratospheric aerosol layer is related to the winter extratropical surface anomalies remains uncertain.

Kevin Hamilton, IPRC Theme 4 leader and Professor of Meteorology, has been investigating the atmospheric processes that may be mediating the warming of certain regions of the Northern Hemisphere troposphere by studying the effects of the largest and best-observed of these 20th-century eruptions, that of Mt. Pinatubo in June 1991. He is conducting this work with colleagues **Gera Stenchikov** and **Alan Robock** (Rutgers University), **V. Ramaswamy** and **Dan Schwarzkopf** (NOAA–Geophysical Fluid Dynamics Laboratory). They are applying the SKYHI troposphere-stratosphere-mesosphere general circulation model to simulate the atmospheric effects. Imposing the detailed space-time evolution of the stratospheric aerosol cloud observed by satellite after the Pinatubo eruption in integrations of the model, they are comparing these perturbed runs with results from long control integrations. Figure 4 shows the model simulated stratospheric geopotential anomalies during (a) the first post-Pinatubo winter, and (c) the following winter, and the simulated mid-tropospheric geopotential anomalies during (b) the first post-Pinatubo winter, and (d) the following winter. The model results agree reasonably well with the observed anomalies for the same periods. As in the observations, the simulated tropospheric circulation anomalies are accompanied by significant surface warming over North America and northern Europe.

The connections between the aerosol perturbation and the winter circulation changes may be quite subtle. The aerosol absorbs more solar radiation at stratospheric levels. In the winter-hemisphere stratosphere, this leads to an enhanced equator-to-pole temperature gradient and a stronger polar vortex (hence the negative geopotential anomalies over the pole in Figure 4a and c). But how are the anomalies in the stratosphere transmitted down into the troposphere? Given the realistic simulations of the post-Pinatubo anomalies with the SKYHI model, Hamilton and his collaborators are now applying the model to study the processes that could produce the anomalous surface warming over North America and northern Europe. The tropospheric anomalies could be due to the purely dynamical effects of the changed stratospheric vortex on the propagation of large-scale planetary waves. Alternatively, such anomalies could result from aerosol-related radiative perturbations to the troposphere. Even determining the significant radiative perturbations is complicated, as the aerosols affect both solar and terrestrial radiation directly via absorption and indirectly through their effects on stratospheric ozone chemistry.

Hamilton and his colleagues have completed a number of other experiments with the model in which, for example, the effects of the aerosol on the stratospheric ozone, or the effects of the aerosol on the absorption of the direct solar beam, are suppressed. Analysis of this array of simulations will produce insight concerning the significance of various mechanisms that connect the presence of the volcanic aerosol to perturbations in the surface climate.

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 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 (KOEs), **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 GCMs: **Tim Li's** newly developed IPRC ECHAM-MOM coupled GCM; **Johannes Loschnigg's** NCAR–CSM; 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.

T. Li and H. Annamalai debating monsoon issues.

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 *anticyclonic* eddies can generate short-term Kuroshio meanders and stressed that prediction of Kuroshio pathways requires an understanding of the region's physical ocean processes.

Peter Hacker describing the APDRC.

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 voriticity.

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°).

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 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 Magaard** from the IPRC.

Keeping Up-To-Date on Decadal Climate Variability

Are you keen to be up-to-date on decadal climate variability but tired of attending far away workshops? A solution is on the way. Soon you will be able to attend such workshops at HOME! And whenever you feel overloaded listening to the many speakers, you can leave the "conference room", get that coffee and ice cream, or take a snooze, and come back refreshed when ready to hear more. All you will need to do is go on your computer to the **Virtual Center for Decadal Climate Variability** at http://www.decvar.org.

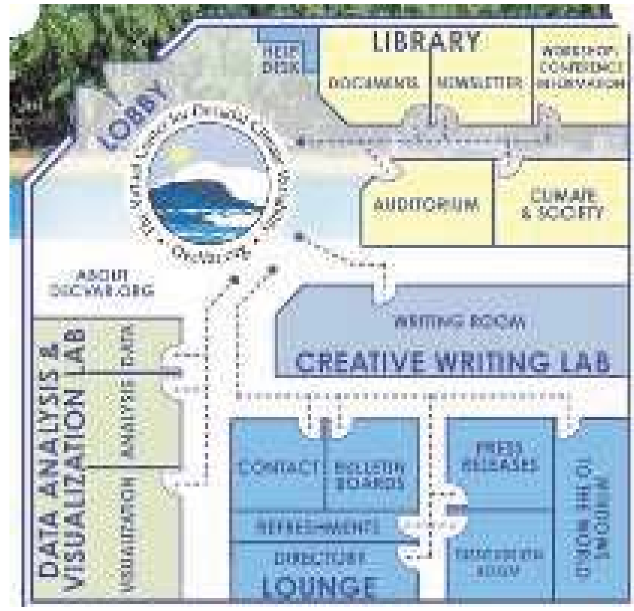
Much of this virtual center has already been built, so let us take a tour through it. After entering the ***Lobby***, we see straight ahead of us the ***Auditorium***. Soon you will be able to hear and see virtual poster sessions, seminars and workshops and you will be able to interact with "speakers" in real time or off-line.

In the room ***Climate and Society***, you find articles on such topics as how global warming will affect health and agriculture. For example, in "Is Global Warming Harmful to Health?" Paul Epstein concludes that many diseases will surge as the earth heats up, and that mosquitoes, carrying dangerous diseases, are already on the march. Next door, you can read *Subtle Signals*, the Dec Center's newsletter, which features opinion pieces, articles not intended for publication (or that cannot be published), program news, meeting summaries, or call-for-papers pertaining to decadal climate variability and its societal impacts. Published and in-press articles on decadal climate variability are in the ***Document*** room. You, yourself, may wish to write an opinion piece for *Subtle Signals* or contribute articles.

In the ***Discussion*** room, still under construction, you will be able talk with colleagues. The ***Writing*** room next door is ideal for working on joint papers. It holds software that automatically collects and organizes coauthors' comments to make the final editing much easier. No need to worry about eavesdroppers—the manuscripts are password protected. Why don't you practice on a sample document?

If you're organizing a conference, just go to ***Bulletin Boards*** to advertise it there. Here you also check for those conferences you actually may wish to take the trouble to travel to.

Very exciting is the ***Data Analysis and Visualization Lab***. It could make your research so much easier. Already the Data room has a description of and links to over 50 data sets covering 40 years or more and useful for decadal climate variability research and applications. For instance, the U.S.S.R. Northern Hemisphere surface pressure and



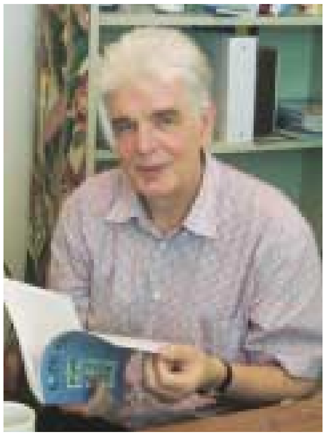
precipitation anomalies: January and July, 1873–1979; or Malaysia, Thailand and Indonesia surface observations: daily and monthly, 1951–1985; Brazil precipitation: daily, 1910–1974.

These data sets are to be linked to analysis systems and data visualizations. You will be able to carry out your analyses at the center and all you need to download are the figures of the outcomes of your analyses. This frees you to spend your time working on the scientific questions you are interested in rather than on time-consuming manipulation of data to adjust them for your research, or on development and adjustment of model codes.

When your head steams from looking at the thousands of numbers on the screen, take refreshment in the refreshment room. And what is a virtual refreshment? Why not try one at http://www.decvar.org/refreshments.php.

The architect of this virtual center is **Vikram Mehta**, a research scientist at the Earth System Science Interdisciplinary Center, University of Maryland, and at the Climate and Radiation Branch, NASA–Goddard Space Flight Center. While a visiting scholar at the IPRC during Summer 2001, Mehta worked on developing the center. His dream, he says, has been to develop a facility that fosters speedier communication within the global, decadal climate variability and applications communities; provides access to a variety of long-term data sets that are integrated with analysis and visualization software; and allows community-wide planning and execution of data set intercomparisons, multi-model experiments, and observing-system studies.

Improving Climate Models
Erich Roeckner's Experience with the ECHAM Model



Erich Roeckner of the Max Planck Institute for Meteorology (MPI), Hamburg, Germany, is the "father" of the widely used ECHAM general circulation model (GCM); he has been guiding its evolution from its beginnings to version 5, soon-to-be released. When Roeckner visited the IPRC in Summer 2001 as a consultant, we thought that our readers might be interested in hearing from him about the challenges of model development.

Roeckner began his work with atmospheric general circulation modeling in the early 1970s for his doctoral dissertation: "The first satellite images of Venus were showing that Venus was very hot. Some strange theories were put forth to account for this, for example, the strong winds on Venus were stirring up sand, creating friction, which heated the atmosphere." He developed a model of Venus' atmosphere and showed that the chemical composition of the atmosphere, the high CO_2 content in particular, was responsible for the high temperature.

About the beginnings of the ECHAM model, Roeckner recalls, "The Max Planck Institute in the early 1980s had an atmospheric GCM for the Northern Hemisphere only. We wanted our own climate model in order to teach students and do research on climate change. But Germany did not have the critical mass of climate researchers for such a huge project, and so we turned to the European Centre for Medium-Range Weather Forecasts (ECMWF) model—the best available then."

"To change this weather forecasting model into a climate model was a lot of work. The purpose of a climate GCM is to understand natural variability on various timescales from seasonal and storm-track variability, to interannual, decadal and longer," explains Roeckner. "Energy, water, and mass in the climate system need to be conserved not over a few weeks but over 100 or more years. A new land-surface scheme was needed and the radiation scheme was not in good shape, so that a new radiation and cloud scheme were also incorporated."

"From the beginning, computing power has constrained model development," says Roeckner. "Physical processes have often been quite well understood and the physical equations representing the processes have been available, but the equations have been only partially usable in the models because the grid size is too large. Larger mesh size means solving the equations only at certain points, and the climate processes have to be simplified and parameterized, resulting in an only partly realistic representation. It's like Seurat's Pointillism, where distinct points represent the continuity of colors in the real world. The closer the points are together, the more closely they will represent reality." How small does the grid size need to be in order to capture reality? "That depends on the process in question."

ECHAM's first version, recollects Roeckner, had a grid of 600 km and no stratosphere, whereas the soon-to-be released ECHAM5 has a flexible grid size ranging from 50 km to 500 km and flexible atmospheric layers that extend into the mesosphere. How one uses ECHAM5 depends upon the process being studied and the computing power available. The model has a new radiation scheme, this time taken from the latest ECWMF version and a new cloud scheme. Deep convection and stratified clouds are still parameterized.

"Model development and validation—comparing the results of model runs with observations—go hand in hand. When a new process or a better way of representing the process is incorporated into a model, results often deteriorate. The challenge," says Roeckner, "is to find the reason for the poorer performance: Is it due to errors in the codes for the scheme? Is the process not represented correctly? Is the problem the result of how the process interacts with other processes? For example, the interaction between radiation and cumulus convection may have changed. At times, problems arise from errors in two processes that cancelled each other in the previous version. With the introduction of a new scheme for one of the processes, the error in the second process now shows up, deteriorating model performance."

"Understanding the model is sometimes just as difficult as understanding the real world. Figuring out why the model has deteriorated means tinkering until you get better performance. It requires much intuition and creativity in knowing how the many processes may be affecting each other." Are there any specific steps for sniffing out the problems? Roeckner has two suggestions to make debugging easier: "One way is to simplify the model, for example, to take out the mountains. Another way is to run the model in the column mode, with a single grid point, and use the results of the GCM as boundary conditions."

To study the sensitivity of Earth's climate to changes in the chemistry of the atmosphere, the ECHAM model has been coupled to different ocean models developed at MPI. Results of two possible future scenarios using ECHAM4 are included in the recent Intergovernmental Panel on Climate Change Report. Projected increases in global-mean surface temperature simulated by the ECHAM model fall into the middle range of outputs from simulations by other models in the report. Increase in global-mean precipitation, however, is substantially lower in the ECHAM model. Roeckner thinks this results from the fact that cloud-water content in the model is higher in the warmer atmosphere; this has a strong effect on albedo, decreasing solar radiation, and therefore decreasing evaporation. Furthermore, in ECHAM4, the thermohaline circulation (THC) does not decay with increased warming as it does in most other models. The ECHAM results suggest the following scenario: An El Niño-like mean state develops in the eastern Pacific (which other climate models also find). This results in subsidence and drought in the Amazon region and more evaporation in the subtropical Atlantic, increasing the salinity there and in the Gulf Stream, maintaining a North Atlantic sufficiently salty to drive the THC. Roeckner is looking forward to study this possible sequence using the ECHAM5 with its greater horizontal and vertical resolutions and better radiation and cloud schemes. The model will be coupled to an MPI ocean model in such a way that the fluxes between atmosphere and ocean are represented directly without the necessity of arbitrary flux corrections.

"Collaboration with other scientists, building upon each others schemes for the many physical processes, is essential to progress in climate modeling and research," says Roeckner. At the IPRC, development and application of the ECHAM model has been truly a team effort. In January 1999, **Bin Wang** discussed with visiting MPI director, **Lennart Bengtsson**, using ECHAM at the IPRC, and in the following summer a contract was signed to transfer the ECHAM 4.3 version to the IPRC.

Since then, Bin Wang, **Tim Li**, **Xiouhua Fu**, **H. Annamalai**, **Renguang Wu**, and **Ping Liu** and others have been working intensely with the stand-alone ECHAM to study various atmospheric responses to SST forcing. Moreover, two coupled models have been developed with ECHAM 4.3 as the atmospheric component. Tim Li has coupled it to the GFDL Modular Ocean Model, and has studied the relationship among the El Niño-Southern Oscillation, the Indian Ocean Dipole, and the Indian monsoon. Xiouhua Fu coupled ECHAM4.3 to the intermediate ocean model developed by Wang, Li, and Chang (*JPO*, 1995); this hybrid-coupled model has been used to study how air-sea coupling affects the annual cycle of the Asian-Australian monsoon, the mean Asian summer monsoon (Fu, Wang, and Li, *J.Climate*, in press), and the intraseasonal oscillations (**Kemball-Cook**, Wang, and Fu, *J.Atmos. Sci.*, in press). Wang, Fu, and Li are currently studying the effect of air-sea interaction on Indian Ocean SST and the Asian-Australian monsoon.

Erich Roeckner with IPRC scientists.

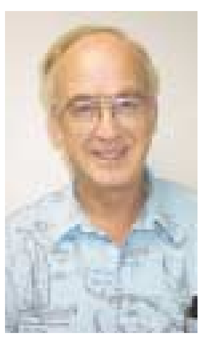
On his visit, Erich Roeckner brought the updated ECHAM4.6 to the IPRC. Wang, Liu, and Li have evaluated this new version, and recognizing ECHAM's weakness in land-surface processes, decided to incorporate the BATS land-surface scheme into ECHAM4.6. **Omer Sen** and Ping Liu are now undertaking this task in order to improve its simulation of the East Asia and Western Pacific monsoons.

News of IPRC Researchers

Kevin Hamilton, IPRC's Theme-4 leader, served as ***Director*** of the ***School on the Physics of the Equatorial Atmosphere***, held September 24–October 5, 2001, at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. The ICTP is sponsored by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and is devoted to facilitating graduate level education and research opportunities for scientists from developing countries.

The School focused on the current state of research on the low-latitude atmosphere and included meteorological phenomena as well as phenomena related to stratospheric ozone chemistry and ionospheric effects on radio propagation. Designed for graduate students and young postdoctoral scientists with some background in atmospheric science, the School attracted 42 students from 27 countries. Hamilton returned from Trieste invigorated, saying that it had been a most rewarding scientific trip. "The School provided a wonderful opportunity to meet graduate students and other young scientists from an amazing array of countries. Hopefully many of the contacts made at the School will evolve into international scientific collaborations. Our colleagues from low-latitude countries are important partners in the global research efforts to study the near-equatorial atmosphere, and settings such as this international school are ways to ensure their full participation."

Selected as the 2001 ***Henry G. Houghton Lecturer*** at the Massachusetts Institute of Technology, **Julian P. McCreary**, IPRC Director, gave a series of seven lectures in Spring 2001 on the dynamics of intergyre exchange circulations in the Pacific Ocean. The lecture series was established by the Henry G. Houghton Fund, with the idea that students at MIT's Center for Meteorology and Physical Oceanography invite distinguished scholars from the outside to conduct two-to-four weeklong mini-courses on topics not covered in the Center's curriculum.



Lorenz Magaard, IPRC Executive Associate Director, was awarded the title of ***Marine Technology Society Fellow*** for his valuable contributions to the study of global climate change and for his excellence in promoting marine science and technology at the university level. He received the award, November 5, 2001, during the OCEANS 2001 Conference at the Hilton Hawaiian Village in Honolulu.

Shang-Ping Xie, co-leader of IPRC Theme 1, was awarded the ***Outstanding Collaborative Research Prize*** by the Ocean University of Qingdao, China, for his research on the "Far-Reaching Effects of the Hawaiian Islands on the Pacific Ocean-Atmosphere System," published in the June 15, 2001, issue of *Science*. The award, which was presented by Huashi Guan, the President of Qingdao University, consisted of a certificate and cash award and was reported in Chinese newspapers.

New Scientific Staff

Takahiro Endoh joined the IPRC in July 2001 as a research scientist from the Frontier Research System for Global Change. He received his Ph.D. in Science from the University of Tokyo, Japan, in March 2001. Endoh's research has focused on the bimodality of the Kuroshio path south of Japan, particularly on simulating observations showing that the transition from the non-large meander path to large meander path is caused by the generation of a "trigger meander" off the southeastern coast of Kyushu and the subsequent amplification of this meander as it propagates eastward off Cape Shiono-misaki. Using an inflow-outflow regional numerical model with realistic topography, Endoh has successfully reproduced this observed transition in the Kuroshio paths. Based on his analysis of the simulation results, he has proposed the following explanation: the trigger meander is generated by the interaction between the Kuroshio and a strong anticyclonic mesoscale eddy approaching the Tokara Strait. When the Kuroshio volume transport is large and vertical current shear strong, the trigger meander propagates eastward up to Cape Shiono-misaki; there it slows down and is significantly amplified through baroclinic instability, which is particularly large in this region due to the local topographic feature, Koshu Seamount, about 200 km south of Cape Shiono-misaki.

At the IPRC, Endoh is working with **Humio Mitsudera**, co-leader of Theme 2, on the three-dimensional structure of the North Pacific subtropical and subpolar gyres, particularly on the influence of outcropping isopycnal layers, mesoscale oceanic features, and bottom topography on the separation of the Kuroshio and the Oyashio from the western coast of Japan. They are planning an eddy-resolving numerical simulation of the North Pacific using a newly developed hybrid-coordinate ocean model (HYCOM) in which coordinate surfaces adhere to isopycnals in the interior ocean, and are geometrically constrained in shallow coastal regions and the mixed layer.

Hyoun-Woo Kang joined the IPRC as a postdoctoral fellow in September 2001. In 1993, he received his M.S. in oceanography from Seoul National University (SNU). As part of his master's degree work, he studied remote ocean sensing technology and its products. Kang continued his doctoral studies at SNU while working as a researcher at the SNU graduate school (in fulfillment of compulsory military service). During this period he participated in projects on coastal processes and marine environment. After receiving his Ph.D. in oceanography from SNU in 2001, he joined the Korea Ocean Research and Development Institute as a part-time research assistant, studying coastal processes and the marginal sea circulation.

For his dissertation, "A Numerical Model Study on the Oceanic Circulation in the Yellow Sea and the East China Sea under Tidal and Wind Forcings," Kang developed a regional model and used this model to study the complicated shelf area of the region, where fast tidal variations and slow ocean-current variations have equally important effects on ocean conditions.

Kang's current research interests include the study of ocean-circulation dynamics and coastal processes using numerical modeling and satellite remote-sensing data. At the IPRC, he is working with **Tangdong Qu**, associate researcher in Theme 2, on low-latitude western-boundary currents in the Pacific. These currents have been shown to play an important role in ENSO and may be a key component of the global thermohaline circulation through their contribution to the Indonesian Throughflow. The project is based on an analysis of a combination of hydrographic data and data from a set of numerical modeling experiments. Since they will be using the IPRC version of the Princeton Ocean Model for process-related experiments, Kang is now investigating the sensitivity of this model to geographic features and wind forcings.

New Scientific Staff

Yoo Yin Kim received his Ph.D. in physical oceanography in June 1999 from Florida State University, where he continued as a postdoctoral research scientist in the Department of Meteorology until joining the IPRC as postdoctoral fellow in October 2001.

While working on his dissertation, Kim participated in two field experiments that gave him experience managing and analyzing moored data: As part of the World Ocean Circulation Experiment–Deep Basin Experiment, he dealt with current-meter observations and hydrographic data in the Mid-Brazil Basin; for the Ocean Margins Program, he analyzed the complete current, salinity, and temperature time-series data collected with ADCP, SEACATs, and about 80 current meters from 25 moorings in the southern part of the Mid-Atlantic Bight shelf.

His research has focused on describing and understanding oceanic and climatic variability on seasonal-to-interdecadal time scales. He has found that sea surface temperature (SST) changes during ENSO are represented as an irregular interplay between two dominant modes, a low-frequency mode and a biennial mode. Studying the response of the tropical subsurface current, temperature structure, heat content, and sea-level height to sea-surface conditions (temperature and wind), he has shown that their variability is connected with the two dominant modes of SST and the propagation of equatorial long-waves associated with ENSO in the tropical Pacific Ocean.

Working in Theme 2 with **Humio Mitsudera** and **Tangdong Qu** at the IPRC, Kim is now investigating the Pacific low-latitude western boundary currents (LLWBCs). He will be analyzing historical and recent hydrographic data, JAMSTEC high-resolution model data, the IPRC GCM data, and Simple Ocean Data Assimilation data to (1) complete a description of the time-averaged structure of the LLWBCs, (2) examine the variability of the LLWBCs from seasonal-to-decadal time scales, and (3) diagnose the ocean processes that maintain the LLWBCs and account for their variability.

Ping Liu joined the IPRC's Theme 3 researchers as a postdoctoral fellow in June 2001. He received his Ph.D. in climate dynamics from the Laboratory of Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics, Beijing, in May 1999. Working with Professors **Duzheng Ye** and **Guoxiong Wu**, he wrote his dissertation on the dynamics of the interannual variation of the subtropical anticyclone over the western Pacific Ocean and the impacts of tropical SST anomalies on this anticyclone. Based on his dissertation research, he proposed that a two-stage thermal adaptation mechanism connects climate variability in the tropical ocean and subtropical monsoon circulation.

Upon graduation, Liu worked as an associate researcher at LASG, where he continued his research on monsoons and climate change using climate models. During November and December 2000, he visited the National Center for Atmospheric Research in Colorado to take part in the Sino-US joint research project on global warming and to research the historical and future climate change over the Sahara Desert. Analyzing their ensemble runs of the Department of Energy's Parallel Climate Model, he and his coauthors found that with increasing greenhouse gas concentrations, there is a shrinking, warming, and northward retreat of the Sahara during the twenty-first century.

At the IPRC, Liu is working with **Bin Wang** and **Tim Li** to study the ability of ECHAM—the atmospheric climate model from the Max Planck Institute for Meteorology in Hamburg—to simulate regional climate, particularly the Asian monsoon by carrying out a suite of model runs that vary in resolution and physical processes. He has nearly completed a comparison between ECHAM and CCM3.6. Moreover, as a subproject principal investigator of the Coupled Model Intercomparison Project, he is diagnosing the output from 29 models on climate change in the Sahara.

New Scientific Staff

Jim Potemra, after graduating with a Ph.D. in physical oceanography from the University of Hawaii in 1998 and a 7-month postdoctoral fellowship at the IPRC, spent two years as a postdoctoral fellow at the University of Washington's School of Oceanography. There he continued his work on Pacific-to-Indian Ocean water exchange by analyzing observations of pressure, temperature and salinity collected in the Indonesian region. Potemra rejoined the IPRC this past August as an assistant researcher and plans to continue and expand on this work as part of IPRC's Theme-2 topic: Determining the influences of western-boundary currents and the Indonesian Throughflow on Asia-Pacific climate.

Upon earning a B.S. in physics from Stevens Institute of Technology in 1986, Potemra worked in the Washington D.C. area for the U.S. Navy in support of their submarine ship design and control systems. He then attended Florida State University for two years and in 1990 received his M.S. in oceanography. Returning again to the D.C. area, he worked at the NASA Goddard Space Flight Center, where his research involved numerical ocean modeling of equatorial Pacific processes. This work led to collaborations with various universities and was the impetus for Potemra to return to graduate school. The result was a five-year stay at the University of Hawaii.

At the IPRC, Potemra will be working on the effects of western boundary currents and the Indonesian Throughflow on climate, which will include further regional modeling and data assimilation and further analysis of data recently collected in the region.

Richard "Justin" Small joined the IPRC in August 2001 to work on analysis of satellite data that will help understand ocean-atmosphere interactions in the tropical Pacific. He comes from southern England and studied at the University of Reading, gaining a degree in Mathematics and a M.Sc. degree in meteorology. He then worked for ten years at the United Kingdom Defence Research Agency, where he investigated underwater phenomena that could affect the propagation of sound from sonar systems. This research concentrated on oceanic internal waves, particularly the high-frequency solitary waves generated by tidal flow. During this time, Small completed his Ph.D. on the refraction and shoaling of internal solitary waves at the Southampton Oceanography Centre. His research has included numerical modeling and analysis of satellite and *in-situ* data. He took part in three sea experiments measuring internal tides and their effects. One of these is the ongoing Hawaiian Ocean Mixing Experiment, which is studying the generation of deep turbulence by internal tides generated at the Hawaiian Ridge.

As a postdoctoral fellow with **Shang-Ping Xie**, co-leader of Theme 1, Small is analyzing satellite data of surface winds and how they relate to SST and sea surface height fields. He is focusing initially on transient events such as Tropical Instability Waves, which are known to influence the atmosphere mainly through their modification of boundary layer stability. He is currently analyzing the relationship between the SST and wind fields and plans to simulate the interaction using the IPRC Regional Climate Model (p. 7). He is also investigating the question whether ocean currents are detectable by measuring the difference between scatterometer derived surface stress and *in-situ* measured wind stress.

Small, furthermore, is continuing his work on internal waves as a side-project and plans to look at mooring data on internal tides in the tropical Pacific to try to determine the source and characteristics of these tides.

Weijun Zhu joined the IPRC as a postdoctoral fellow in July 2001. He obtained his B.Sc. and M.Sc. degrees in synoptic dynamic meteorology from the Department of Meteorology, Nanjing Institute of Meteorology (NIM), China, in 1991 and 1994, respectively. While an assistant professor in the Department of Atmospheric Sciences at NIM, Zhu continued his studies there, and in 1999, he obtained his Ph.D. in meteorology. For his research on the effect of ENSO events on the Pacific storm track, he received, in January 1999, the prestigious Xue-Do-Feng-Zheng-Jiang award from the Institute of Atmospheric Physics, Chinese Academy of Science.

Shortly before coming to the IPRC, Zhu was associate professor and vice dean of the Department of Atmospheric Sciences at NIM. He was also an instructor at NIM's Regional Meteorological Training Center of the Word Meteorological Organization.

Zhu's research interest covers such topics as observations and modeling of the interaction between ocean and atmosphere, general atmospheric circulation and short-term climate prediction. At the IPRC, he is working with **Kevin Hamilton**, leader of Theme 4. He will conduct and analyze multi-decadal integrations with a coupled ocean-atmosphere model with different levels of solar forcing. These experiments will be analyzed to determine how well the global climate sensitivity to external forcing can be estimated on the basis of geographical and temporal variability in the model control run. Model integrations will also be examined to understand how the upper-tropospheric water vapor is maintained and how the water vapor and its sensitivity to climate perturbations may depend on the cumulus parameterization.

Visit by JAMSTEC Chairman

Dr. **Hiroshi Ohba**, Chairman of the Japan Marine Science and Technology Center JAMSTEC, Mr. **Masato Chijiya**, Executive Director of JAMSTEC, Mr. **Seiichi Nishimura**, Staff Supervisor at JAMSTEC, and Mr. **Hisayuki Tanami**, Associate Director, Kawasaki Heavy Industries, Ltd., met with IPRC Frontier researchers and Dr. Shang-Ping Xie on November 6, 2001, to discuss research at the IPRC. Dr. Ohba was in Honolulu to attend the OCEANS 2001 Conference and to receive the prestigious ***Compass International Award*** of the Marine Technology Society at the award luncheon held on November 7, 2001, at the Hilton Hawaiian Village.

Visiting Scholars

The IPRC has an active visitor program. Our visiting scholars give seminars and work with IPRC research staff. From April 2000 to October 2000, the IPRC sponsored the scientists named below for visits of one week or longer.

Tomoo Watanabe
Tohoku University, Sendai, Japan

Masaru Inatsu
Hokkaido University, Sapporo, Japan

Hiroshi Hashizume
Hokkaido University, Sapporo, Japan

Kwang-Yul Kim
Florida State University, Tallahassee, Florida

Vikram Mehta
NASA–Goddard Space Flight Center, Greenbelt, Maryland

Amita Mehta
NASA–Joint Center for Earth Systems Technology, University of Maryland, Baltimore, Maryland

Leland Jameson
Lawrence Livermore National Laboratory, Livermore, California

Erich Roeckner
Max Plank Institute for Meteorology, Hamburg, Germany

Mezak A. Ratag
Indonesian National Institute of Aeronautics and Space (LAPAN), Bandung, Indonesia

William Lau
NASA–Goddard Space Flight Center, Greenbelt, Maryland

Jong-Ghap Jhun
Seoul National University, Seoul, Korea

Friedrich Schott
Institute for Marine Research, University of Kiel, Kiel, Germany

Gabriel Vecchi
NOAA–Pacific Marine Environmental Laboratory, Seattle, Washington

Willa Zhu
NOAA–Pacific Marine Environmental Laboratory, Seattle, Washington

Jong-Ghap Jhun and Bin Wang join forces in looking for teleconnection patterns of the East Asian monsoon.

Amita Mehta and Zuojun Yu contemplate "rainy" data.

Gabriel Vecchi: "Just because data points are extreme, doesn't mean they're outliers."

Mezak Ratag and Lorenz Magaard savor the prospects of cooperation in regional climate modeling between Indonesian institutes and IPRC.

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