

MEETINGS

Climate Change and the Pacific Islands

Rapid environmental changes befell the Pacific islands around AD 1300–1400, according to evidence presented at the interdisciplinary workshop “Climatic Changes in the Last 1500 Years: Their Impact on Pacific Islands,” hosted by the IPRC at the East-West Center on November 13–14, 2007. The years around AD 1300 also mark the transition in the Northern Hemisphere between the Medieval Warm Period, AD 750–1250, and the Little Ice Age, AD 1350–1850. Were the environmental changes in the Pacific caused by these large-scale climate changes or by local human activities?

The manifestation of climate change in the Pacific is seen in a variety of proxy data, such as coral skeletons from the central tropical Pacific, ice cores from South America and the Himalayas, lake sediments, and biostratigraphic layers and tree rings from the Pacific islands. These records provide a rich, natural archive that permits reconstruction of the spatial and temporal features of Pacific climate over the last 1500 years.

One of the most intriguing changes occurred in rainfall and was detected

in lake sediments on Christmas Island and Washington Island. Today Christmas Island is arid, whereas Washington Island, only 3 degrees further north, receives much rainfall because it lies under the Intertropical Convergence Zone (ITCZ). Sediment layers from Washington Island show that during the Medieval Warm Period, the island was as arid as Christmas Island is today.

This extreme shift from dry to wet climate on Washington Island, but not on Christmas Island, can be explained by a shift of the ITCZ. The picture emerging from these proxy records is that during the Medieval Warm Period, the tropical Pacific resembled a ‘permanent’ La Niña state, with lower sea surface temperature (SST) in the central, and higher SST in the western tropical Pacific than today. Computer climate simulations support these two major changes in the tropical Pacific climate. Especially the teleconnections between La Niña and the well-documented droughts in western North America appear in simulations as robust features.

The forces that may have driven



Lonnie Thompson during the workshop “Climatic Changes in the Last 1500 Years: Their Impact on Pacific Islands.”

these climate shifts were widely debated during the workshop. Although changes in incoming solar radiation and volcanic eruptions are believed to have caused some past climate changes in the tropical Pacific, computer model solutions point to intrinsic climate variability and forcing from the Atlantic and the Indian Ocean as other important factors.

The workshop promoted lively dialog and forged partnerships among scientists in such diverse fields as anthropology, archaeology, history, climatology and paleoclimatology. Such partnering is bound to advance knowledge of our climate system.

A special public IPRC lecture, “Abrupt Climate Change: Past, Present, and Future,” by world renowned glaciologist **Lonnie Thompson** from Ohio State University closed the workshop.



Thompson, whose years of research on glaciers took him to some of the world's remotest regions and highest mountains, received the National Medal of Science for his work, which provides explicit evidence of global climate change.

NOAA's Integrated Data and Environmental Applications (NOAA IDEA) Center co-hosted the workshop. Support also came from NOAA's Climate Program Office (Climate Change Data & Detection). **Henry Diaz** from the NOAA/OAR Environmental Systems Research Laboratory and **Oliver Timm** from the IPRC organized the workshop.

Air–Sea Interaction in the Kuroshio Extension

JAMTEC-PMEL-IPRC Study Group Meeting

Transporting huge amounts of heat, the Kuroshio Extension is an important region of the Indo-Pacific climate system. Knowledge about this current is getting a boost from a program of buoy measurements in the western North Pacific, which is conducted by a partnership among the Japan Agency for Marine–Earth Science and Technology (JAMSTEC), NOAA's Pacific Marine Environmental Laboratory (PMEL), and the IPRC. On November 16 and 17, 2007, the IPRC hosted a workshop for researchers working on observations, data analysis, and modeling of the dynamics and air–sea interaction in the Kuroshio Extension.

Hiroshi Ichikawa (JAMSTEC) and **Meghan Cronin** (PMEL) outlined the existing partnership on buoy deployment between their institutions. Since 2004, the PMEL KEO buoy has been measuring air–sea fluxes south of the Kuroshio Extension, and since 2007, the PMEL-designed J-KEO, owned by JAMSTEC, has been taking measurements north of the Kuroshio Extension.

Ichikawa stressed the need for accurate and long-term records of the extra-tropical air–sea fluxes to understanding climate variations. These measurements are especially important given the recent findings of the effects of the SST fronts created by such warm currents as the Kuroshio and the Gulf Stream. Cronin recounted her experiences with KESS and the US CLIVAR Western Boundary Currents Working

Group and the difficulties in obtaining reliable observations from moorings. She emphasized the need for close interaction between international groups and projects, particularly in developing assessment metrics for existing and future numerical models.

Workshop topics also dealt with presentations of such recent findings as the effects of the Pacific Decadal Oscillation on the North Pacific Gyre and the effects of ocean fronts on atmospheric-boundary and ocean-mixed layers. The usefulness of such tools as the high-resolution general circulation models for the Earth Simulator (OFES and CFES) toward

understanding the complex climate-related processes at the Kuroshio Extension front was demonstrated. Moreover, the benefits of using a variety of in situ observations, such as buoy, Argo profilers and sea gliders to correct biases and validate satellite measurements of eddy mixing, air–sea interaction, and mixed-layer evolution were discussed at length. For the workshop agenda, please visit <http://iprc.soest.hawaii.edu/meetings/workshops.html>.

An outcome of the intensive two-day discussions was the establishment of the Kuroshio Implementation Panel or KIP.

The panel consists of representatives from JAMSTEC, PMEL, IPRC, UH, and Woods Hole Oceanographic Institution, and its goal is to promote new research and to seek support for expanding the observational buoy array. **Masanori Konda** (JAMSTEC) organized the workshop with local assistance by IPRC's **Niklas Schneider**, **Nikolai Maximenko**, and **Shang-Ping Xie**.

Jets and Fronts

Peter Rhines, professor in the Oceanography and Atmospheric Sciences departments and head of the Geophysical Fluid Dynamics Laboratory at the University of Washington, visited the IPRC for nearly 3 weeks in December 2007. Rhines is well known for his work on the theory of the general circulation of the ocean, waves and eddies.

IPRC scientists **Nikolai Maximenko** and **Niklas Schneider** took the opportunity of Rhines' visit to organize an informal half-day workshop on December 6, 2007. The aim was to share with Rhines the work done by IPRC scientists



Photo courtesy of Takeaki Sampe



“Jets and Fronts” Workshop participants with Peter Rhines, front right.

and their students on ocean dynamics, particularly on fronts and ocean jets. In a friendly, informal atmosphere, participants of the workshop discussed geophysical fluid dynamics of the ocean and the atmosphere and challenges for today’s observational, theoretical, and numerical modeling efforts.

Among the topics were layer-thickness form drag and the energetics of the global ocean, particle dispersion by waves and jets, the validation of quasi-stationary, jet-like structures in the eastern Pacific, the origin and dynamics of the eddy-driven subthermocline jets, the observation and simulated dynamics of the subsurface zonal jets in

the northern tropical Pacific, mixing in the equatorial ocean associated with jets, and ocean conditions that could lead to the formation of zonal jets. For the complete agenda please visit <http://iprc.soest.hawaii.edu/meetings/workshops.html>.

Rhines also gave a special lecture sponsored jointly by the IPRC and the UH Oceanography and Meteorology departments about his current research on the atmospheric and climate dynamics in the subpolar oceans and his sea-going projects in the high-latitude climate system: “Exploring the Subarctic Seas from Above and Below: Satellite Altimetry and Robotic Seagliders.”

Advanced Institute on “The Asian Monsoon System”

Satellite observations and computer modeling have increased greatly the understanding of the Asian monsoon. In early January 2008, the IPRC therefore co-sponsored with the Asia Pacific Network (APN), the SysTem for Analysis, Research and Training (START), and the East-West Center the two-weeklong advanced institute on “The Asian Monsoon System: Prediction of Change and Variability.” The institute was aimed at giving young Asia-Pacific scientists and professionals with doctoral degrees in climatology or meteorology up-to-date knowledge of the advances in monsoon science and its hydrological cycle.

The institute included lectures and group discussions on such topics as the coupled monsoon system, interannual monsoon variations and ENSO-monsoon interactions, the effects of atmosphere–land interactions on the monsoon and the water cycle, and the intraseasonal variability, predictability and simulation of the monsoon. The students also learned to access and use



Participants of the Advanced Institute on “The Asian Monsoon System.”

the climate data-bank of IPRC's Asia-Pacific Data-Research Center.

Twenty students from China, India, Indonesia, Korea, Malaysia, Nepal, Pakistan, the Philippines, and Vietnam, as well as from the US and Canada attended the institute. The institute gave them the opportunity to build networks and familiarized them with such international climate research organizations as the Climate Variability and Predictability (CLIVAR) Project of the World Climate Research Programme (WCRP) and the Monsoon Asia Integrated Regional Study (MAIRS).

IPRC's **Bin Wang** organized the institute and **Julian McCreary**, **H. Annamalai**, **Xiuhua Fu**, **June-Yi Lee**, **Tim Li**, and **Jim Potemra** participated as lecturers.

Making Climate Models More Realistic

The partnership between JAMSTEC and IPRC scientists helps to build ever-more realistic computer models of the ocean, atmosphere, and their interaction. JAMSTEC has the scientists with expertise in developing cutting-edge climate models for the Earth Simulator, and IPRC has the scientists that focus on climate processes and analysis of observational data to test the models' validity. In February, six JAMSTEC scientists visited the IPRC so that the two groups could exchange their newest findings on model improvement and forge plans for new experiments.

JAMSTEC's **Akira Kuwano-Yoshida** and **Takeshi Enomoto** have implemented into the Atmospheric General Circulation Model for the

Earth Simulator, AFES, a new cloud scheme that simulates more low-level clouds than the previous version in such critical areas as off the coasts of California and Peru. The better clouds are expected to produce, among other things, more realistic sea surface temperature (SST) off the Peruvian coast, a region where many coupled models have a large warm bias. Indeed, an integration of the medium-resolution Coupled General Circulation Model for the Earth Simulator, CFES, by **Bunmei Taguchi** and **Nobumasa Komori** with the new AFES cloud scheme, improves simulated SST, surface wind, and precipitation throughout the tropical Pacific.

Scientists have long been puzzled by the so-called "missing mixing" problem. Global-scale observational data suggest that to sustain the global, deep overturning circulation (the conveyor belt), a certain amount of mixing is required in the deep ocean. Estimates of deep internal-wave energy, based on high-resolution, ocean-only numerical models and driven by wind products from re-analysis or satellites, however, had suggested that wind-generated internal wave energy was insufficient to account for the mixing required in

the deep ocean. Now the most recent work conducted by Komori with CFES shows a surprisingly strong internal-wave activity in the deep ocean. This remarkable result was possible because the high CFES resolution resolves oceanic internal waves and, because in a coupled model, the ocean component is forced by the atmosphere at a much higher frequency than in the ocean-only models. This difference in wind-forcing frequency seems to be the reason for the elevated internal-wave energy in CFES. The discovery should ignite a fresh interest in wind-generated internal waves as a source of the missing mixing energy.

The high-resolution Ocean General Circulation Model for the Earth Simulator (OFES) continues to yield new insights into ocean circulation. For example, OFES was able to simulate a recirculation gyre north of the Kuroshio Extension. The gyre's existence had been suspected, but was only recently confirmed by profiling float measurements according to **Bo Qiu's** (UH Oceanography) study. Furthermore, **Yoshikazu Sasai** found that the high resolution of OFES is necessary for its biological model to simulate certain biological processes.



"High-Resolution Climate Modeling" workshop participants.

Hideharu Sasaki has developed an ultra-high-resolution, 1/30 degree, version of OFES for the North Pacific. The output from the planned run with this version will allow exciting new studies that are bound to expand our knowledge, not only of Pacific Ocean climate but also of ocean dynamics in general. For example, eddies, an important aspect of ocean dynamics, are known to dissipate into smaller and smaller eddies. In the standard OFES version, eddies are too energetic and do not seem to dissipate enough; scientists are hoping the ultra-high-resolution run will furnish insight into the processes of eddy-dissipation.

Output from this ultra-high-resolution OFES run will be of interest to research conducted by IPRC scientists on such phenomena as the work spearheaded by **Niklas Schneider** on simulation of the Kuroshio paths and the work led by **Nikolai Maximenko** on the jet-like ocean currents (p. 28).

Other projects at the IPRC may contribute to improving the models for the Earth Simulator. For example, the research by **Ryo Furue**, **Julian McCreary**, and **Zuojun Yu** on the stratification of the Pacific subthermocline circulation has revealed processes that may lead to a more realistic equatorial thermocline in the CFES ocean component. Another example where IPRC work may contribute relates to Red Sea outflow. The Bab el Mandeb is about 30-km (20-mile) wide and connects the Red Sea and Arabian Sea via Gulf of Aden. Red Sea outflow is vital for the high salinity water in the Arabian Sea at depth and may be responsible for the oxygen minimum zone there as well. The research by McCreary and Yu, and also by **Hidehiko Aiki**, shows that the

Red Sea water spreads across the Arabian Sea in their models. Yu's simulation in a regional 6.5-layer ocean model further illustrates the effect of the absence of Red Sea outflow on salinity, which may help the OFES team (**Akio Ishida**) improve its model performance in the region.

East Asian Monsoon Variability and Predictability

The first joint workshop on "East Asian Monsoon Variability and Predictability" among the University of Hawai'i (UH), Seoul National University (SNU), and Pusan National University (PNU) was held at the IPRC on February 14 and 15, 2008. The workshop provided an effective platform for exchanging information on understanding and modeling Asian monsoon variability. About 30 participants from UH, SNU and PNU in Korea, Ocean University of China (OUC) in China, and Nagoya University (NU) in Japan presented latest results on the East Asian monsoon and discussed future research thrusts and possible collaborations.

The scientific presentations focused on the following major topics: diurnal-to-decadal monsoon variability, local and remote impacts on the monsoon, and modeling and predicting intraseasonal monsoon oscillations and the year-to-year monsoon variations. The workshop ended with discussions of future collaboration in the following research areas: inter-annual-to-decadal changes in the monsoon; changes in the monsoon that may be related to the El Niño–Southern Oscillation and Indian Ocean climate; predictability of the intraseasonal oscillation; tropical cyclones, extreme events and interannual monsoon variations; modeling studies of the relationship between the stratocumulus-topped boundary layer and convective momentum transport; and understanding the influence of stratosphere-troposphere interaction on the monsoon.



Participants of the "East Asian Monsoon Variability and Predictability Workshop."

Bin Wang (IPRC), **Kyung-Ja Ha** (Division of Earth Environmental System, Pusan National University), **Jong-Gap Jhun** (School of Earth and Environmental Sciences, Seoul National University) were the workshop organizers; Brain Korea 21, a program of Korea's Ministry of Education, was the sponsor.

NICAM and High-Resolution Global Atmospheric Modeling

IPRC scientists are starting to analyze output from the cloud-resolving Nonhydrostatic Icosahedral Atmospheric Model (NICAM). An informal meeting of IPRC researchers with interests in high-resolution global atmospheric modeling and NICAM was held in March in conjunction with the visit of **Kazuyoshi Oouchi**, research scientist at JAMSTEC's Frontier Research Center for Global Change (FRCGC). Oouchi reviewed results of a simulation of tropical intraseasonal variations in NICAM.

NICAM directly calculates deep convection and meso-scale circulations, which are key processes in the tropical and global atmospheric circulations. In order to drastically increase horizontal resolution, a new framework for global atmospheric models that uses nonhydrostatic governing equations and icosahedral grids was adopted. NICAM was first developed by **H. Tomita** and **M. Satoh** and is now being further developed in a partnership between the Center for Climate Systems Research and JAMSTEC.

Atmospheric Composition Minisymposium

A minisymposium on Atmospheric Composition Research at JAMSTEC, the IPRC, and UH was held April 22, 2008, in conjunction with the visit of **Hitoshi Irie**, research scientist at FRCGC. Organized and chaired by IPRC Interim Director **Kevin Hamilton**, the meeting featured, in addition to Irie, participation by visiting JAMSTEC research scientist **Yoshikazu Sasai** and several faculty, researchers, and students from the IPRC and the UH Meteorology and Oceanography departments. Irie presented his results on innovative ground-based observations of atmospheric gases and aerosols and comparisons with satellite-retrieved values. **Barry Huebert** (UH Oceanography) discussed field work by his research group and outlined how more sophisticated direct field measurements of air-sea fluxes of gas could contribute to an improved understanding of the global carbon budget. IPRC's **Yuqing Wang** showed results from the simulation of clouds in the southeast Pacific in the IPRC Regional Atmospheric Model, and **Axel Lauer** reviewed his work on implementing more sophisticated cloud microphysics schemes in the IPRC Regional Atmospheric Model. **Vaughan Phillips** (UH Meteorology) presented new ideas for treating ice-nucleation in glaciated clouds.

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At the Atmospheric Composition Minisymposium, seated around the table from left, Yuqing Wang, Vaughan Phillips, Axel Lauer, Kevin Hamilton, Barry Huebert, Yoshikazu Sasai, John Porter, and Hitoshi Irie.