# iprc climate

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**Newsletter of the International Pacific Research Center**

***The center for the study of climate in Asia and the Pacific at the University of Hawai‘i***

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On a rainy day in 1932, two ladies cross Benkei Bridge in Tokyo.

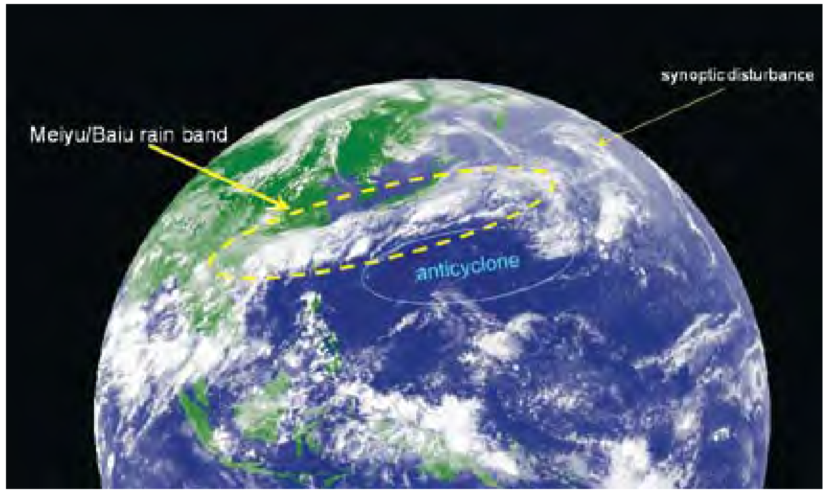
## Research



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

Cover - Raindrop on the leaf of a spider lily.
(Photo courtesy Gisela Speidel)

# Jet Stream Anchors Meiyu-Baiu Rainband



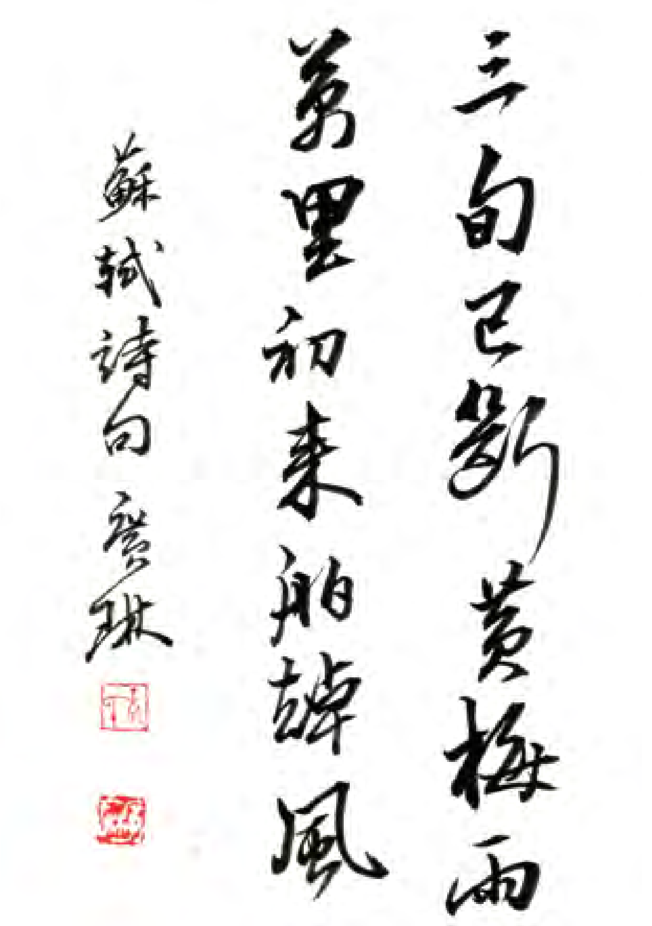

Satellite image of Meiyu-Baiu on June 12, 2008 (by Japan Meteorological Agency).

**by Takeaki Sampe and Shang-Ping Xie**

The weather in June and early July is typically gloomy for residents in much of Japan and eastern China along, and south of the Yangtze River. Dark gray clouds hang in the sky, and the days are rainy and sticky. This weather is so distinct from the hot and sunny mid-summer that people call it "Meiyu" in China and "Baiu" in Japan, both words standing for "plum rains," as plums ripen during this season. The Meiyu-Baiu brings much needed rain for the drier mid-summer; but the heavy rains can also cause flooding and landslides. It is not surprising, therefore, that the Meiyu-Baiu is viewed as an extremely important climate event in the highly populated regions of East Asia, and that meteorologists have conducted and published extensive research on the topic, studying it mostly as a weather phenomenon. Yet, the mechanism that controls the formation—the location and timing—of the rainband has eluded us: why does the Meiyu-Baiu recur every year about the same time and the same place? Our recent research identified a key puzzle piece that sets the time and place of the rainband—the jet stream!

Satellite images during the Meiyu-Baiu season reveal the long cloudband stretching from the Yangtze River Valley in China to Japan and eastward over the North Pacific (satellite image). Embedded in the cloudband are mesoscale convective systems that produce heavy rainfall as they move eastward. In contrast, south of the Meiyu-Baiu rainband are few clouds as the subtropical high hovers over this region.

What triggers the rainband and why does it occur as a long east-west band over the Yangtze River Basin and Japan? These questions have not been answered convincingly because complicated feedbacks exist between the rainband and the atmospheric circulation. In previous studies, the characteristics of the low-level circulation, such as low-pressure belt at the surface and strong moisture-laden southwesterly winds, have been regarded as important in maintaining the rainband. The low-level circulation, however, is a result of heating from condensation in the rainband. This view, thus, leads to a chicken-and-egg problem, and no matter how much we examine those characteristics, we won't know what triggers the Meiyu-Baiu formation. Other studies have focused on the convective systems embedded in the elongated rain band: since convection produces heavy rain during the Meiyu-Baiu, releasing large amounts of latent heat into the at-



The close association between the Meiyu and winds is well known to those who dwell under the recurring rain band and whose livelihood depends on its behavior. The great poet Shi Su (1037–1101) of the Song Dynasty wrote, "As Meiyu ceases in July, southeast breezes bring home sails from far seas." Chinese merchant ships sailed for the coasts of Southeast Asia and the Indian Ocean during the northeast monsoon, and rode home to Zhejiang Province on the southeasterly winds. Calligraphy by Guanglin Meng, member of the Shandong Calligraphy Society.

mosphere, convection has been regarded as the Meiyu-Baiu engine. Studying individual convective systems, though, does not reveal why central-eastern China and Japan are more prone to convection during June than other regions.

When we set out on our Meiyu-Baiu study, we wanted to know what drives and steers the climatological rainband. We needed to take a new path. After months of trial and error, we noticed something special about the circulation at the mid-tropospheric level, at an altitude of about 5.5 km (18,000 ft). An experiment with a linear model showed us that deep-heating by convection and rainfall in the rainband generates a strong response in the upper and lower troposphere, but only a weak wind response in the mid-troposphere. Thus, we realized that by examining what happens in the mid-troposphere, we can skip the chicken-and-egg problem between convection and low-level flow.

Our analysis of the mid-topospheric circulation revealed that the location of the rainband corresponds closely to the region in which the jet stream advects warm air (Figure 1). In early June, as the Tibetan Plateau warms up, active monsoon convection takes place north of the Bay of Bengal, giving rise to a mid-tropospheric temperature maximum over the southern flank of the Tibetan Plateau. The westerly jet stream at the mid-troposphere advects this warm air eastward and northeastward to cental-eastern China, Japan, and the North Pacific around 35°N (Figure 2). This horizontal advection forces air upward (Figure 1). The induced updraft in the mid-troposphere pumps the low-level warm moist air upward, triggering convection and precipitation. Once convection kicks in, it releases large amounts of latent heat that greatly amplifies the upward motions. Eventually the updraft

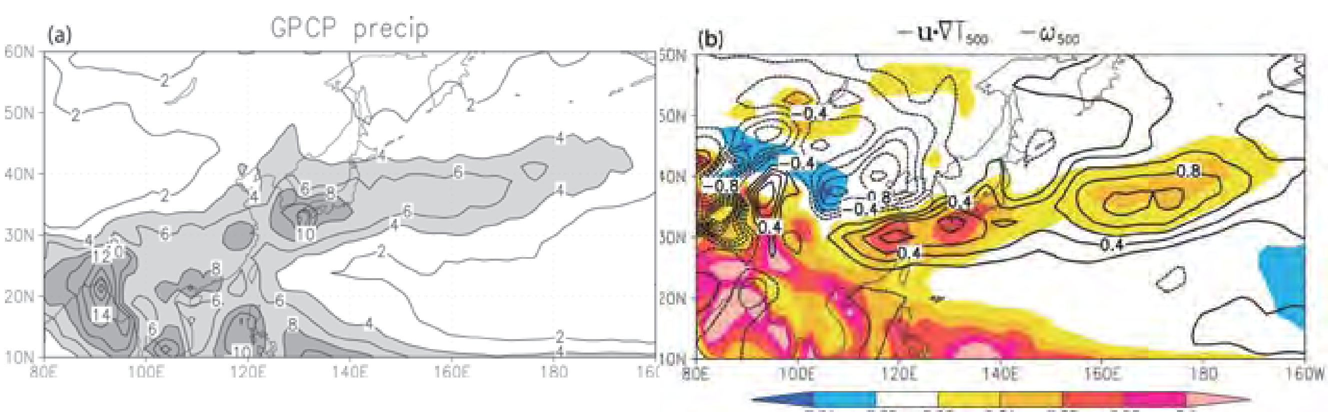



**Figure 1. (a) Map of rainfall (mm/day) during 6/16-7/15, averaged from 1979 to 2004. (b) Map of horizontal advection of temperature (contour, K/day) and upward velocity of air (color, Pa/s) at 500 hPa.**

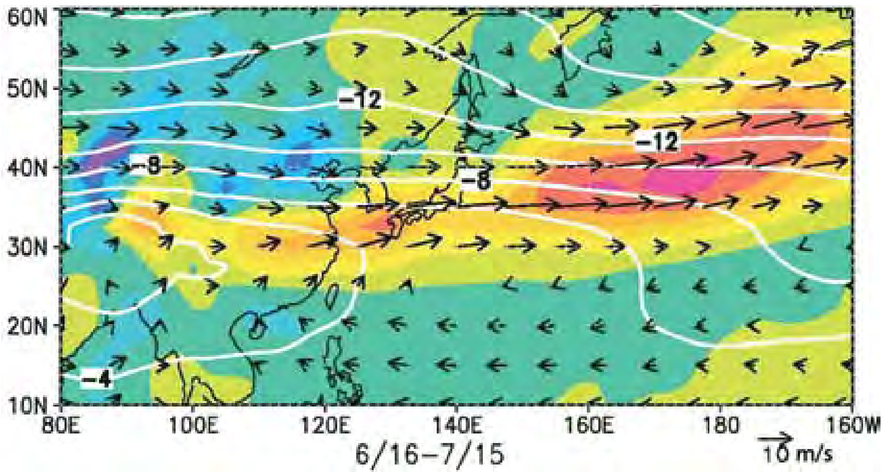



Figure 2. 500-hPa temperature (white line), wind vector, and temperature advection (color). Warm advection forms downstream of the temperature maximum over the continent, along the southern flank of the jet stream.

becomes much stronger than that first induced by the mid-tropospheric warm advection. Weather disturbances in midlatitudes guided by the jet stream into the Meiyu-Baiu region further increase atmospheric instability and the strong updraft, fueling convection along the jet stream. The cyclonic vortex from the eastern slope of the Tibetan Plateau may also foster storms in the upper reaches of the Yangtze River Valley.

The pattern of mid-tropospheric warm advection by the jet stream also explains the season of the rainband. In May, when the temperature maximum is over northern Indochina, the warm advection by the jet stream occurs downstream over southern China, Taiwan and Okinawa, consistent with a peak of precipitation observed there. In June, when the jet stream has migrated to 30°N-35°N, the Meiyu-Baiu rain band forms over central-eastern China and Japan. The end of the rainy season there is then marked by the further northward migration of the jet stream to around 45°N in mid-July. At this position, the jet stream, flowing far north of the temperature maximum anchored over southern Tibet around 30°N, no longer advects much warm air.

As a first step toward developing climate dynamics of the Meiyu-Baiu formation, our research will help to understand and make better predictions of early summer climate in East Asia.

This story is based on

Sampe, T. and S.-P. Xie, 2009: Large-scale dynamics of the Meiyu-Baiu rain band: Environmental forcing by the westerly jet. *J. Climate*, DOI: 10.1175/2009JCLI3128.1, in press.

Two ladies cross Benkei Bridge in Tokyo in 1932. They wear ashida or tekageta, high sandals worn in the rain.

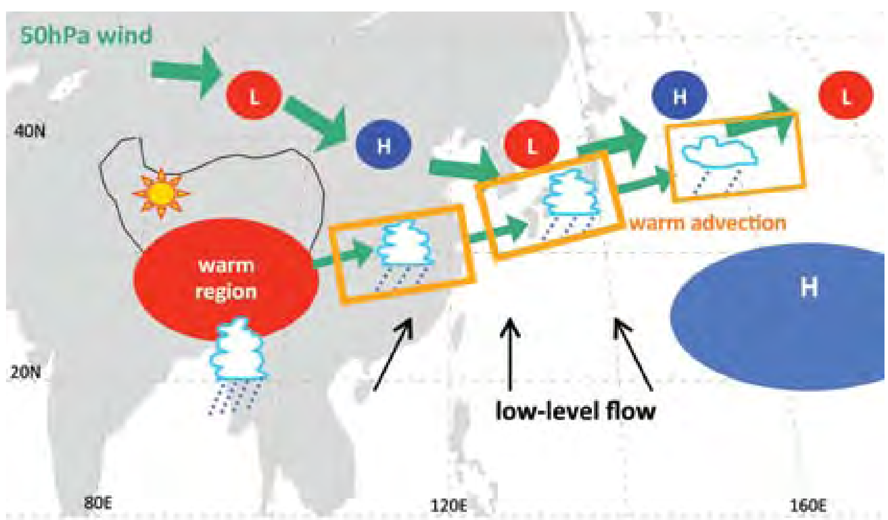
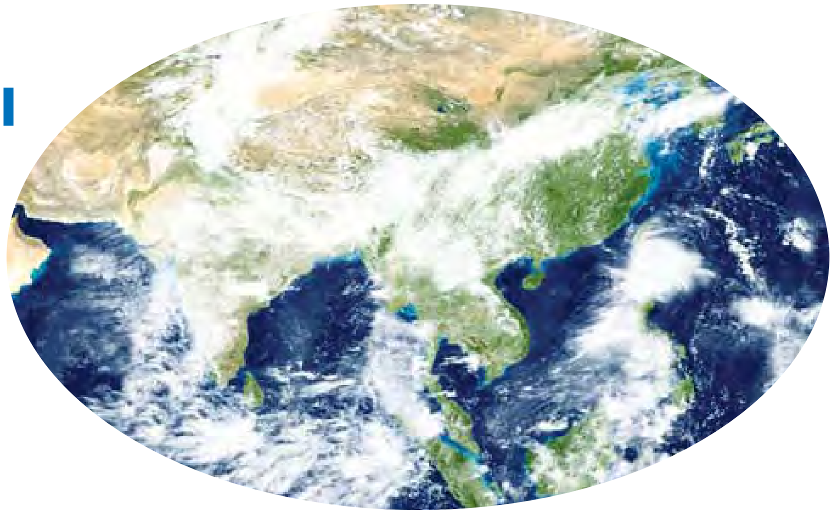



Figure 3. Schematic showing important factors in the formation of the Meiyu-Baiu rainband. Mid-tropospheric winds (green arrows) advect warm air south of the Tibetan Plateau to central China and Japan (orange), which induces updraft and triggers convection in the presence of low-level warm moist air from the south. An upstream branch of the jet stream steers weather disturbances (small circles with "H" and "L") from midlatitudes into the Meiyu-Baiu region to help trigger convection.

# Mysterious Summer Rains

## How Does the Tropical Indian Ocean Affect Summer Climate of the Northwest Pacific and East Asia?



Satellite image of clouds over Asia. Earth observatory NASA blue marble

Summer is the rainy season for much of East Asia. In some summers or some regions, the rains may be strong, causing severe floods, in other summers or other regions, they may fail. Already in the 1980s, meteorologists noted a peculiar relationship: the Meiyu-Baiu rainfall and summer rainfall in certain parts of East Asia correlate not with concurrent equatorial Pacific sea surface temperature (SST) as would be expected, but with an El Niño that occurred two seasons earlier. The major floods that devastated vast regions in the Yangtze River Basin during 1998 summer are a striking example of prolonged effects of a major El Niño event. A series of studies by **Shang-Ping Xie, Jan Hafner, Hiroki Tokinaga,** and **Takeaki Sampe** at the IPRC, and colleagues at the Ocean University of China and the Chinese Academy of Sciences, now provide strong evidence that these anomalous rainfall patterns are induced by El Niño conditions that linger on in the far away tropical Indian Ocean.

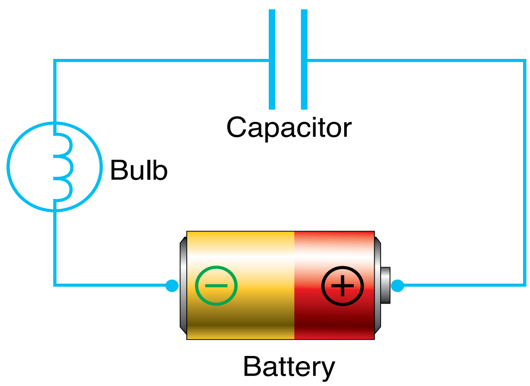
### The Mystery

El Niño peaks in December and by the following summer, the atypical warm surface water in the central and eastern Pacific has usually disappeared. What provides the memory of these conditions that impact East Asia's summer climate six months after the El Niño peak? Previous studies linked these East Asian climate anomalies to an El Niño-induced anticyclonic circulation and suppressed atmospheric convection over the subtropical Northwest Pacific. Other anomalies, however, also persist into the next summer after an El Niño. For example, the troposphere in the tropics warms when El Niño peaks in winter, and this warming persists into the next summer. These two sets of anomalies—the surface circulation in the subtropics and the tropospheric warming trapped mostly in the narrow equatorial belt—are far apart both geographically and vertically. The team of scientists, however, discovered that they are intimately linked through something happening in the tropical Indian Ocean.

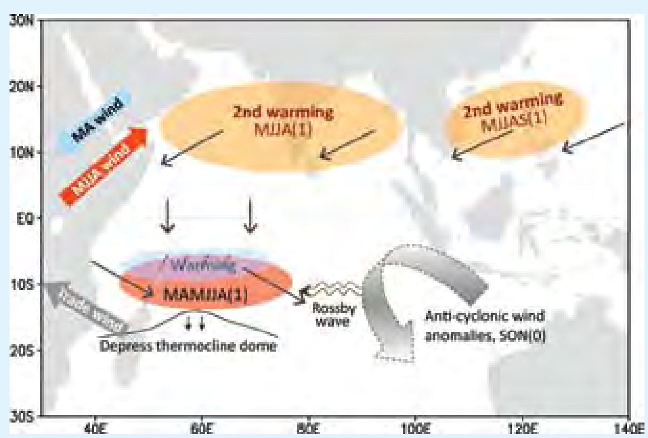
Hukou County (Jiangxi Province) government building in summer 1998. Photo source: Hukou government website.

## The Capacitor Effect

It has been well known that El Niño conditions warm the tropical Indian Ocean basin-wide through teleconnection mechanisms. A 2007-collaborative study by Xie and colleagues at the Ocean University of China proposed that El Niño charges the tropical Indian Ocean like a battery charges a capacitor, and the persisting tropical Indian Ocean warming exerts its climatic effect like a discharging capacitor after El Niño itself has dissipated. See "Charging the Indian Ocean Capacitor" [Side Bar] for details of this significant study.




How a capacitor works.




Schematic of the asymmetric atmospheric anomalies triggered by Rossby Waves over the thermoclime dome in the tropical South Indian Ocean, and the northeasterly wind anomalies that lead to the second summer warming over the North Indian Ocean.

### *Charging the Indian Ocean Capacitor*

The basin-wide surface warming of the tropical Indian Ocean a few months after an El Niño peaks came to scientific attention in the late 1970s. Then in 1999, in a survey of historical ship observations, **Stephen Klein** and colleagues at the Geophysical Fluid Dynamics Laboratory found that the changes in clouds and wind-induced evaporation during an El Niño form an atmospheric bridge in which the descending circulation branch warms the tropical Indian Ocean. Experiments with atmospheric GCMs coupled to ocean mixed-layer models support this bridge effect.

The work led by **Yan Du**, formerly at IPRC and now at the South China Sea Institute of Oceanology, Chinese Academy of Sciences, revealed that in the North Indian Ocean and the South China Sea the sea surface temperature peaks twice. The first peak occurs during the peak of El Niño, signaling the direct effect of the atmospheric bridge from the Pacific. The second peak, however, occurs in June–July after El Niño has dissipated. This second peak must be induced by some form of memory mechanism beyond the Pacific, the scientists concluded.

That mechanism, they found, consists of downwelling ocean Rossby waves triggered during El Niño in the tropical Southern Indian Ocean. As these waves propagate westward, they warm the tropical southwestern Indian Ocean by deepening the usually shallow thermocline. The slowly propagating warm Rossby waves anchor a wind pattern that intensifies atmospheric deep convection during the spring after El Niño. This excites a basin-wide asymmetric atmospheric circulation, with anomalous northeasterlies north of the equator and anomalous northwesterlies south of the equator (see figure). As the prevailing winds turn southwesterly with the summer monsoon onset, the opposing northeasterlies weaken the southwest monsoon, giving rise to the pronounced second warming over the northern tropical Indian Ocean and the South China Sea.

This second warming is confined in the North Indian Ocean to the mixed layer and results mostly from a change in wind-induced evaporation, as Klein and colleagues have shown. The new piece in the climate-dynamics puzzle is the finding that the slow Rossby waves propagating on the thermocline anchor the North Indian Ocean wind anomalies. Given the climatic effects (see main text), this ocean-atmosphere interaction can be exploited for seasonal climate prediction.

## Tropospheric Warming and Kelvin Wave Induced Rainfall

The work on the capacitor effect led to a new puzzle: Why are the most pronounced anomalies of rainfall and surface circulation observed in the subtropics and not on the equator?

Xie and his colleagues at the IPRC and the Chinese Academy of Sciences found the answer to these questions. During the summer following an El Niño, the warm tropical Indian Ocean heats the troposphere in towering cumulonimbus convection. This tropospheric warming spreads horizontally in accordance with equatorial wave dynamics first described by Taroh Matsuno in 1966. Specifically, Rossby waves carry the warming westward off the equator, while to the east, a wedge-like Kelvin wave, trapped on the equator, penetrates into the western Pacific (red contours in Figure 1). The tropospheric temperature warming resembles the equatorial wave response to isolated heating on the equator, a solution first described by Adrian Gill in 1980.

And how does the Kelvin wave circulation induce rainfall anomalies in the subtropics? Surface friction is the key. The warm Kelvin wave is accompanied by low surface pressure centered on the equator. Surface friction drives southwesterly winds (green vectors in Figure 1) on the northern flank of the Kelvin wave. The resulting surface divergence suppresses atmospheric convection in the subtropical Northwest Pacific (light gray in Figure 1), and the reduced latent heat release spins up the anomalous anticyclonic circulation, which in turn intensifies surface divergence. These anomalous conditions are part of a north-south dipolar teleconnection that retains a memory of this past. This meridional atmospheric teleconnection with suppressed convection over the Philippines and Guam and a low pressure center just east of Japan is called the Pacific-Japan pattern, first discovered by **Tsuyoshi Nitta** in 1987. This teleconnection favors the summer hemisphere because feedback between circulation and convection is stronger there than in the winter hemisphere.

The atmospheric circulation adjustment due to Kelvin-wave induced Ekman divergence illustrates that convective feedback in the tropics can result in moist teleconnections that differ from those in dry wave dynamics. More research into moist teleconnection dynamics should improve understanding and prediction of climate impacts that are of tropical origin.

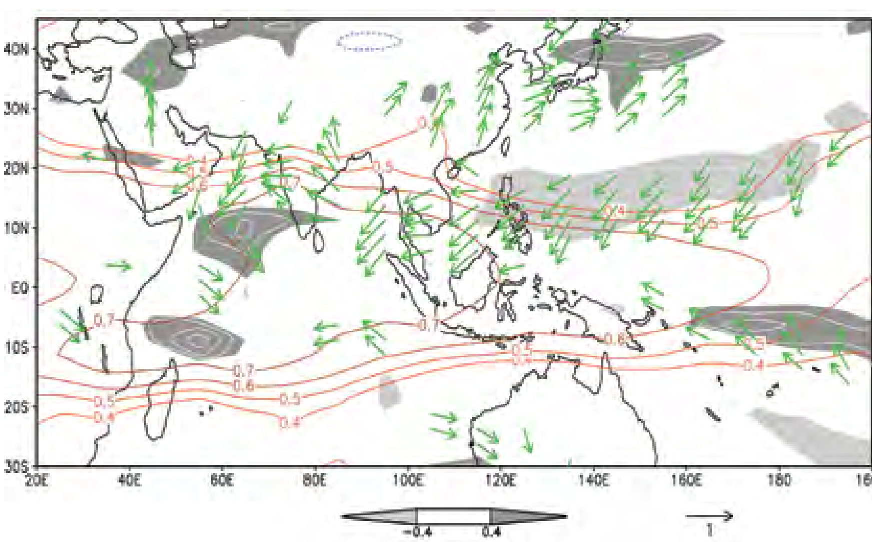



**Figure 1. June–August correlation with previous November–January Niño-3.4 SST index: tropospheric (850–250 hPa) temperature (contours), precipitation (white contours at intervals of 0.1; dark shade > 0.4; light < −0.4), and surface wind velocity (vectors).**

**Above: Flooded boulevard in Huangshi City along the Yangtze River in summer 1998. Source: http://www.hsdcw.com/html/2009-8-18/211092.htm.**

## Prediction Experiment

Postdoctoral fellow **Jasti Chowdary** led an IPRC–JAMSTEC collaboration to study a hindcast of East Asian climate for 1997–98, the period of the "El Niño of the century." Peaking in December 1997, El Niño had decayed almost completely when in the following summer, stations of the Yangtze River Basin recorded the highest river levels ever. Although the government spent enormous efforts to build levees along great stretches of the riverbanks, the destruction was immense. The floods left 14 million people homeless.

The 1998 summer floods fit the typical pattern of the Northwest Pacific–East Asian response to El Niño. A strong anomalous anticyclone circulation with suppressed convection developed over the subtropical Northwest Pacific, exciting the Pacific-Japan pattern with unusually heavy rainfall from eastern China to Japan.

The hindcast was run with the coupled ocean-atmosphere forecast model developed by **Jing-Jia Luo** at JAMSTEC. The control run, initiated three months beforehand, showed the unusual circulation pattern over Asia in summer 1998 and the anti-cyclonic circulation over the subtropical Northwest Pacific (Figures 2a and 2b). Although the model run displaced the heavy rainfall over eastern China and the Yangtze Basin offshore to the southeast, it captured the strong southwest winds that fed the huge rainfall over eastern China, and it showed the broad tropospheric warming over the tropical Indian Ocean and the warm Kelvin wave wedge penetrating into the western Pacific along the equator.

The team tested specifically for the capacitor effect in a model run without the tropical Indian Ocean warming due to El Niño. Results are shown in Figure 2c. This run reproduced only a weak version of the El Niño related pattern, supporting Xie's and his colleagues' explanation for the mysterious lingering effects of El Niño on East Asia and Northwest Pacific climate. This new understanding of the link between climate conditions in the Pacific and Indian Oceans, and the East Asian summer rainfall and Pacific-Japan pattern, bodes well for predicting future extreme events.

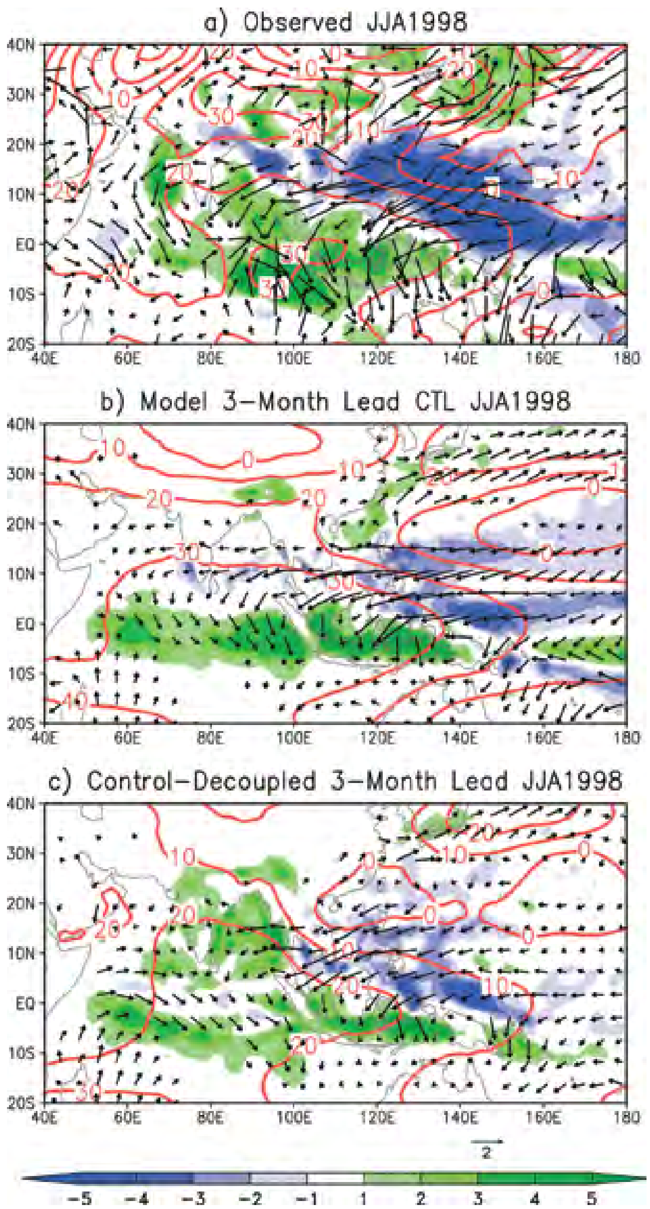



**Figure 2. Anomalies of precipitation (shaded in mm/day), tropospheric temperature represented by geopotential height difference between 200 hPa and 850 hPa (contours in m) and surface winds (vectors in m/s) during June–August 1998: (a) observations, (b) Control run, and (c) Control minus No Tropical Indian Ocean (NoTIO) run. Both Control and NoTIO runs were initiated with conditions 3 months earlier, in March.**

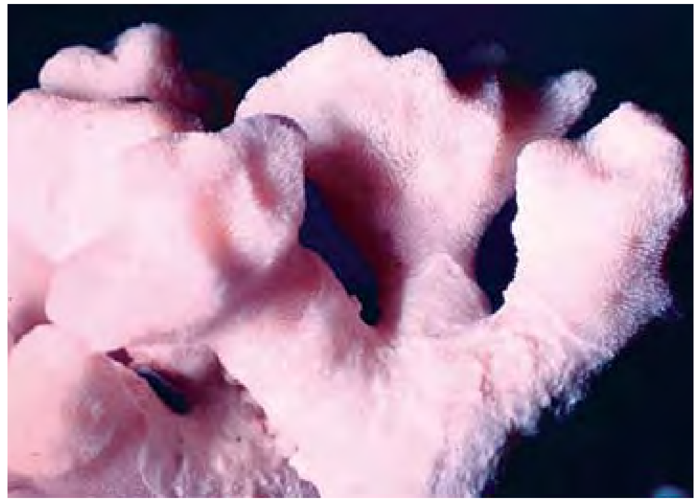
This story is based on the following scientific articles:


Chowdary, J. S., S.-P. Xie, J.-J. Luo, J. Hafner, S. Behera, Y. Masumoto, and T. Yamagata: Predictability of Northwest Pacific climate during summer and the role of the tropical Indian Ocean. *Clim. Dyn*., in press.

Xie, S.-P., K. Hu, J. Hafner, H. Tokinaga, Y. Du, G. Huang, and T. Sampe, 2009: Indian Ocean capacitor effect on Indo-western Pacific climate during the summer following El Niño. *J. Climate*, **22**, 730–747.

Du, Y., and S.-P. Xie, K. Hu, G. Huang, 2009: Role of air-sea interaction in the long persistence of El Niño-induced North Indian Ocean warming. *J. Climate*, **22**, 2023–2038.

# Unlocking El Niño's Past to Forecast its Future



Associated with droughts, floods, and other weather disturbances, the El Niño-Southern Oscillation has grave consequences for agriculture and fisheries worldwide. Thus a rather urgent question is, how will El Niño change with the warming projected for the 21st century? Clues to El Niño's future behavior might be found in its past. Scientists have been reconstructing climate from such records as tree rings, ice cores, corals, and sediments that reflect past El Niño events. These proxy records, however, have a drawback. They vary greatly amongst each other for reasons that could range from inaccurate dating of the proxy to contamination from non-El Niño-related climate signals. And this is where a new proxy index of El Niño events is making a significant contribution. Developed by IPRC scientists **Shayne McGregor, Axel Timmermann,** and **Oliver Timm**, the new index matches the instrumental record closely, but extends much further back, to 1650. Already it has confirmed suspicions that El Niño events have been becoming stronger and that volcanic eruptions may create favorable conditions for El Niño.

The El Niño-Southern Oscillation, called ENSO for short, manifests itself by alternating warm phases (El Niño) and cool phases (La Niña) of surface waters in the central and eastern tropical Pacific Ocean and by a large-scale seesaw in atmospheric surface pressure between Tahiti and Darwin, Australia. The phase of the oscillation is monitored by measurements of sea surface temperature (SST) between 120°W–170°W and 5°S–5°N (the Niño 3.4 region, the box in Figure 1), and surface pressure in Tahiti and Darwin.

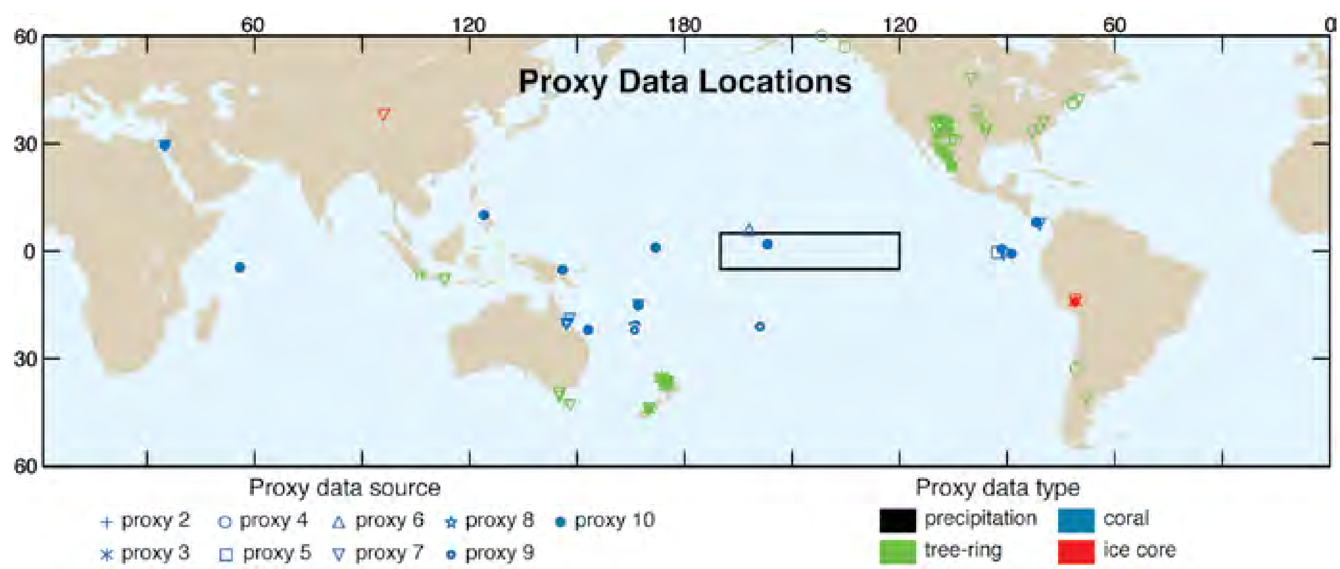



**Figure 1. Proxy location and source-type for the Unified Proxy Index derivation. Black box shows Niño3.4 sea surface temperature region.**

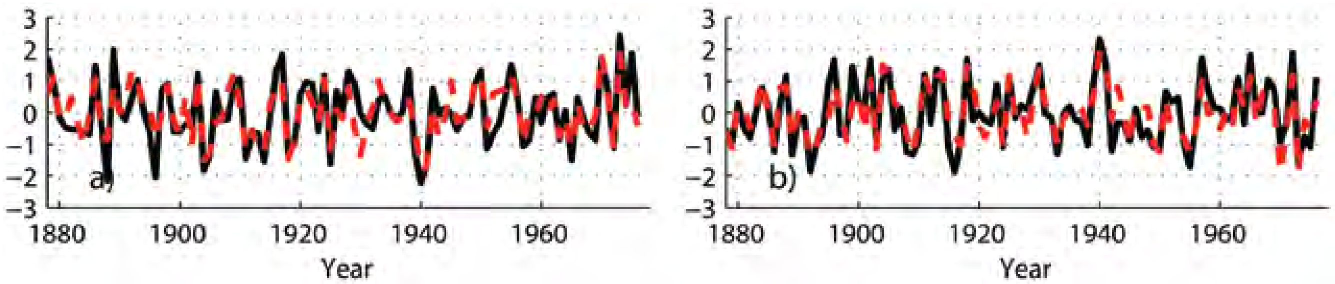



**Figure 2. Time series of the (a) Southern Oscillation Index, and (b) Niño3.4 sea surface temperature both show close correspondence between observations in black, and the Unified ENSO Proxy Index in red.**

To create a reliable and valid index of El Niño past behavior, the IPRC team selected 10 proxy records of ENSO variability that had been defined in previous studies and that compared well to the instrumental record of Niño 3.4 SST or sea level pressure at Tahiti and Darwin. The proxies are derived from networks of precipitation, tree-ring, coral, and ice-core records. The input to the networks is geographically widely distributed, from the Indian Ocean and Tibet, to Australia and New Zealand, to South and North America (Figure 1). Some of the proxies are in regions directly influenced by ENSO, other network regions sampled are far away and influenced by teleconnection signals. By using principal component analysis, the team extracted a coherent ENSO signal for the 10 input proxies. This signal accounts for over half of the covariation in the 10 proxy networks during the period 1650–1977. Since the new proxy correlates nearly perfectly with the mean of the 10 proxies from which it is derived, the scientists named it the "Unified ENSO Proxy."

This unified proxy fared well on rigorous testing. A comparison with instrumental ENSO records from 1856 to 1977 showed that it correlated better (> 0.80) with Niño 3.4 SST regions and with the Southern Oscillation Index (–.81) than any of the individual proxy sets. The index captured more discrete El Niño and La Niña events, i.e., periods in which Niño 3.4 SST was above or below the defined respective thresholds, than any of the original input proxies. The unified index was also compared to different historical documentations of El Niño and La Niña events from 1650 to 1977, and once again the index identified their occurrences well and performed better than any of the individual input proxy reconstructions.

The unified proxy has already answered several significant questions. Previous El Niño reconstructions have suggested that El Niño and La Niña events have gradually become stronger since 1650. The trend could stem from uncertainties in the reconstructions. After controlling for such uncertainties, however, the scientists found that the unified proxy still showed clear evidence to support the increasing amplitude. In other words, from the early period (1650 to about 1720) until present day, the year-to-year swings in Niño 3.4 SST and the seesaw in Tahiti–Darwin sea level pressure have grown larger (Figure 3). This

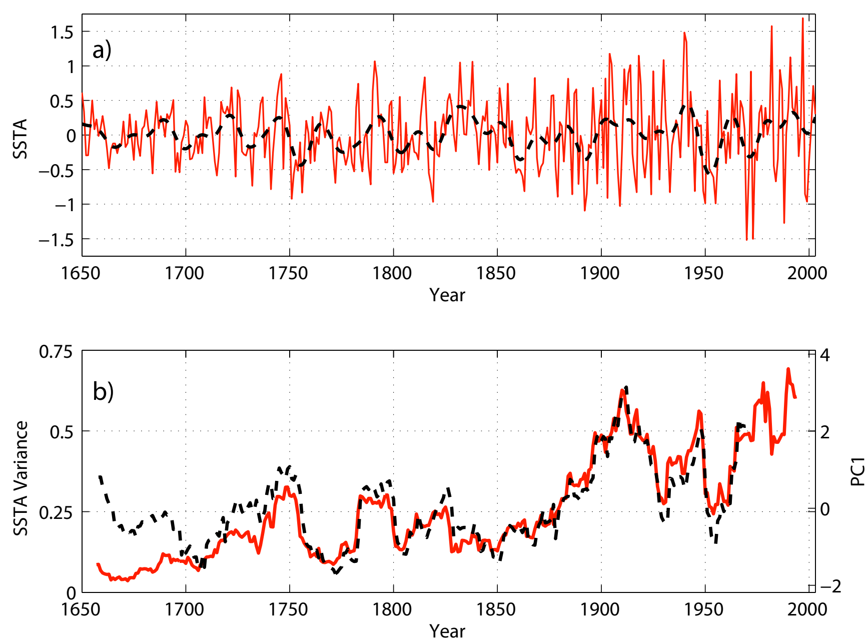
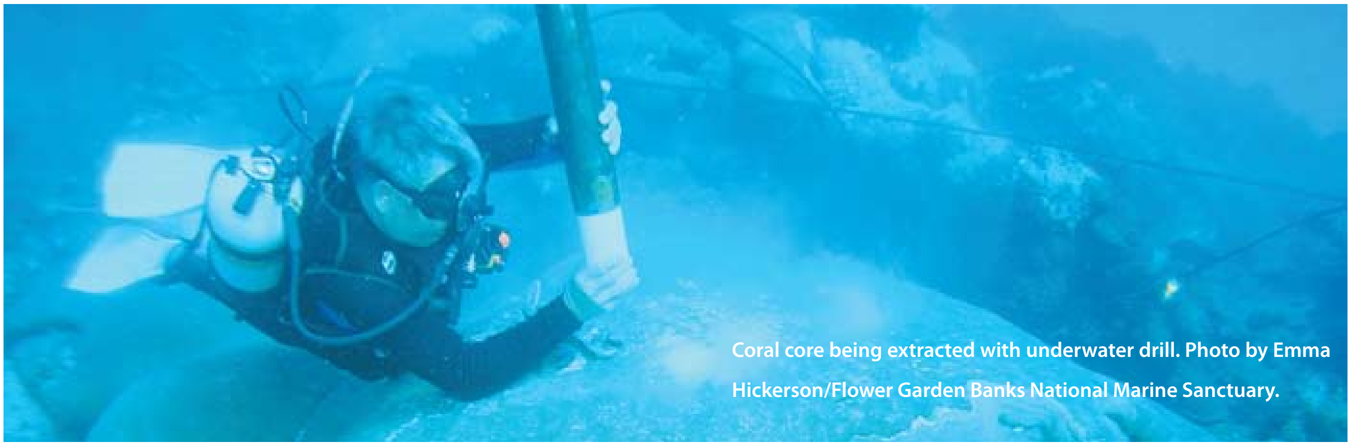



**Figure 3. (a) The scaled Unified ENSO Proxy (red) and its 13-year low-pass filtered variability (black); (b) the 16-year running window variance of the scaled index (red) and the first principal component of the running variance of all 10 input proxies (black).**



Coral core being extracted with underwater drill. Photo by Emma Hickerson/Flower Garden Banks National Marine Sanctuary.

increase in variance is supported by the historical chronologies and by proxies not used in creating the new ENSO proxy. The source of this increase in ENSO variance is unclear, but the team notes an interesting parallel with a reported increase in the Western Pacific warm pool temperature, an increase that theoretically could bring about greater ENSO variance.

It has long been known that the amount of energy the Earth receives from solar radiation directly affects global climate. Changes in solar radiation, therefore, have been thought to impact ENSO. The current view is that less solar radiation leads to greater ENSO swings. The unified proxy record, however, suggests the opposite: the increased variance is accompanied by increased solar radiation. Thus there is reason to question the previously proposed mechanisms on how solar radiation impacts ENSO.

The new proxy calls into question another previously proposed idea. In the early 1990s, an El Niño event persisted for about 5 years. This unusual event became the topic of many scientific papers, with one study concluding that such an event can occur only once in every 1500 to 3000 years. Over the 350-year period, the Unified ENSO Proxy shows that events of such long duration occur more frequently (about every 100 or so years) suggesting that these long events were not as unusual as first thought. The unified proxy, however, does agree with earlier studies of the instrumental record which suggest that the large shift noted in Pacific climate in the late 1970s was not unusual but appears to be part of a multi-decadal signal.

Finally, the team tested the hypothesis that volcanic eruptions affect the mean state or the probability of occurrence of El Niño or La Niña events. They analyzed two ice-core-derived indices of volcanic events from 1650 to 1977. For each reported eruption, they catalogued the values of the unified proxy for 2 years before, during, and 5 years after the event. They found that in the year of an eruption, the ENSO mean state was impacted and the probability of an El Niño (i.e., SST 0.5°C above the mean) rose from 26% in non-eruption years to either 58% or 70% depending upon the ice-core record used. Three years after a volcanic event the chances of a La Niña event occurring increased significantly from 25% to 55% or 50%, even though no significant change was detectable in the mean state.

The greatest contribution of the unified proxy is that it provides a robust index of ENSO activity over the last 350 years, an index that now allows solid validation of numerical modeling experiments. Used together with computational models of the ocean-atmosphere system, this index will improve our understanding of the source of ENSO variability.

This story is based on

McGregor, S. A. Timmermann, O. Timm, 2009: A Unified Proxy for ENSO and PDO variability since 1650. *Climate of the Past Discussions*, **5**, 2177–2222.

**A Bristle Cone Pine. Reaching an age of over 5000 years, these trees are invaluable as climate proxies for research.**

## Year of Tropical Convection

The IPRC hosted the *Year of Tropical Convection Implementation Planning Meeting* July 13–15, 2009, at the East-West Center. A joint initiative of the World Climate Research Programme and the World Weather Research Programme, the "Year of Tropical Convection" (YOTC) began August 1, 2008. The initiative calls for an extended period of coordinated observing, modeling, and forecasting with a focus on organized tropical convection, its prediction, and predictability (http://www.ucar.edu/yotc/index.html).

A central component of the project is the preparation of high-resolution global reanalysis data sets during YOTC by the European Centre for Medium-Range Weather Forecasts (ECMWF), the US National Centers for Environmental Prediction (NCEP), and the NASA Global Modeling and Assimilation Office (GMAO). These centers will also conduct experimental extended-range forecasts for the YOTC period. NASA will provide a special portal to access relevant satellite data (e.g., NASA A-Train, TRMM, geostationary) using the NASA "Giovanni" web-based interface.

The July workshop provided a forum to review relevant field programs that overlap the YOTC period, such as the VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS), the Asian Monsoon Year (AMY), and the THORPEX Pacific Asian Regional Campaign (T-PARC). Although the focus is on tropical convection and its effects, the reanalyses and other data products produced for YOTC will have wide application in weather and climate research.

The July meeting identified specific events that occurred during the YOTC period and that will be targets for special analysis, for example active MJO phases, tropical easterly waves and tropical cyclones. Specific modeling and analysis projects to be conducted as part of YOTC were also discussed. These projects include 5-day initialized forecasts for each day of the YOTC period. The forecasts are to use a wide range of climate models; some experimental forecasts are to use very fine-resolution global models.

Participants unanimously recommended that YOTC be extended through April 2010 to include what appears to be a developing El Niño in winter 2009–10. The extension will complement the beginning of the YOTC period when La Niña conditions prevailed.

The meeting attracted 28 external participants from several countries as well as many IPRC and other University of Hawai'i scientists. The meeting agenda can be downloaded from http://iprc.soest.hawaii.edu/meetings/workshops.php.

**Organizers of the YOTC planning meeting from left, Jim Caughey (World Meteorological Organization), Mitch Moncrieff (NCAR), Kevin Hamilton (IPRC), and Duane Waliser (Jet Propulsion Laboratory).**

## 9th Annual Symposium

Symposium organizer Nikolai Maximenko at the IPRC Poster Session.

The 9th IPRC Annual Symposium was held at the East-West Center in Honolulu June 1–2, 2009. As in previous years, the symposium featured presentations from a large number of IPRC faculty, researchers, and postdoctoral fellows, each covering a highlight of recent research efforts. This symposium had two new features: one was a poster session, which included interactive computer presentations and animations displayed on IPRC's Magic Planet spherical projection system; the other was a webcast of the entire proceedings using the "GoToMeeting" software. This allowed web browser access to real-time audio and video-camera feeds as well as to an image of the computer screen of the presenter. The symposium was organized by an energetic committee led by IPRC Senior Researcher **Nikolai Maximenko**. The workshop agenda is at http://iprc.soest.hawaii.edu/meetings/workshops.php.


Participants at the 9th IPRC Annual Symposium.

## IPRC Website Has New Design

On October 16, 2009, we launched our redesigned IPRC website, which includes a new IPRC mission statement and statements of the IPRC vision and unique role in the climate research community. Another novel feature is the presentation of our research as it is captured in our quarterly reports. We invite you to visit the redesigned site (http://iprc.soest.hawaii.edu/) and give us feedback on its usefulness and clarity, and how we might make it better.

iprc INTERNATIONAL PACIFIC RESEARCH CENTER

## IPRC Governing Committee Meets

The IPRC Governing Committee held its annual meeting at the IPRC from April 15 to 17, 2009. **Shiro Imawaki**, Executive Director of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), who joined the Governing Committee this spring, served as Japanese co-chair; NASA Program Scientist **Eric Lindstrom** continued as US co-chair. The meeting reviewed governance issues and overall progress at the IPRC. For the first time it was extended to three full days to allow the members to hear extensive presentations from IPRC scientists on their recent research results.

Governing Committee participants from left: Eric Lindstrom (NASA), Hidetoshi Nakamura (JAMSTEC), Shiro Matsugaura (JAMSTEC), Howard Diamond (NOAA), Kevin Hamilton (IPRC), Yukio Masumoto (JAMSTEC), Masao Fukasawa (JAMSTEC), Brian Taylor (SOEST), Shiro Imawaki (JAMSTEC).

## Interim Director Visits JAMSTEC Headquarters

Interim IPRC Director **Kevin Hamilton** visited JAMSTEC headquarters in Yokosuka on August 25, 2009, to review the progress in research conducted under the partnership between the IPRC and JAMSTEC (JAMSTEC–IPRC Initiative or JII). He met with Executive Director **Shiro Imawaki**, Research Director of the Research Institute for Global Change **Masao Fukasawa**, International Affairs Division (IAD) Manager **Eiichi Kikawa**, International Cooperation Coordinator **Hidetoshi Nakamura** and **Shiro Matsugaura** of IAD. The visit also set the stage for the face-to-face meeting of the JII partnership's research-theme leaders scheduled for November in Yokohama.

## *Kuroshio* - IPRC 's New Supercomputer

IPRC has purchased and installed a new 488 core Dell Linux cluster. Appropriately named after the swift Kuroshio current, the new cluster provides nearly an order of magnitude upgrade of IPRC's computing capability.

Components waiting to be assembled into the new IPRC computer *Kuroshio*. Inset. IPRC Computer System Manager Ronald Merrill with the assembled *Kuroshio*.

## IPRC Scientists Active in the Climate Research Community

IPRC Interim Director **Kevin Hamilton** participated in the Western Regional Workshop for the National Climate Change and Wildlife Science Center, a new program of the US Geological Survey (USGS) geared toward providing information on climate change relevant to wildlife management. Held June 4–5 in Seattle, the workshop brought together USGS managers with a broad group of potential stakeholders in the new program, including scientists from universities in the western US, Alaska and Hawai‘i. The workshop focused on hearing stakeholders' views and their priorities for the new National Center. A meeting summary is at http://nccw.usgs.gov/documents/NCCWSC_Western_Workshop_Summary.pdf

Hamilton also made a presentation at the NOAA Pacific Islands Fisheries Science Center (PIFSC) Climate Workshop held August 5–6 in Honolulu. PIFSC sought input at the workshop for integrating climate-change research into their program over the next three years. With over 200 employees, the PIFSC has the mandate to administer scientific research and monitoring programs that support the conservation and management of living marine resources.

At the NOAA Pacific Island Fisheries Science Center Climate Workshop from left: Eileen Shea (Chief of Climate Monitoring and Services Division, NOAA National Climatic Data Center), Laura Hamilton (NOAA Pacific Regional Coordinator), and Kevin Hamilton.

**Kaoru Sato,** Professor of Earth and Planetary Science at the University of Tokyo, and **Toru Sato**, Professor of Communications and Computer Engineering at Kyoto University, kindly invited Kevin Hamilton to visit the world-renowned MU Radar Observatory near Shigaraki, Japan. Consisting of a phased array of 475 antennas operating at 1 megawatt power, the MU radar can profile three-dimensional wind, temperature and turbulence in the troposphere and lower stratosphere with very high temporal and vertical resolution. By far the most capable instrument of its kind in the world, it not only measures variables related to climate, but has also been applied to track the space debris in low Earth orbit. While at the observatory, Hamilton enjoyed interacting with graduate students from the University of Tokyo and Kyoto University who are using the MU radar for their thesis projects.

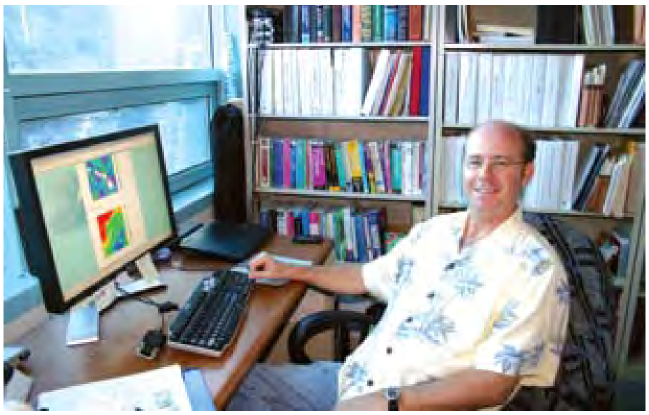
Kevin Hamilton with Professor Kaoru Sato (right) and students at the MU Radar Observatory.

The CLIVAR Asian-Australian Monsoon Panel (AAMP) has asked IPRC scientists **Xiouhua Fu** and **Bin Wang** to include the IPRC Hybrid-Coupled Model in the multi-model hindcasts of the intraseasonal weather disturbances that are the focus of AAMP and Asian Monsoon Year projects. The Panel was impressed with the fact that the model was able to "forecast" beyond one month the eastward movement and associated rainfall of the leading tropical disturbance, the Madden-Julian Oscillation, as it was observed during the TOGA-COARE field experiment.

IPRC faculty member **Yuqing Wang** has accepted the invitation to become an associate editor of *Advances in Atmospheric Sciences* (AAS), a Springer-published journal of the Institute of Atmospheric Physics of the Chinese Academy. AAS is an international scientific journal with papers dealing with a full range of the atmospheric sciences including the dynamics, physics, and chemistry of the atmosphere and ocean.

## James Potemra Receives AGU Award

James Potemra, Assistant Manager of IPRC's Asia-Pacific Data-Research Center, was among the recipients of the American Geophysical Union (AGU) 2008 Editors' Citations for Excellence in Refereeing. The awardees are commended by the editors of AGU journals for "consistently providing constructive and thoughtful reviews" of manuscripts.



## IPRC Scientists Participate in Aquarius Mission

Our understanding of ocean processes has benefited for many years from global satellite observations of sea surface temperature and sea surface height, but no comparable satellite observations of ocean salinity have been available. This situation will change in 2010 with the launch of the Aquarius/SAC-D satellite mission. The satellite will measure sea surface salinity and provide a global view of salinity variability at space and time scales not resolved by other parts of the Global Ocean Observing System. As with all measurement systems, the quality of the new Aquarius data must be evaluated, and IPRC scientists will be contributing to such evaluation.

In October, IPRC Senior Researcher **Nikolai Maximenko** joined the NASA Ocean Salinity Science Team. He is also the principal investigator (with **Jim Potemra** and **Peter Hacker** co-principal investigators) on a four-year NASA contract recently awarded to the IPRC for the project *Aquarius salinity calibration, error quantification, signal-to-noise analyses, and resolution studies using historical and concurrent data to study salinity structure and variability at ocean fronts and due to air-sea interaction.*

The IPRC team will focus on producing the best possible satellite-derived ocean salinity data sets by validating the data with in situ and complementary satellite data products; they will use these new data sets to analyze and characterize the space-time variability of sea surface salinity fronts.

IPRC Senior Researcher **Tangdong Qu** is participating as co-principal investigator on another part of the Aquarius Mission that is being led by **Ichiro Fukumori** at the NASA Jet Propulsion Laboratory. Under this contract, Qu will be assessing the quality of Aquarius sea surface salinity measurements using an "Ocean State Estimation System." The use of this system for comparison with the Aquarius data will bring significantly more observations to bear on assessing the Aquarius-data quality than would otherwise be possible.

Aquarius Mission Satellite. Photo courtesy of NASA.

## IPRC Publications Have Impact

The work of IPRC's **Yuqing Wang** and **Hironori Fudeyasu** and their JAMSTEC colleagues on predicting tropical cyclones with the powerful, global cloud-system-resolving Nonhydrostatic Icosahedral Atmospheric Model (NICAM) was featured in *Kaunana*, a magazine that publishes research conducted at the University of Hawai'i for a general audience.

**Bin Wang's** study on the formation of annular hurricanes was chosen as an Editors' Highlight by the American Geophysical Union. The paper was co-authored with UH Meteorology graduate student **Xiaqiong Zhou**. Citation: Zhou, X., and B. Wang, 2009: From concentric eyewall to annular hurricane: A numerical study with the cloud-resolved WRF model. *Geophys. Res. Lett.,* **36**.

The review article on the Indian Ocean circulation and climate variability by **Fritz Schott, Shang-Ping Xie**, and **Jay McCreary** was ranked in *ScienceDirect* TOP25 Hottest Articles as second most weekly downloaded article among all journals of the American Geophysical Union. Citation: Schott, F.A., S.-P. Xie, and J.P. McCreary Jr., 2009: Indian Ocean circulation and climate variability. *Rev. Geophys.*, **47**.

# IPRC Scientists Active in the Community

IPRC faculty member **Axel Timmermann** participated in a panel discussion following the showing of the film "A Sea Change," which deals with acidification of our oceans due to high concentrations of atmospheric $CO_2$. Invited by Honolulu's Bishop Museum, which hosted the July event, Timmermann was joined by 5 other panel members who came from the NOAA Pacific Islands Fisheries Science Center, the Bishop Museum, and the UH Hawai'i Institute of Marine Biology.

Timmermann was also featured on July 22, 2009, in a Hawai'i Public Radio news interview with **Ben Markus** about results from the ongoing climate model simulation on the Oak Ridge National Laboratory supercomputer. The climate

model provides an unprecedented view into the mechanisms of abrupt climate change in the past. The impetus for the Timmermann interview was a contribution by Timmermann and **Laurie Menviel** to *Perspectives* in the July 16, 2009, issue of *Science*. The interview can be heard at www.hawaiipublicradio.org/markus/climate_22.mp3.

A breakout group at the Leadership Summit, from left: Kevin Hamilton, 'Aulani Wilhelm (Superintendent, Northwest Hawai'ian Islands Marine National Monument), Deanna Spooner (Executive Director, Hawai'i Conservation Alliance), Kenneth Kaneshiro (Director, UH Center for Conservation Research and Training), Tom Giambelluca (UH), Barry Stieglitz (Project Leader, Hawai'ian and Pacific Islands National Refuge Complex), Bill Thomas (Director, NOAA Pacific Services Center).

Interim Director **Kevin Hamilton** represented the IPRC at the *Hawai'i Climate Change Leadership Summit* on July 31, 2009, in Honolulu. The summit brought together leaders from academic centers, state and federal government agencies, and nonprofit private organizations that all have interest in climate-change adaptation in Hawai'i and other Pacific islands. The meeting provided a forum for exchange of concerns and information among climate researchers and officials with responsibility for natural resource management.

Hamilton was also invited as the keynote speaker at the 2009 Earth Day observances at Windward Community College (WCC) on Oahu. WCC students, administrators, and faculty, along with members of the general public came to hear Hamilton's talk "Our Climate Dilemma: What We Know and What Options Remain" (http://kaohana.windward.hawaii.edu/story.php?aID=434).


Kevin Hamilton with WCC Vice-Chancellor Richard Fulton (left) and WCC Student Counselor Lokelani Kenolio, who organized the Earth Day event. They are standing beside a WCC innovation - a recycle bin for plastic bottles that itself is made from recycled plastic bottles!

## IPRC Teams with Adventure Sailor

There is a long tradition in oceanography and meteorology of employing “ships of opportunity” whose crew take measurements incidentally as they pursue their course through the ocean. IPRC has now engaged its own very unusual ship of opportunity, one that will take novel measurements of solid pollution in the ocean. The adventure sailor **Jim Mackey** is attempting a solo circumnavigation of the globe and has volunteered to take samples of floating debris as he makes his way from his starting point in the North Atlantic through the South Atlantic, Indian, and South Pacific Oceans, back into the Atlantic. To collect the samples, he will use a trawl designed and built by **Markus Eriksen** (Algalita Marine Research Foundation) especially for use on his small sailboat. By trawling for debris samples in seldom visited regions, his voyage will contribute to several scientific programs.

IPRC’s **Nikolai Maximenko** and **Jan Hafner** have supplied Jim with equipment and key navigational data so that he can measure the levels of partially defragmented plastics in the eastern part of the South Pacific, where Maximenko’s model predicts is the world’s ocean strongest convergence of flows and where floating matter collects from the Southern Hemisphere (see story in *IPRC Climate*, Vol. 8, No. 2). Guided by the model results, Jim will also be looking for plastic fragments in the subtropical convergences of the South Atlantic and South Pacific and along the Antarctic Circumpolar Current.

A Rival 34, the type of sailboat on which Jim is sailing. Photo source http://www.yachtsnet.co.uk/index.htm

Trawl built by Markus Eriksen for measuring marine debris from Jim’s boat.

Projected route of Jim Mackey’s solo circumnavigation.

## Visitors

**Tetsuo Nakazawa** (Japan Meteorological Research Institute), **Masaki Satoh** (University of Tokyo and JAMSTEC), and **Hiroyuki Yamada** (JAMSTEC) visited the IPRC in July. Nakazawa, who was a researcher at the University of Hawai'i in the early 1980s, discovered the nested hierarchy of cloud variability within the large-scale eastward propagation of the Madden-Julian Oscillation (MJO) and introduced the concept of the MJO supercluster. IPRC scientists took the opportunity to meet with the visitors for a lively and enlightening discussion on the space-time organization of tropical convection in observations and models.

Seated around the table from left: Ping Liu, Hiroyuki Yamada, Masaki Satoh, Tetsuo Nakazawa, Kevin Hamilton, Hironori Fudeyasu, Kazuyoshi Kikuchi, and (back left) Kazuyoshi Soma.

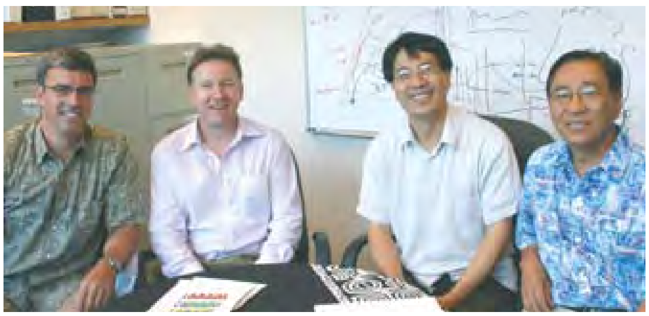
**Qinghong Zhang** from the Department of Atmospheric Sciences, Peking University, visited the IPRC from August 30 to September 29, 2009. Zhang is an expert in the areas of tropical cyclone and regional climate research and has collaborated in several projects with IPRC's **Yuqing Wang**. Their co-authored paper on hail trends in China was highlighted in *Geophysical Research Letters* and *Nature China* last year. During her visit, Zhang continued her collaboration with Wang on investigating whether observational data of hail stones show any changes in size that could be attributed to recent climate change.

The Director of the Indian Institute of Tropical Meteorology (IITM) **B.N. Goswami** visited the IPRC in July 2009. A member of the Joint Scientific Committee of the World Climate Research Programme, Goswami has contributed significantly to understanding monsoon dynamics and variability. In his meeting with the IPRC Monsoon Research Team, he stressed the urgency of more precise prediction of intraseasonal and year-to-year monsoon rainfall and of forecasting the monsoon behavior to be expected with the anticipated global warming. He also talked about events at the IITM and the exciting establishment of the new Center for Climate Change Research.

Qinghong Zhang (left) discusses hail sizes with Yuqing Wang.

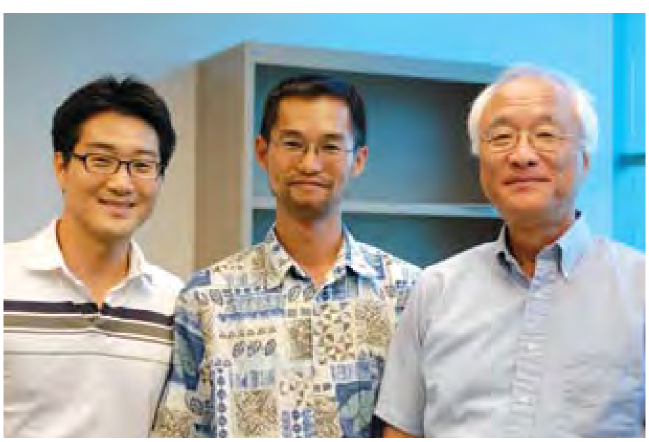
Senior Researcher H. Annamalai (left) with B.N. Goswami.

**Scott Power**, Co-director of the Pacific Climate Change Science Program (Centre for Australian Weather and Climate Research, Bureau of Meteorology) visited the IPRC in July. This new AUD $20 million climate program will help the developing island-countries in the South Pacific to understand better how climate change will affect them and assist them with adapting to the change. The program intends to produce a report on climate change for the South Pacific using a similar framework as the 2007 Working Group 1 report of the Intergovernmental Panel on Climate Change. To discuss the work ahead and possible collaborations with the IPRC, particularly studying sea level changes, Power met his IPRC host **Axel Timmermann** and several other IPRC scientists.



From left, Niklas Schneider, Scott Power, Bo Qiu (UH Oceanography), and Bin Wang.

**Masao Kanamitsu**, researcher at Scripps Institution of Oceanography, visited the IPRC in August 2009. Kanamitsu has made notable contributions to global atmospheric modeling and aspects of weather and climate forecasting. Most recently, he has been leading efforts at Scripps on regional atmospheric modeling. At the IPRC he presented a seminar titled “Dynamical Downscaling for Climate Study: Basic Concepts, Misunderstandings, and Possible Solutions.”



Masao Kanamitsu with IPRC postdoctoral fellows Hyodae Seo and Yoshiyuki Kajikawa.

**Anne Mouchet** from the University of Liege, Belgium, visited the IPRC for a week in October 2009. During her visit she gave a joint Oceanography - IPRC seminar on climate interactions with the carbon cycle. She is collaborating with **Laurie Menviel** and **Axel Timmermann** on the response of carbon isotope tracers to glacial circulation changes. Carbon isotopes ($^{13}C$ and $^{14}C$) are frequently measured in ocean sediment cores and have become one of the main paleo-proxies for ocean circulation changes. With the new version of the earth system model LOVECLIM, a model frequently used by Timmermann’s research team, this paleo-proxy can be simulated, and model results can be directly compared with paleo-oceanographic data. Mouchet also helped in developing a carbon isotope module for the vegetation model in LOVECLIM, and as a result of her visit, a new series of climate-change simulations is now being configured to elucidate the origin of $CO_2$ changes during periods of weakened Atlantic Meridional Overturning Circulation. Together with new ice core data of $^{13}CO_2$ and the new LOVECLIM model simulations that predict $^{13}CO_2$, Menviel and Timmermann will be able to test a hypothesis to explain the $CO_2$ increase in paleo-records during so-called Heinrich events.

Anne Mouchet with postdoctoral fellow Laurie Menviel.

# IPRC Takes Part in SOEST Open House


Over 4000 students and community members filled the halls and grounds of SOEST for its 10th Biennial Open House on October 16 and 17. IPRC scientists put on five different shows for the occasion: **Oliver Timm** and **Axel Lauer** focused on climate change; **Jim Potemra** illustrated how wind drives ocean currents; **Tobias Friedrich**, in his description on ocean acidification, delighted students with demonstrations on how corals dissolve in vinegar; **Yanli Jia** created a show on the annual cycle of ocean surface temperatures around Hawai'i; and **Jan Hafner** used animations of **Nikolai Maximenko's** ocean circulation model on tracer movements to describe how garbage collects in two great patches in the Pacific: the North Pacific patch, which is already well known and the one in the South Pacific, which still needs to be found. The recently acquired Magic Planet, which allows animations to be shown on a glowing 24-inch-diameter sphere, took center stage in the demonstrations.

**Konstantin Lebedev** and **Oleg Melnichenko** helped with preparations, and **Ryo Furue, Nat Johnson, Sachiko Yoshida, Tony Ma, Jing Xu, Francois Ascani, K.P. Sooraj, Hyodae Seo,** and **Jasti Chowdary** ensured that everything ran smoothly.

**Photos by Tony Ma.**

# Aloha and Welcome to the IPRC

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