iprc climate

Vol. 8, No. 1, 2008

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

Vol. 8, No. 1, 2008 **Newsletter of the International Pacific Research Center**

Road to the Mauna Loa Observatory, "a premier atmospheric research facility that has been continuously monitoring and collecting data related to atmospheric change since the 1950's."

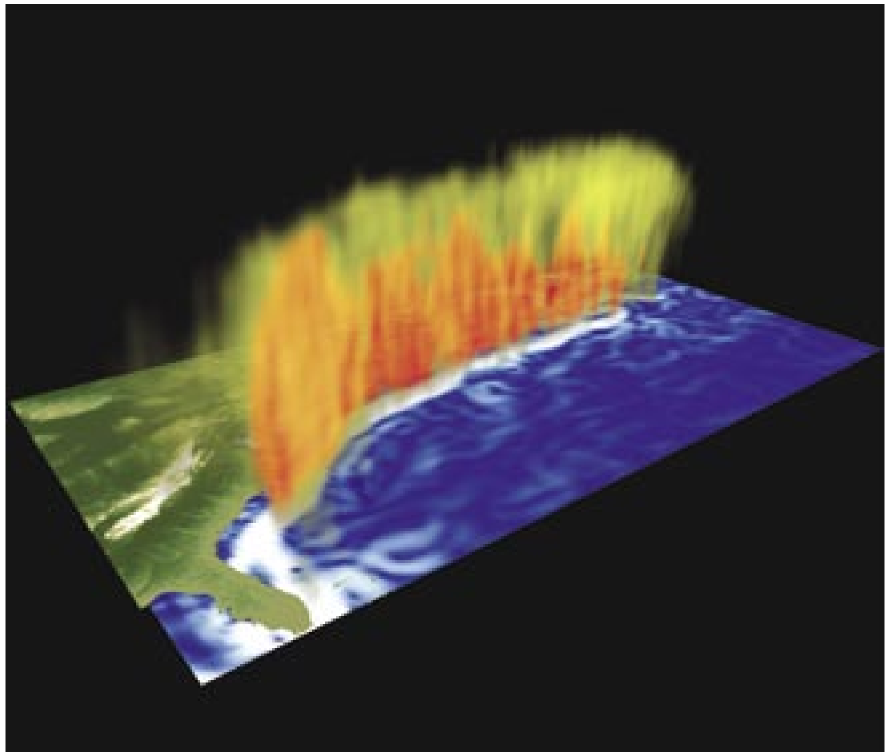
Research

Meetings

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

Cover - View of Mauna Kea from Mauna Loa

The Gulf Stream's Pathway to Impact Climate



Graphic representation of the Gulf Stream surface current speeds in blue-white (white is the fastest) and upward wind velocities in yellow-red (red for stronger winds), along with land-surface topography of eastern North America. Image, courtesy of Fumiaki Araki and Shintaro Kawahara at JAMSTEC, was made for cover of *Nature* issue.

Ocean surface temperatures and wind speeds tend to vary together across ocean basins away from tropical regions. Typically, stronger surface winds are seen over cooler and weaker winds over warmer water, because strong winds cool the ocean surface by evaporation and by stirring up cold subsurface water. But is this always the case? Aside from warm tropical oceans, where moist air ascends high into the atmosphere, are there instances where the ocean significantly impacts the deep atmosphere? Meteorologists have been skeptical, believing that at midlatitudes, the ocean's effect on the atmosphere is shallow, restricted mainly to the planetary boundary layer.

IPRC scientists and their colleagues at other institutions have been seeking to answer this question by looking at ocean fronts, where currents bring about sharp gradients in sea-surface temperature. Some of the first support came in 2002 from air soundings over the spectacular meanders, called *Tropical Instability Waves*, along the Pacific equatorial front.[1] The soundings revealed that these meanders affect the whole planetary boundary layer. Next, analyses of satellite data showed stronger winds over the warm flank and weaker winds over the cold flank of the Kuroshio as it flows along the southern coast of Japan.[2] When the Kuroshio switched between 1998 and 2001 from a straight path that hugs the coast to a meander offshore, the wind fields shifted together with the shift in the Kuroshio path.

Now the results published in the March 13 *Nature* article "Influence of the Gulf Stream on the Troposphere" show that the signature of this narrow warm current flowing in the cold North Atlantic extends surprising 7 miles high into the upper troposphere.[3]

The Gulf Stream's impact on climate, keeping Iceland and Scotland comfortable in winter compared to the deep-freeze of Labrador at the same latitude, has been known for a long time. That cyclones tend to spawn over the Gulf Stream is also well known. The study by **Shoshiro Minobe** at Hokkaido University, **Akira Kuwano-Yoshida** and **Nobumasa Komori** at JAMSTEC, and **Shang-Ping Xie** and **Justin Small** at IPRC, now reveals that the Gulf Stream has effects beyond those due to local, low-level atmospheric warming. The rain band that it anchors has strong upward motions that reach as high as the jet stream, where it can excite planetary Rossby waves.

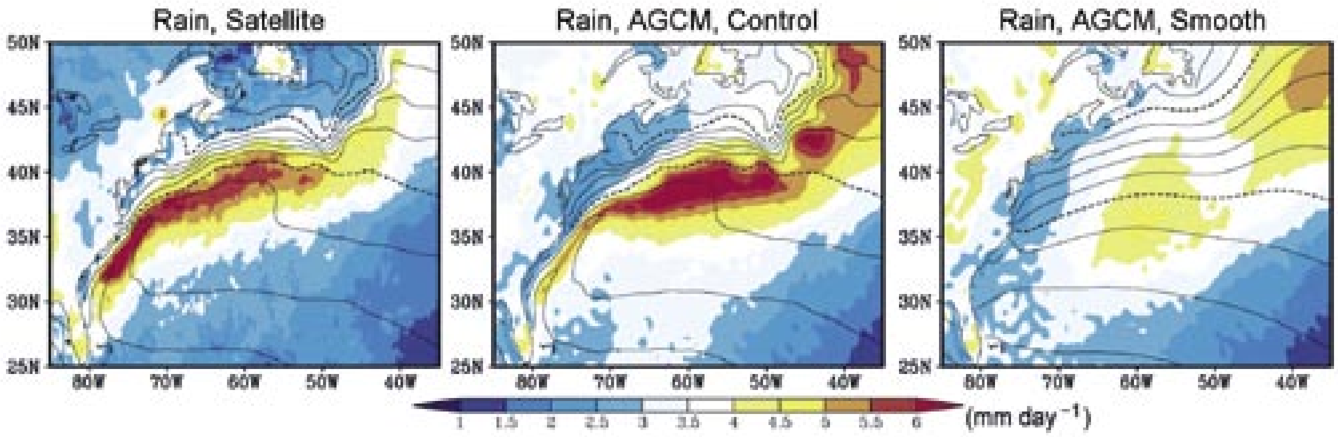


Figure 1. Annual climatology of rain rate: (left) observed by satellites; (middle) in AFES with observed and (right) smoothed SSTs. Contours for SST at 2°C intervals, and dashed contours for 10°C and 20°C (adapted from Minobe et al., 2008, *Nature*, 452, 206–209) .

Isolating the climatic influence of the Gulf Stream from energetic weather variations was challenging. Minobe had noticed in high-resolution satellite images the narrow rain band that tends to hover over the warm current. In particular, the narrow rain band hugs the Gulf Stream's warmer flank wherever temperatures rise above 16°C. The winds accelerate and converge over the warm flanks where the rain band is seen. The satellite instruments, however, did not allow measurement of any impact above the marine boundary layer to show the mechanism by which the sea-surface temperature front of the Gulf Stream affects the atmosphere.

The high-resolution European Center for Medium-range Weather Forecast (ECMWF) model analysis provided the data that Minobe needed. The analysis successfully captured the observed downward motion and diverging wind flow on the cold flanks, and the converging winds and rising air over the warm flanks of the current. The analysis, moreover, suggested that the converging winds and rising air resulted from atmospheric pressure differences related to Laplacian sea-level pressure. Previous studies favored the notion that winds over narrow sea-surface temperature fronts accelerate due to vertical mixing of air. A marine atmospheric boundary layer model simulation of the Gulf Stream region, however, supported the sea-level pressure adjustment mechanism. The upward winds are strongest just above the marine boundary layer, but are still visible at 4 miles, and in the upper troposphere, they diverge right above the Gulf Stream's narrow band.

Experiments conducted by Akira Kuwano-Yoshida and Nobumasa Komori with the high-resolution JAMSTEC Atmospheric General Circulation Model for the Earth Simulator (AFES) provided further evidence that it is indeed the Gulf Stream that caused the rain band and the strong upward wind motion. They first drove AFES with the actual Gulf Stream sharp sea-surface temperature gradient. The model successfully captured the rain band and its signature in the upper troposphere. In the second experiment, they drove the model with smoothed Gulf Stream temperatures; the narrow rain band disappeared (Figure 1).

Analyses of evaporation in the models and in the satellite measurements indicate that evaporation also follows the narrow ribbon of the Gulf Stream, and that this evaporation supplies much of the water vapor that condenses into rain clouds. The ECMWF operational model analysis shows further telltale signs: the converging and diverging winds are more or less in balance; the upward motion of air above the Gulf Stream, however, is much stronger than the downward motion over its cold flanks. The strong upward motion, the authors suggest, reflects the heating released by the condensation of the moist air.

Finally, an analysis of outgoing longwave radiation shows that a high, narrow cloud band hovers slightly to the north of the Gulf Stream ribbon. These high clouds have temperatures frequently below freezing. These observations provide further evidence that the Gulf Stream's influence on the atmosphere reaches far above the lower atmosphere and high enough to excite planetary Rossby waves disturbing the atmosphere.

The findings take on even more significance when considering the fact that the Gulf Stream is the upper branch of the Atlantic portion of the ocean conveyor belt that drives the global ocean circulation. The conveyor belt is predicted to slow down with global warming. During times that Earth's climate switched between ice ages and warm periods, the Gulf Stream's strength changed markedly. Closely linked to these changes have been climate changes not only in the Atlantic, but also in the Pacific and even in the Southern Hemisphere. Scientists have suspected that in addition to the Gulf Stream's role in ocean circulation, there is an atmospheric bridge that conveys climate signals emitted from the Gulf Stream to other regions in the Northern Hemisphere.

Thus, the narrow Gulf Stream creates a vertical pathway—the deep heating of the atmosphere—by which it can impact large-scale climate (Figure 2). The heating can generate planetary waves that alter climate over Europe and beyond by riding on the westerly jet stream in the upper troposphere.

REFLECTIONS

The Gulf Stream article created a stir. Newspapers around the world picked up the press releases, and the authors were interviewed by reporters in Japan, United States, United Kingdom, and other European countries. The study was described in such popular-scientific magazines as the *Scientific American* and the *Geotimes*. The editors of the *IPRC Climate* thought, therefore, that our readers might like to find out how this article came about, and we asked the authors to send us their reflections.

Shoshiro Minobe: I begin this reflection with saying that Shang-Ping Xie and I were colleagues at Hokkaido University during the latter part of the 90's. Stimulated by a series of Xie-san's papers using QuikSCAT and TRMM,[1,2,4,5] I started sometime in 2005 to analyze satellite precipitation data. Before then, I had looked neither at precipitation nor surface wind satellite data. Soon I noticed the precipitation band over the Gulf Stream and that the surface wind convergence could not be explained by vertical mixing, a popular hypothesis others have used to explain wind patterns near sharp ocean fronts. I suspected that pressure adjustments may be the responsible mechanism, and in order to test this idea and to determine which signatures in other physical parameters related to the phenomenon, I requested the high-resolution ECMWF operational analysis in early 2006. Also, roughly at the same time, I invited Komori-san at the Atmosphere and Ocean Simulation Research Group of the Earth Simulator Center to collaborate with me on simulation of ocean-to-atmosphere feedback over the Gulf Stream using the Atmospheric General Circulation Model for the Earth Simulator (AFES).

The collaboration with Xie-san began, when for the Spring 2006 meeting of the Meteorological Society of Japan in Tsukuba, I submitted an abstract of my results on the satellite observations, and Xie-san, who was the convener at that meeting of the special session "Coupled ocean-atmospheric phenomena in the Indo-Pacific region," noticed the abstract and contacted me. I was actually impressed by the fact that he grasped the potential importance of our study from the one-page abstract. Fortunately, I happened to travel on business to Hawai'i before the meeting and was able to visit the IPRC for one day in April 2006. Xie-san and I met, and we discussed the findings and what kind of experiments would be most effective with AFES. Just before my visit to the IPRC, I found the important results from the ECMWF operational analysis that showed the surface wind convergences are closely related to

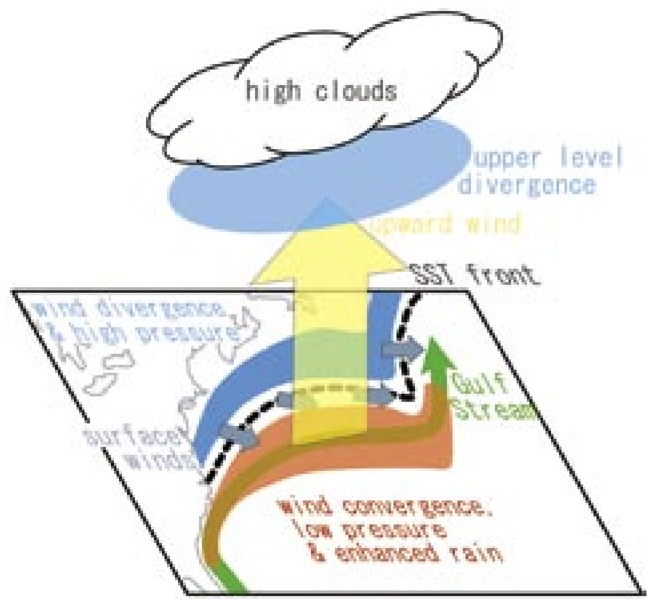
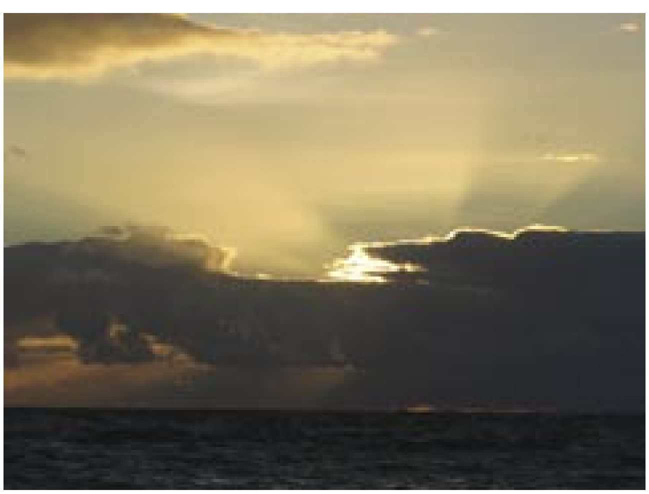


Figure 2. A schematic of the climatic responses to the Gulf Stream. The warm Gulf Stream (green arrow) creates a sharp sea-surface temperature front (black dashed line) in the cold Atlantic. The surface winds flow toward the warm Gulf Stream (gray arrows) and the warm air rises (yellow arrow), creating a region of rain (orange band). The upward motion over the Gulf Stream penetrates into the upper troposphere, creating high clouds. In the upper troposphere, the winds branch out (blue oval), forming planetary waves that travel eastward toward Europe (adapted from Minobe et al. 2008; *Nature*, vol. 452).

Laplacian sea-level pressures. Also, the upward winds occur roughly over the Gulf Stream in the ECMWF analysis; they are prominent at 500 hPa and discernible even at 300 hPa. This is quite exciting; the aforementioned vertical mixing process mainly occurs in the surface layer, which is usually assumed to occupy the lower one-tenth of the atmospheric boundary layer or the lowest 100 m. The deep penetration of the upward winds and associated horizontal wind divergence in the upper troposphere indicate that the direct influence of the Gulf Stream penetrates about 100 times higher than that expected from vertical mixing alone.

At the May meeting in Tsukuba, Xie-san, Komori-san, Yoshida-san and I discussed and agreed upon the conditions for the AFES experiments. The experiments were to demonstrate that the precipitations and warm rising air were effects of the narrow Gulf Stream sea-surface temperature gradient. Komori-san and Yoshida-san ran the experiments on the Earth Simulator, completing them by August. About the same time (September 2006), I found the outgoing longwave radiation signature along the Gulf Stream that documented the high altitude of the clouds. So, we essentially obtained the results presented in *Nature* within about one year or so.

The writing took a little longer than I expected. My one week visit to the IPRC in February 2007 was helpful. Without Xie-san's broad knowledge and insightful comments, we would probably not have made it into *Nature*. My next visit to the IPRC in August 2007 was also fruitful, particularly the talks with Justin Small, who examined the linear response of the atmosphere to heating above the Gulf Stream. His results indicate that the atmospheric heating due to the Gulf Stream can generate atmospheric Rossby waves with sizable amplitudes. All in all, I think that the process from inception to publication was amazingly fast.



Akira Kuwano-Yoshida and Nobumasa Komori: We, Akira and Nobu, are immigrants from Earth to the virtual earth called "CFES" (Coupled General Circulation Model for the Earth Simulator). Since this virtual planet was unexplored, we grew forests, dug ground, opened straits, and made clouds to mimic our mother planet. Sometimes, we go back to Earth and report on the current status of CFES. A first encounter with Minobe-san from Earth was at the 2005 Spring Meeting of the Meteorological Society of Japan (MSJ) in Tokyo, when Nobu showed some pictures taken of our virtual planet. The pictures included a precipitation band over the Kuroshio extension front. Minobe-san asked the virtual oceanographer, "How tall is the signal?" He again asked the same question at the 2005 IAG/IAPSO/IABO Joint Assembly in Cairns, Australia, but Nobu did not have any idea yet. Finally, Minobe-san came all the way to our virtual earth in Yokohama on 14 February 2006 (St. Valentine's Day) and Akira, a virtual meteorologist, joined the discussion as a translator between the Earth climatologist and the virtual oceanographer. Using satellite observations of Earth, Minobe-san had found that precipitation is anchored by sea-surface temperature (SST) gradients, such as along the Gulf Stream. He had already figured out the cause, pressure adjustment mechanism. Although we had noticed a similar feature in CFES, we did not have enough time and knowledge to determine its causes. We were so busy breaking in CFES. By coincidence, it was just one month before Bunmei, which means "civilization" in Japanese, emigrated to our barren planet from an island of perpetual summer, where Xie-san lives.

At the 2006 Spring Meeting of the MSJ in Tsukuba, Minobe-san and Xie-san suggested the experiment using AFES, the atmosphere of CFES. When we fed the down-on-earth SST from satellite observations to AFES, we saw a similar concentration of rain over the Gulf Stream as the satellite pictures show. The rain band disappeared when we fed AFES with artificial smoothed SST! Furthermore, we found that extratropical cyclone activity was also anchored by the Gulf Stream and disappeared in the smoothed SST run. We sent only a small part of the experiment data, about 400 GB, to Minobe-san in September 2006. Using outgoing longwave radiation data from our virtual earth, he found in just 10 days that high clouds occurred frequently over the Gulf Stream. He verified this with satellite observations of Earth. It was amazing for us: our virtual earth was able to capture Earth's real behavior that had been unknown to humans.

The authors from left, Shoshiro Minobe, Justin Small, Shang-Ping Xie, Akira Kuwano-Yoshida, and Nobumasa Komori.

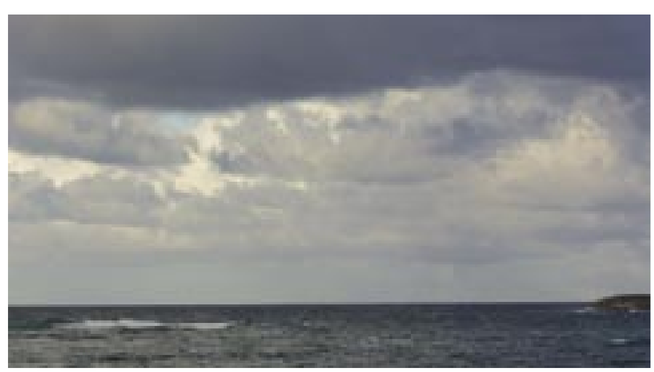
After that, all we could do was to follow tempestuous discussions between the Earth men, Minobe-san and Xie-san, and *Nature*. A large number of emails with energetic discussions passed in front of us. We, of course, continued to explore our planet and looked into whether cyclone activity varied with seasons. Akira presented the results at IUGG in Italy in July 2007. At the end of November 2007, fortunately, the paper received quite positive evaluation from the editor of *Nature*. We were happy, because *Nature* recognized that our virtual earth was comparable to "nature", and "pacific" days came back to our life.

But not for long! It was 11 December 2007, when Minobe-san brought up the idea of making a cover for *Nature*. Xie-san knew that visualization researchers also live on our virtual planet and suggested we get their help. They study how the virtual earth, consisting of only digits, can be seen by human eyes. We asked some of them, Fumiaki and Shintaro, to make a 3D picture from the ECMWF data within a week. They agreed readily, making beautiful pictures, and one of them was chosen as the cover of *Nature*!

The *Nature* paper is the start, not the goal for us in the exploration of our virtual CFES earth, though the days of success were precious for us young virtual earth researchers.

Shang-Ping Xie: In 2003, the Ocean-Atmosphere Group at the Earth Simulator Center, in collaboration with the Frontier Research Center for Global Change (FRCGC), began producing results from their high-resolution simulations. During that summer, Youichi Tanimoto invited me to visit Hokkaido University. He and Shozo Yamane, then at FRCGC, made available the output from the high-resolution AFES simulations. In browsing the AFES output in Sapporo, I noticed that the Gulf Stream anchors a narrow rain band that meanders with the warm current, a collocation I confirmed with microwave satellite observations. That was interesting but still needed additional results to be a substantial paper. Subsequent reading of the literature made me aware of observations hinting at strong climatic effects of the Gulf Stream: stratocumulus clouds often begin to develop strongly on the warm flank of this warm current during winter cold surges; coastal weather radars, with a limited offshore range, suggested high echo tops over the Gulf Stream; most interestingly, satellites record high occurrence of lightning over the Gulf Stream, indicative of tall and cold clouds there. All these observations went into our *Nature* paper as circumstantial evidence for robust and deep atmospheric effects of the Gulf Stream.

On his visit to IPRC in 2005, Tatsushi Tokioka, the director general of FRCGC, suggested holding a joint session at a semiannual meeting of the Meteorological Society of Japan (MSJ). As a result, Hisashi Nakamura of FRCGC and The University of Tokyo and I convened a special session on Indo-Pacific climate variability at the 2006 Spring Meeting of the MSJ in Tsukuba. Two months before the meeting, Shoshiro Minobe submitted an abstract on the Gulf Stream's climatic effects; the abstract struck a chord with me. I immediately e-mailed Shoshiro and the rest is detailed in his reflections. I have known Shoshiro for 20 years, but this is the first time we collaborated on a paper. Shoshiro's drive, initiative, leadership, and perseverance made it possible for our paper to appear in *Nature* and on its cover. His idea to relate sea-level pressure Laplacian to surface wind divergence is ingenious, and his enthusiasm affected and drove us all involved.

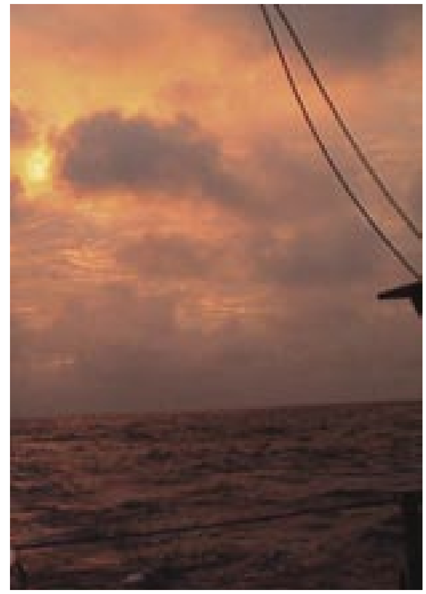


As often happens, the success of this project owes much to those who are not on the author list. Some of their names appear above. They enlightened us and afforded opportunities for us to connect and go beyond what we can do by ourselves.

The paper travelled with us far beyond Japan and Hawai‘i as we worked on it. I received a version of the manuscript last summer while visiting the Ocean University of China in Qingdao. I locked myself up and worked on the paper. Another time, on a very early morning after getting off a red-eye cross-Atlantic flight, I was in the lobby of an Amsterdam hotel waiting for my room to be ready, when I received the first decision from *Nature*, which Shoshiro had forwarded to me. I was thrilled that two reviews were very positive, but the third had concerns. Shoshiro and I then exchanged many e-mails and phone calls to discuss the revision. We were very pleased that eventually all three reviewers enthusiastically supported our paper in *Nature*.

Justin Small: I had been working at IPRC on how the atmosphere responds to Tropical Instability Waves, in collaboration with Shang-Ping Xie and Yuqing Wang. I was naturally curious to see if similar effects occurred over mid-latitude fronts. Therefore I was glad to be introduced to the work of Minobe and Xie on the Gulf Stream at an early stage. Looking at the estimates of "diabatic heating" in the atmosphere (mostly caused by condensation of water vapor during convection) from the Tropical Rainfall Measuring Mission satellite, I noticed that convection over the Gulf Stream occurred deep in the atmosphere. However, the accuracy of these new estimates was not clear, and so the independent results of Minobe-san helped me in interpreting the satellite data.

I extended this analysis by running model simulations of the planetary wave response to the deep diabatic heating over the Gulf Stream. I was very pleased that Minobe-san and Xie were interested in this research, and they asked me to be a co-author, which I gladly accepted. It was a fascinating and enjoyable way to bring my research at IPRC to a close.



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Model Globally, Measure Locally!

Mauna Loa

A JAMSTEC-NOAA-IPRC collaboration explores the fine-scale structure of atmospheric thermal tidal oscillations.

The great 18th century German explorer and naturalist Alexander von Humboldt famously wrote that in the tropics the variation of atmospheric pressure through the day is so regular that a barometer can be used instead of a clock to tell the local time! As a randomly chosen example, Figure 1 shows the pressure at Hilo Airport on the Big Island of Hawai‘i (19.7°N) for 48 hours in February 2008. Although over the full 48-hour period the pressure falls as the synoptic-scale weather pattern evolves, the pressure reaches a peak around 9–10 o'clock each morning and evening— a pattern repeated almost every day at all locations in the tropics.

This regular daily march of barometric pressure is a surface manifestation of the atmospheric thermal tides excited by the daily cycle of solar radiation. The atmospheric tides are global phenomena and an adequate theoretical treatment requires a global model. However, the tides are also modulated by local variations in topography, leading to an interesting dynamical problem involving interaction of very disparate scales of motion. Such multiscale problems are common in meteorology and are particularly difficult to investigate using observational diagnostic approaches, since appropriately detailed observations are typically not available globally at high resolution. The advent of comprehensive global atmospheric simulation models that can be run at very fine spatial resolution has opened up new avenues to study such challenging problems. Ironically the application of such models actually may result in an enhanced desire for detailed observations (at least in some limited geographical regions) for model evaluation. In this kind of approach, detailed diagnostics are computed from the complete model global fields and the model itself is validated against some specialized set of fine resolution observations. A recent project on tidal variations in the atmosphere has brought together such fine-resolution global modeling and a local-scale observational campaign. The project has also brought together the expertise of scientists at JAMSTEC, NOAA and the IPRC.

On a local scale, the daily cycle of solar radiation induces variations in the effective surface heating over land and ocean, creating land-sea breezes, and over topographic slopes, mountain-valley breezes. These local circulations are roughly balanced between radiatively driven horizontal pressure gradients

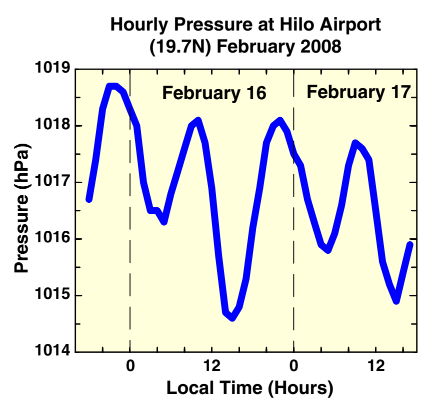

Figure 1. The hourly sea-level pressure for a typical 48-hour period at Hilo Airport (19.7°N, 155°W) plotted against local time. Data provided by the National Weather Service.

IPRC's Kevin Hamilton (right) and NOAA's Steve Ryan inspecting the pressure station located at the Mauna Loa Observatory.

and small-scale turbulent "friction"; they are generally restricted to the lowest 2–3 km of the atmosphere and have only small pressure signatures. On a larger horizontal scale, the pressure gradients caused by diurnal heating variations are balanced by Coriolis and acceleration terms, and the response can be regarded as large-scale inertia-gravity waves. On the global scale, this results in a large sun-following thermal tide that propagates vertically upward and/or downward from its forcing altitudes and is observed most readily from surface pressure measurements. This wave is conventionally resolved into diurnal (24 hour), semidiurnal (12 hour), terdiurnal (8 hour), etc. components. Although the tides contribute only modestly to barometric pressure variations in the extratropics, at low latitudes the daily tidal pressure variation, particularly that of the semidiurnal tide, exceeds that associated with typical day-to-day weather changes.

The amplitude and phase of the semidiurnal surface pressure oscillation, denoted S2(p), have now been determined at several hundred observation stations. The determinations are based on a simple Fourier analysis of long records of hourly barometric observations and are expressed as an amplitude and a local time phase (time of maximum). In the tropics and midlatitudes, S2(p) is dominated by zonally-symmetric (in local time) components. The semidiurnal tide is excited most efficiently by coherent heating sources that extend over a deep layer of the atmosphere, notably by solar heating of the stratospheric ozone. Thus, to first order, the semidiurnal tide at the ground results from a global inertia-gravity wave propagating downward from the ozone layer. This wave (which looks zonally-symmetric when the phase is expressed in local time) interacts with orography at the earth's surface, leading to geographical modulations of S2(p).

An interesting implication of our theoretical understanding of the semidiurnal tide as a vertically-propagating wave is that the amplitude of the pressure perturbations by topography should vary roughly as the inverse square-root of the mean density. This suggests a first order effect of topography on S2(p) may simply be a reduction of amplitude over that at sea level at the same latitude. Earlier authors have noted that in several cases the S2(p) at high altitude stations appear to be anomalous relative to lower elevation stations, although this possibility apparently has not been explored systematically previously. There have been a number of earlier studies of the semidiurnal atmospheric tide that have used comprehensive global models dating back to the pioneering works of Zwiers and Hamilton (1986) and Tokioka and Yagai (1987). Since at that time those models had to be run at fairly coarse spatial resolution (horizontal grid spacing of 300 km or more), these studies could not adequately simulate the effects of regional topographic features.

IPRC Interim Director **Kevin Hamilton** and JAMSTEC's **Wataru Ohfuchi** (Leader of the Atmosphere and Ocean Simulation Research Group at the Earth Simulator Center) are collaborating to examine the S2(p) simulated in an ultra-high resolution version of the AFES (Atmospheric General Circulation Model for the Earth Simulator; Ohfuchi et al. 2004). Specifically, they are examining integrations with a version of the model with T1279 horizontal spectral resolution and 96 levels in the vertical up to about 60 km. The model spectral fields are reconstructed on a 3840x1920 latitude–longitude grid, corresponding roughly to a 10-km horizontal grid spacing. The model employs a slightly filtered version of realistic T1279 resolution topography. As an interesting aside, Hamilton has estimated that integrating the fine resolution AFES requires more than

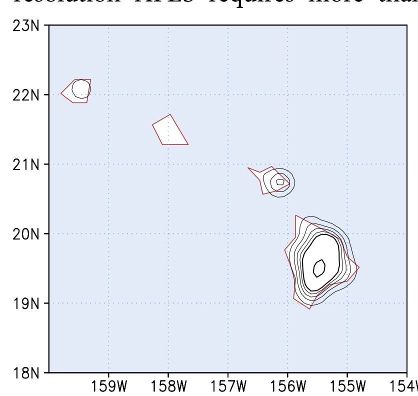

Figure 2. Topographic heights for the Hawaiian Islands as represented in the T1279 AFES model. Thin contours are for 200, 400, 600, 800 m, thick contours for 1000 and 2000 m.

one million times the computational effort per day of simulation as the models used by Tokioka and Yagai or Zwiers and Hamilton, which represented the state-of-the-art two decades ago! The amazing increase in computational power in the last two decades, including the advent of the JAMSTEC Earth Simulator in 2003, has opened entirely new avenues in atmospheric modelling.

In their analysis, Hamilton and Ohfuchi have found some small-scale features in the AFES-simulated semidiurnal surface-pressure tides in the vicinity of high and steep topography. While some limited observational support for these simulated patterns is available from previous single station determinations of S2(p) in various parts of the world, they identified a need for a set of observations of S2(p) concentrated around some large and steep topographic feature.

The Big Island of Hawai'i is an ideal test bed for the effects of tall and steep local topography on the tide. Hamilton and Ohfuchi have shown that in AFES the tall mountains of the island modulate the tides in interesting ways. Figure 2 shows the topography of the Hawaiian Islands as represented in the model. Due to the limited spectral resolution, it is unrealistically smooth, representing the Big Island as a single ridge oriented roughly north-south with a peak height of about 2200 m. The island's real topography (shown in Figure 3) has two very tall peaks, Mauna Loa (4150 m) in the south and Mauna Kea (4200 m) in the north, separated by about 30 km and a valley dropping to about 2000 m. Despite the limitation in resolution, AFES should allow a reasonable topography-tide interaction for the region. In both the real world and the model topography, the distance between the highest points and sea level on the west coast of the island is roughly 50 km, resulting in quite steep mean slopes in the east-west direction (~.05–0.1). Each circle in Figure 4 shows the normalized S2(p) amplitude as simulated at one grid point and plotted as a function of the topographic elevation of the grid point in the model. The values are normalized by the amplitude means at the grid points closest to Hilo (model grid point at 19.72°N, 154.97°W) on the east coast and Kona (model grid point at 19.72°N, 156.0°W) on the west coast. Results are shown for points in the box 19°N–20°N, 155°W–156°W, which includes almost all the Big Island land mass and a small amount of surrounding ocean. Results for the eastern half of the box

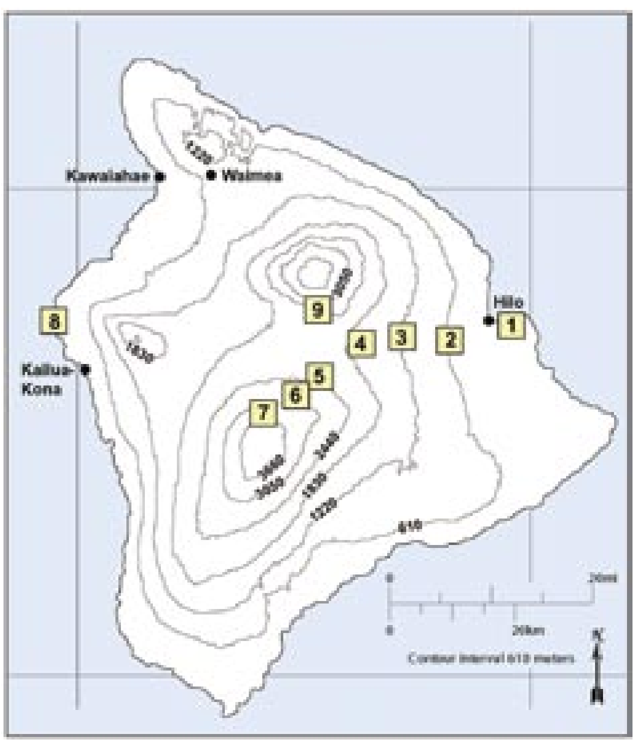

Figure 3. Topographic map of the Big Island of Hawai'i with the positions of the barometric stations deployed by the Mauna Loa Observatory marked as squares. Station numbers correspond to those in Figure 4.

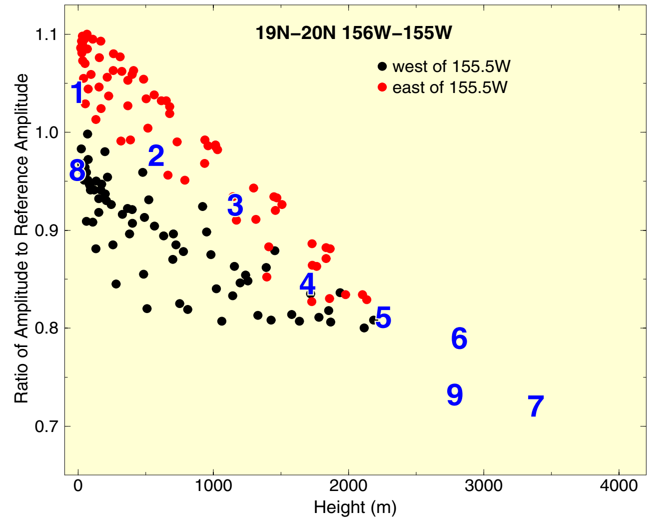

Figure 4. A plot of S2(p) amplitude and topographic height at individual grid points in the AFES simulation, where S2(p) amplitude at each grid point is divided by the average of the amplitudes at grid points near Hilo (east coast) and Kona (west coast; see text for details). Results are shown for the box 19°N–20°N, 155°W–156°W, with the eastern half in red and the western half in black. The blue numbers show the normalized two-year mean S2(p) amplitudes from barometric observations at the network of 9 stations shown in Figure 3. The observations are normalized by the average of the station amplitudes at Hilo and Kona.

are shown in red and for the western half in black, roughly corresponding to the grid points on the eastern and the western slopes. The general decay of pressure amplitude with height is very evident. The amplitudes, moreover, are clearly higher on the eastern than the western slopes.

Hamilton and Ohfuchi suggest a simple explanation for these results: the low S2(p) amplitudes on the west side are due to wave scattering by the mountains. Figure 5 shows a schematic of the group velocity associated with a large-scale inertia-gravity wave directed downward and westward towards a topographic feature. Simple-plane wave theory for a wave with semidiurnal frequency would predict a slope of 0.015 from the horizontal for the group velocity vector. It is reasonable to expect that steep topography casts a long "shadow" to the west, reducing the S2(p) amplitude in the shadow region.

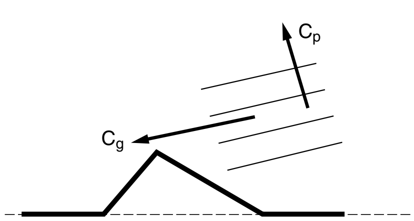

Figure 5. A schematic of a large-scale inertia-gravity wave directed downwards and westward towards a topographic feature.

In a quest for observational support of their model results, Hamilton and Ohfuchi have teamed up with **Steve Ryan** of the NOAA Mauna Loa Observatory (MLO). MLO has deployed a network of 9 identical data-logging instruments recording surface pressure and surface air temperature at 1 second intervals across the Big Island. The station locations are shown in Figure 3. Station #1 is at Hilo Airport and station #8 is at Kona Airport. Station #7 is at elevation 3396 m at the Mauna Loa Observatory on the north slope of Mauna Loa, almost due north from the summit. Stations #2 to 6 lie in a rough line between Hilo and MLO ascending the northeast slope of Mauna Loa, and station #9 is on the south slope of Mauna Kea at 2797 m, almost due south of the summit. The network allows an unprecedented sampling of S2(p) over a large range of elevations in a small geographical region.

S2(p) amplitude and phase for the station network have been determined from two full years of observations. The amplitude for each station, normalized by the mean of the values at Kona and Hilo, is plotted as a function of elevation in Figure 4 for easy comparison with the AFES grid point results. A tendency for amplitude to drop off with height is apparent in the station observations, and the rate of decrease with height is comparable to that in the AFES simulation. Also the contrast in amplitude between Hilo and Kona provides some observational support for the east-west asymmetry of S2(p) across the Big Island in the AFES simulation. Specifically, the ratio of the observed S2(p) amplitude at Hilo to that at Kona is 1.08; the AFES simulated amplitudes at the grid points near Hilo and Kona are also in the ratio of 1.08. The simulated local time phases of S2(p) are 9.44 hours at the grid point near Hilo and 9.64 hours at the grid point near Kona, showing a similar contrast as the observed station values (9.50 and 9.60).

This study used the AFES simulations to investigate longstanding issues in the regional modulation of the semi-diurnal tide. Numerical weather prediction models are being run in major operational centers at increasingly fine spatial resolution. A realistic simulation of the topographic modulation of the daily pressure variation in such models should help to accurately assimilate surface pressure observations, and thus improve weather predictions. The study also provided a chance to evaluate the AFES model itself. It is encouraging that this high-resolution model is able to successfully simulate such detailed regional structures as found in S2(p).

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Mapping High Sea Winds from Space

Wouldn't maps be useful that show where gales are common over the ocean? They would come in handy, for instance, for setting shipping routes, selecting oil rig placements, planning wind farms, or preventing coastal erosion. Such maps, however, have not been available because ships try to avoid places where they expect to hit high winds. The coming of satellites carrying scatterometers that scan surface winds uniformly over the ocean now makes the systematic observation of winds over the ocean possible without any danger. IPRC postdoctoral fellow **Takeaki Sampe** and research team leader **Shang-Ping Xie** have taken advantage of this new data to create such wind-frequency maps.[1]

Sampe and Xie examined the twice-daily data relayed by the NASA QuikSCAT satellite from September 1999 to August 2006. After removing rain-flagged data, they counted the number of observations with wind speeds greater than 20 m/s (40 knots or about 46 mph) for each calendar month at each grid point, and then determined for each grid point the percentage of the total valid observations that the wind speed was greater than 40 knots. With these percentages, they then created a monthly climatology of the frequency of high sea winds over the open ocean. This climatology is available as world maps at http://iprc.soest.hawaii.edu/~takeaki/highwind/. Figure 1 shows the maps for the December–February, and July–August periods.

Although typhoons and hurricanes are the most powerful storms on Earth, the maps show hardly any region in the Tropics where high winds occur more frequently than 1% of the time. The exception is east of Taiwan in summer, where the presence of tropical cyclones raises the frequency to 2–3%.

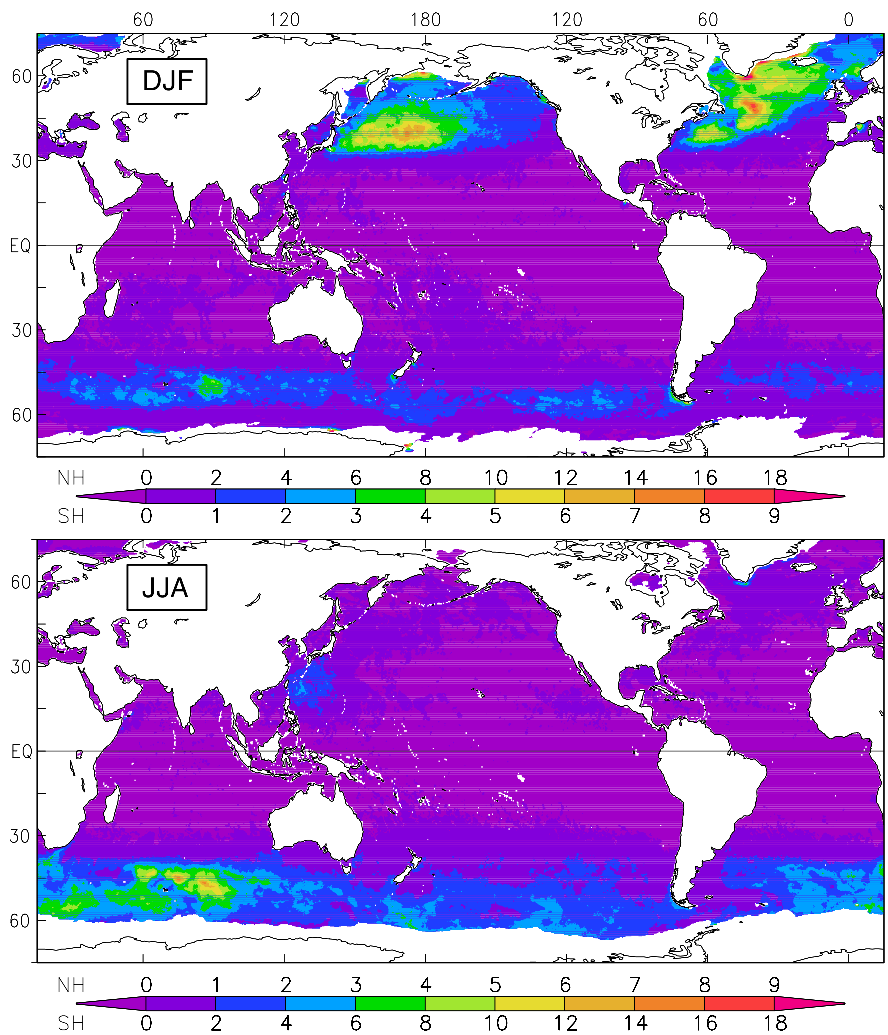

Figure 1. December–February (top) and June–August (bottom) climatology of the frequency of high-wind (>20 m/s) occurrence (%) based on QuikSCAT observations. Different color scales are used, with a reduction by a factor of 2 for the summer hemisphere. (Adapted from Sampe and Xie, 2007: Mapping high sea winds from space: A global climatology. *BAMS*., 88 (12), 1965–1978.)

Photo courtesy of Takeaki Sampe

In contrast, at midlatitudes in both hemispheres, storms leave a strong signature in the monthly satellite images. Occurring more frequently during winter when north–south SST gradients are large, midlatitude storms are organized into storm tracks. In the Southern Hemisphere, the summer storm tracks remain vigorous enough to maintain a band of high winds, making the summer–winter seasonal differences less than in the Northern Hemisphere.

There are two further remarkable features in these maps. High sea winds are seen most frequently either over small-scale, but sharp ocean sea-surface temperature (SST) gradients or they are linked to orographic features. This occurs in the Atlantic, the Pacific, and the Southern Ocean.

Take the North Atlantic (Figure 2). Embedded in the broad winter storm track are smaller regions of frequent high sea winds. Bands of strong winds are found particularly frequently over the southern, warm flank of the Gulf Stream. In the midst of the stormy North Atlantic, however, is a calm spot southeast of Newfoundland, where cold waters border the warm current. During winter, this calm region registers winds above 40 knots only 2% of the time, whereas a few hundred miles away on a warm meander of the Gulf Stream, the frequency shoots up eightfold to 16%. The transition between calm and strong winds is sometimes so sharp that the front appears as a line visibly separating calm water on the colder flank and white caps on the warmer flank.

The powerful effect of orography is seen at Cape Farewell in Greenland. This is the place visited most often by strong winds. It tops the windiest place on the yearly average, with sea winds over 40 knots more than 16% of the time; it also tops the winter list, with such winds blowing more than 25% of the time. Indeed, where tall coastlines or where high mountains meet the ocean, winds often accelerate. Such regions are responsible for half of the top 10 entries in the wind maps of Sampe and Xie, and include such places as the Gulf of Lion, where the mistral shoots down from the Alps into the Mediterranean Sea.

In the North Pacific, high winds frequently occur in winter between 35°N–45°N over the western and central North Pacific, a region roughly corresponding to the North Pacific storm track and to the region of the largest meridional SST gradient in the North Pacific. The small-scale impact of the SST gradient on winds is not as evident as along the Gulf Stream, perhaps because the gradient is not as sharp as that created by the Gulf Stream.

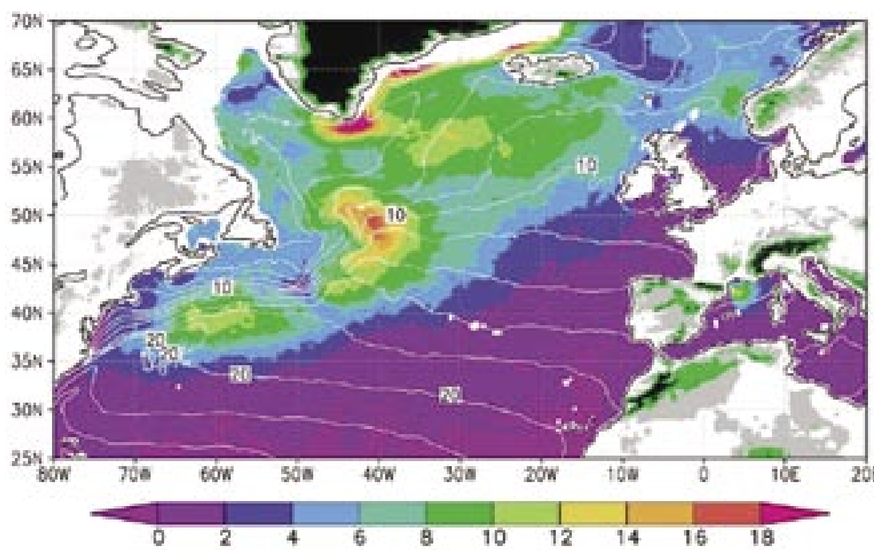

Figure 2. 2000–2006 QuikSCAT winter climatology of the frequency of winds higher than 20 m/s or 44 mph (color in %), and AVHRR sea surface temperature (white contours at intervals of 2°C). Topography higher than 500, 1000, and 1500 m is shown in gray, green, and black, respectively. (Adapted from Sampe and Xie, 2007: Mapping high sea winds from space: A global climatology. *BAMS*, **88**, 1965–1978.)

As in the Atlantic, orography is a major cause of high winds in the Pacific. For example, high winds are frequently observed south of Vladivostock, where the northwesterlies are forced through narrow mountain gaps; in the Taiwan Straits through which the northeasterly winter monsoon blows; and in the eastern Pacific, the Gulf of Tehuantepec, where the easterly trade winds shoot through a gap in the Sierra Madre.

In the Southern Hemisphere, once again gale winds blow most often over the warmer side of the Antarctic Circumpolar Current. The orographic impact on high winds is seen in several coastal regions, especially during austral winter, June–August, around Tasmania, the Cook Strait, and along the southern Chilean coast, with a maximum near Cape Horn.

Whether vertical mixing or pressure adjustments are the reason why high winds frequently occur near small-scale, but sharp SST gradients is still in debate. However, calculations over the Gulf Stream conducted by Minobe and his colleagues in the previous article suggest that surface wind convergences are closely related to Laplacian sea-level pressures.

The high-sea-wind-frequency maps generated by Sampe and Xie have both practical and scientific applications. Practical applications, as mentioned in the opening paragraph, are for such decision-making as oil-rig placement and ship-route planning. The maps could also come in handy for ships that want to avoid the brunt of a forecasted cyclone by steaming to nearby safer waters.

From a scientific point of view, high winds are important for Earth's climate. They draw tremendous heat out of the ocean, leaving behind cold, salty water that sinks to the bottom. The cold, salty water that sinks off the Greenland coast and that flowing out at the bottom of the Mediterranean are thought to be crucial for driving the deep global ocean circulation, the so-called conveyor belt. Changes in the strength and vigor of this conveyor belt have been implicated in the past in the sudden switch between colder and warmer climates, with temperature changes of up to 10°C over the North Atlantic and Europe.

Besides affecting heat flux and deep water formation, strong winds are important for air-sea gas exchange - including the greenhouse gas CO_2 - and ocean mixing. High winds, furthermore, spawn life by pumping up nutrients from ocean depths on which planktons feed. Finally, together with other recent work, the study shows the marked impact that sharp SST fronts can have on the atmosphere and climate.

As useful as these new high-wind-frequency maps are, the data from which they are derived still can use more precision. The current scatterometers do not measure accurately wind speeds above 60 mph and thus do not differentiate hurricanes according to category strength. The instruments do not see oceans within 25 km off the coast because of the scattering of radar waves by land surfaces. Xie and Sampe are looking forward to the next generation of scatterometers that will allow them to create maps with finer wind-speed gradations.

[1] T. Sampe and S.-P. Xie, 2007: Mapping high sea winds from space: A global climatology. ***BAMS***, **88**, 1965–1978.)

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Climate Change and the Pacific Islands

Lonnie Thompson during the workshop "Climatic Changes in the Last 1500 Years: Their Impact on 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 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

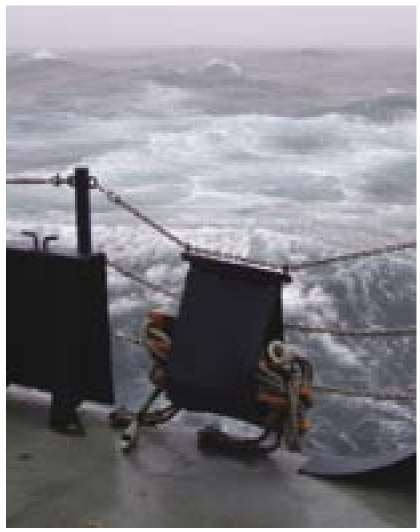

Photo courtesy of Takeaki Sampe

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

"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**, **Xiouhua 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 Mande 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 **Hidenori 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: interannual-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 mesoscale 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.

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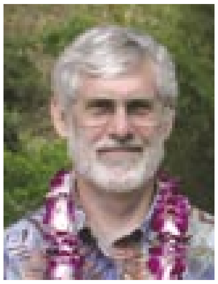
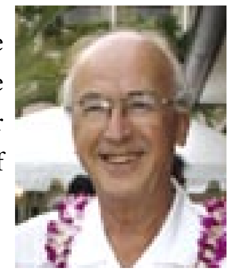


Julian McCreary stepped down from the IPRC directorship on April 1, 2008. McCreary, who had served for fifteen years as Dean of the Oceanographic Center at Nova Southeastern University in Florida, became IPRC's first director in February 1999. Under McCreary's leadership, the IPRC grew into a climate research center of international acclaim, increasing from15 scientists to nearly 50. McCreary's professional awards include the Sverdrup Gold Medal of the American Meteorological Society (AMS) and election to Fellow of the AMS and of the American Geophysical Union. McCreary remains as professor in the IPRC and the Oceanography Department.

Lorenz Magaard, Associate Executive Director since IPRC's inception in 1997, stepped down on April 1, 2008. Magaard has been at the University of Hawai'i since 1975 as Professor of Oceanography. He has served as Oceanography Department Chair from 1984 to 1990 and again from 2005 to 2006, and as Associate Dean of the School of Ocean and Earth Science and Technology for the period 1992–2000. He continues as the Director of the International Center for Climate and Society and as Professor of Oceanography.



Kevin Hamilton is IPRC Interim Director. Hamilton, a former Research Meteorologist with the NOAA Geophysical Fluid Dynamics Laboratory at Princeton University from 1988 to 2000, joined the IPRC in 2000 as Leader of the Impacts of Global Environmental Change research and as Professor of Meteorology. Hamilton served as Meteorology Department Chair from 2004 to 2007. Hamilton's professional awards include the Meisinger Award of the American Meteorological Society (AMS), the Jule Charney Lectureship of the American Geophysical Union, and election to Fellow of the AMS.

IPRC Scientific Advisory Committee Meeting

The IPRC Scientific Advisory Committee met on December 19 and 20, 2007. The IPRC had just had its 10th birthday, and the 10-member team of leading scientists from Japan and the United States reviewed and praised IPRC's scientific accomplishments. The committee discussed how the IPRC, unique as an international research center that is focused on Asia-Pacific climate, can contribute to the climate-research challenges of the coming decade.

Scientific Advisory Committee: (seated) Roberto Mechoso, Toshiyuki Hibiya, Masahisa Kubota, Humio Mitsudera (Japan co-chair), Masahide Kimoto, (standing) Peter Cornillon, Harry Hendon, Jerry Meehl (US co-chair), Julian McCreary, Susan Wijffels, and Clara Deser.

IPRC CELEBRATES 10 YEARS!

To celebrate completion of 10 years of research achievements, the IPRC held a special anniversary version of its annual symposium on May 5 and 6, 2008, at the East-West Center. The symposium opened with a welcome by Interim Director **Kevin Hamilton**, followed by a message from the Consul General of Japan **Toshio Kunikata** delivered by Consul **Yukie Kawai**, and remarks by JAMSTEC Executive Director **Kiyoshi Suyehiro**, NASA Program Manager **Eric Lindstrom**, and UH Vice Chancellor for Research and Graduate Education **Gary Ostrander**.

Professor **Toshio Yamagata** from the University of Tokyo then spoke on "IPRC viewed from its prehistory: Success produces new challenges." Yamagata was a major force in the founding of the IPRC and has been a steadfast supporter through its lifetime. For the opening of the second day of the symposium, University of Maryland Professor **Antonio Busalacchi**, long-time US chair of the IPRC Scientific Advisory Committee, gave his retrospective on IPRC accomplishments and the impact that IPRC science has made on climate research.

(Front) Kiyoshi Suyehiro, Jay McCreary, Toshio Yamagata, Eric Lindstrom, Lorenz Magaard; (back) H. Annamalai, Jim Potemra, Antonio Busalacchi, Kevin Hamilton, and Brian Taylor.

For the remainder of the symposium, IPRC scientists presented highlights of their research, many with a historical perspective showing the advances they had made over their years at the IPRC in understanding a particular aspect of the climate system.

In honor of **Jay McCreary**'s years of leadership and Toshio Yamagata's 60th birthday, a reception and dinner at the Halekulani Hotel ended the first day of the symposium.

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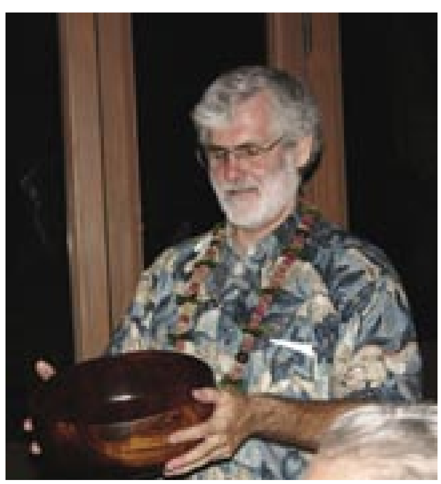


Dinner celebration: Antonio Busalacchi giving a toast, Jay McCreary receiving a koa bowl and Toshio Yamagata a koa paddle from the IPRC.

Shang-Ping Xie giving a lecture at Hokkaido University.

IPRC–Hokkaido University Partnership in Educating Climate Scientists

Visiting the IPRC during his sabbatical leave from Hokkaido University in 2007, **Youichi Tanimoto** discussed with Team Leader **Shang-Ping Xie** the possibility of Hokkaido University graduate students coming to the IPRC. He applied for a grant posted by the president of Hokkaido University for education-exchange programs with overseas universities and received one million yen (~$10,000) for students to visit the IPRC and for IPRC faculty to give lectures at Hokkaido University.

The grant has helped to support several Hokkaido PhD students in spring 2008: **Shunya Koseki** and **Hiroki Tokinaga** visited the IPRC for 3 months to study the Kuroshio Extension influence on the atmosphere; **Kunihiro Aoki** visited for 6 weeks to study ocean Rossby wave propagation and structure. In March, Xie gave a 2-day lecture series entitled "Dynamics of tropical climate: Role of air-sea interaction" at Hokkaido University. Continuing the exchange program, **Kelvin Richards** will give a lecture series at Hokkaido on ocean mixing.

IPRC Scientists Active in the Climate Research Community

IPRC Team Leader **Bin Wang** is chairing the Science Steering Committee for the project "Asian Monsoon Years" (AMY) together with **Jun Matsumoto** (Tokyo Metropolitan University). The goal of the AMY initiative, which runs from 2007 to 2012, is to improve Asian monsoon prediction by coordinating international research on understanding the variability of this monsoon. The project is part of the International Monsoon Study, a coordinated observation and modeling effort under the leadership of the World Climate Research Programme (http://www.wcrp-amy.org/). Wang helped to organize the AMY Implementation Planning Meeting, held at the Frontier Research Center for Global Change in Yokohama on January 26–27, 2008.

The Hawai'i Conservation Alliance sponsored the forum "Climate Change in Hawai'i" on March 26, 2008, at the East-West Center in Honolulu. As a partnership of 16 federal and state government agencies and non-profit organizations, the alliance promotes environmental conservation in the Hawaiian Islands. The nine invited talks featured speakers from the University of Hawai'i, Stanford University, NOAA, the United States Fish and Wildlife Service, and Conservation International. Three of the invited speakers were from the IPRC, attesting to the central role of IPRC in current research on climate change in Hawai'i. Postdoctoral Fellow **Oliver Timm** spoke on "Statistical Projection of Global Climate Change Scenarios onto Hawaiian Rainfall." IPRC Interim Director **Kevin Hamilton** spoke on "Late 21st Century Climate Change in Hawai'i Simulated with a Fine-Resolution Global Model." Hamilton also gave the talk "Dynamical Downscaling Approach for Hawaiian Regional Climate" for IPRC faculty member **Yuqing Wang**, who was on travel.

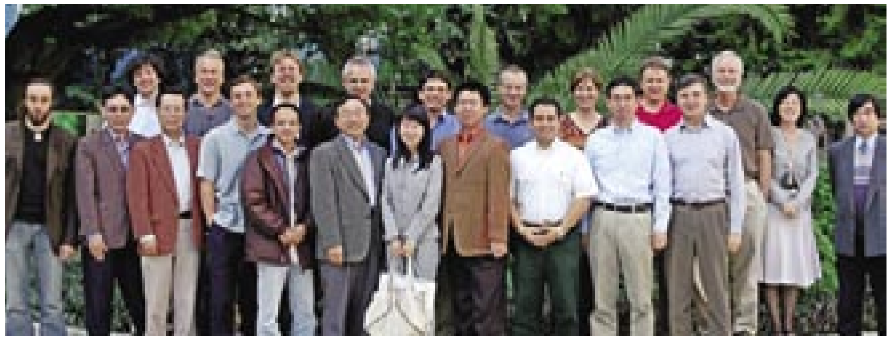
Oliver Timm speaks at the "Climate Change in Hawai'i" Forum.

Research Team Leader **Tim Li** gave a keynote address at the March 3, 2008, symposium celebrating the renaming of the Taiwan National Central University's Institute of Hydrological Science to Institute of Hydrological and Oceanic Sciences. The renaming reflects the institute's research expansion to ocean–atmosphere processes. Li spoke about advances in understanding the role of ocean–atmosphere interaction in Asia-Pacific climate.

As Chair of the International CLIVAR Pacific Panel, **Axel Timmermann** co-organized the workshop on "Western Tropical Pacific: Hatchery for ENSO and Global Teleconnections," held in Guangzhou, China, on November 26–28, 2007. The workshop dealt with the role of the South China Sea in the climate system, and with ENSO processes, impacts and prediction. Immediately following the workshop, Timmermann held the 4th Session of the CLIVAR Pacific Implementation Panel in Guangzhou on November 29–30.

Kevin Hamilton was reappointed to a third three-year term as an editor of the journal *Atmospheric Chemistry and Physics*, published by the European Geosciences Union. In a notable milestone, the journal earned the highest *Institute of Scientific Information* impact factor for 2006 of any atmospheric science journal—4.362. (www.atmospheric-chemistry-and-physics.net/news_acp_isi_impact_factor.pdf). Hamilton has also been appointed to the inaugural Editorial Advisory Board for the *Open Atmospheric Science Journal*, a new open-source journal published by Bentham Scientific Publishers (www.bentham.org/open/toascj/index).

Research Team Leader **Niklas Schneider** gave invited talks on Pacific Ocean climate variability and circulation at the "Ocean and Climate Forum" in April 2008 at Yale University and on the North Pacific Gyre Mode (a project with Emanuele Di Lorenzo, Georgia Institute of Technology) at the 2007 AGU Fall Meeting in San Francisco.



Participants of the 4th Session of the Pacific Implementation Panel.

IPRC Participates in SOEST Open House

The IPRC took part again in the UH School of Ocean and Earth Science and Technology (SOEST) biennial Open House, which is an occasion for the public to learn about the school's scientific activities. It was held October 19 and 20, 2007, and IPRC researchers put on a great show, entertaining the public with a series of animations. The HYbrid Coordinate Ocean Model, implemented for the Hawaiian region by IPRC's **Yanli Jia**, illustrated the circulation around the Hawaiian Islands and seasonal changes in ocean temperatures. An animation created by **Jan Hafner** showed the satellite rain data over the Island of Oahu during the October 31, 2005, storm that caused millions of dollars in flood-damage to the main UH library. The visitors enjoyed also an animation on ice ages generated by our JAMSTEC colleagues and an animation created by **Nikolai Maximenko** from an ocean model on the dispersion of floats over 1000 years. The floats may be seen as representing the journey of garbage dumped into the world's ocean. Bishop Museum's **Leon Geschwind** showed animations of climate change on the Magic Planet, a spherical projection system.

Students listening to Postdoctoral Fellow Ingo Richter at the Ice Age station during Open House.

IPRC Scientists Active in the Community

Timmermann and Representative Lyla Berg.

Axel Timmermann was invited by Hawai'i State House Representative **Lyla Berg** to speak at a district community forum held in Kahala, Honolulu. His talk, "Global Warming, Is It Real?" sparked much discussion. The youngest in the audience were high school students, who listened attentively and asked questions about what they can do to prevent further rise in greenhouse gas emissions.

Timmermann also participated in the radio show "Native America Calling" that had as topic global warming and how it might affect native peoples around the world. Part of the voice stream is available on the IPRC news web site.

Kevin Hamilton participated in a forum on global warming, held as part of the International Association of Defense Counsel's (IADC) midyear meeting in February at the Waikoloa Fairmont Orchid Resort on Hawai'i. The IADC is an association of corporate lawyers, and the forum came about because of their interest in legal implications of manmade global environmental effects.

Partnerships in Tropical Cyclone Research

Tropical cyclone research at the IPRC is getting a boost from the partnerships IPRC's **Yuqing Wang** is forging. In December 2007, **Chun-Chieh Wu**, a tropical cyclone expert with the Department of Atmospheric Sciences, National Taiwan University (NTU), visited the IPRC to plan a project using the IPRC Regional Atmospheric Model (iRAM) to determine the impact of global warming on western Pacific tropical cyclones. NTU graduate student **Yi Lu**, therefore, came to the IPRC for 4 weeks in January–February to learn about iRAM. During his visit, Lu helped create an algorithm that automatically tracks tropical cyclones in iRAM.

As Overseas Director of the Pacific Typhoon Research Center (PTRC) at Nanjing University of Information Science and Technology (NUIST), Yuqing Wang is helping to develop international partnerships and train NUIST researchers and students. Two postdoctoral fellows from PTRC are visiting the IPRC for one year: **Yongqing Wang** is analyzing the remote effects of tropical cyclones over the western Pacific on precipitation in Japan, and **Jinhua Yu** is studying the impact of global warming on the potential maximum intensity of global tropical cyclones.

Qingqing Li, a visitor from Shanghai Typhoon Institute, has expertise in modeling tropical cyclones with the Fifth-Generation NCAR/Penn State Mesoscale Model (MM5) and the Weather Research and Forecasting (WRF) Model. At the IPRC, he is investigating the dynamics of the tropical cyclone inner core and the processes that control tropical cyclone structure and intensity changes.

Lastly, **Haiming Xu**, an IPRC postdoctoral fellow from 2002 to 2005 and now Associate Dean and Professor in the School of Atmospheric Sciences at NUIST, is an expert in regional climate modeling. He returned to the IPRC for 2 months during early 2008 in order to improve the IPRC Regional Coupled Model (iROAM) and configure it for the South China Sea. He will be using the model to study the air–sea interaction associated with the South China Sea summer monsoon and the tropical cyclone formation associated with the tropical intraseasonal oscillation.

Tropical cyclone researchers from left: Jinhua Yu, Jia Hu, Yuqing Wang, Chun-Chieh Wu, Yongqing Wang, and Li Zhou.

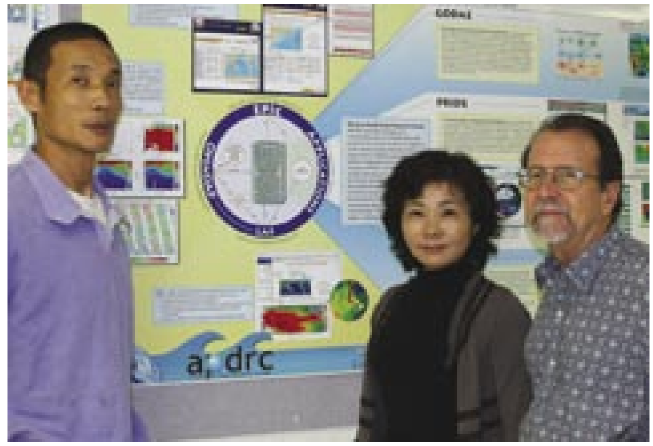
Visitors

The IPRC welcomed in January a group of JAMSTEC scientists who are developing high-resolution numerical climate models: **Akio Ishida**, **Nobumasa Komori**, **Akira Kuwano-Yoshida**, **Yoshikazu Sasai**, and **Hideharu Sasaki**. The scientists discussed recent developments in the general circulation models for the Earth Simulator - AFES, OFES, and CFES - and planned experiments and analyses of model runs (see High-Resolution Modeling Workshop). Hideharu Sasaki stayed on to work with IPRC Team Leader **Kelvin Richards** and Ocean-mixing Specialist **Andrei Natarov** on an OFES project dealing with equatorial interleavings and to work on OFES and CFES improvements with **Ryo Furue** and **Niklas Schneider**.

Ryo Furue (left), Hideharu Sasaki, and Niklas Schneider discussing OFES results.

Yumi Nakayama, science reporter for *Asahi Shimbun*, visited the IPRC on April 1, 2008. Nakayama participated in the International Visitors Leadership Program of the U.S. State Department and was hosted in Hawai‘i by the Pacific and Asian Affairs Council. Nakayama has a longstanding interest in environmental issues and recently spent 14 months in Antarctica with the 46th Japanese Antarctic Observation Wintering Team. Nakayama was interested in the climate research at the IPRC and in the challenges in predicting details of climate change in the tropical Pacific.

Yumi Nakayama, *Asahi Shimbun* science reporter, with Kevin Hamilton.



Sha Li with Research Systems Specialist Yingshuo Shen and APDRC Manager Peter Hacker.

Sha Li, Director of the Information Service Center of the South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Sciences, visited the IPRC for 6 months to learn more about the ocean–atmosphere database of IPRC’s Asia-Pacific Date-Research Center (APDRC) and to build a partnership with the APDRC scientists. This partnership will benefit the climate research on Asia-Pacific at both SCSIO and IPRC.

Ken Sperber is joining the IPRC from March to August 2008, while on sabbatical leave from Lawrence Livermore National Laboratory. Sperber and IPRC’s **H. Annamalai** are evaluating long climate simulations to test such theories of the initiation of the intraseasonal oscillation as extratropical incursions into the tropical Indian Ocean region, SST induced convection, and Kelvin-wave forcing. In these simulations, they will investigate monsoon predictability by testing the null hypothesis that the predictability is limited by chaotic intraseasonal variability. Analyses of the models may yield further insight into predictors of intraseasonal rainfall variations.

H. Annamalai with Ken Sperber.

Richard "Rit" Carbone, Director of The Institute for Integrative and Multidisciplinary Earth Studies (TIIMES) at the National Center for Atmospheric Research in Boulder, visited the IPRC during April 2008. He discussed the latest TIIMES research initiatives with Interim Director **Kevin Hamilton**, who is a member of the TIIMES external advisory committee. Carbone talked also about his own research on the dynamical mechanisms controlling midlatitude warm-season rainfall and his concerns whether these mechanisms are adequately represented in coarse-resolution global climate models. This concern struck a chord with Hamilton, who notes similar issues in modeling rainfall over tropical islands such as the Hawaiian Islands.

Kevin Hamilton with Rit Carbone.

Published!

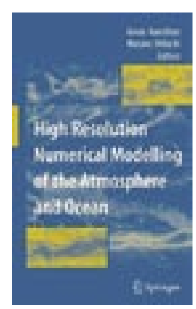
"Influence of the Gulf Stream on the Troposphere" appeared as the cover article of the March 13 *Nature* issue. **Shoshiro Minobe** (Hokkaido University) is the lead author, and JAMSTEC's **Akira Kuwano-Yoshida** and **Nobumasa Komori**, and IPRC's **Shang-Ping Xie** and **Justin Small** are co-authors. The study showed that the heat released by the Gulf Stream affects the upper troposphere, where it could have far-reaching impacts on climate (see p. 3).

Axel Timmermann was the co-author on **Lowell Stott's** (University of Southern California) "Southern Hemisphere and Deep Sea Warming Led Deglacial Atmospheric CO_2 Rise and Tropical Warming," which appeared in the September 28, 2007, issue of *Science*. The paper reported that oxygen isotope variations in microfossils show the Southern Ocean warmed before the rise in atmospheric CO_2 seen in ice-core records, an indication that an increase in Southern Hemisphere insolation triggered the warming, which was then enhanced by released CO_2.

Tangdong Qu spearheaed the work for the article "Subduction of South Pacific Waters" with **S. Gao**, **I. Fukumori**, **R. A. Fine**, and **E. J. Lindstrom** in the January issue of *Geophysical Research Letters*. The article, selected by the American Geophysical Union for its *Highlights*, reveals that the South Pacific subtropical cell, a sparsely charted circulation, contributes significantly more than had been suspected to the formation of climate-important water layers in the equatorial Pacific El Niño region.

"Mapping High Sea Winds from Space," featuring the gale-wind frequency maps developed by **Takeaki Sampe** and **Shang-Ping Xie**, appeared in the December 2007 issue of the *Bulletin of the American Meteorological Society*. The maps show that sea surface temperature fronts, such as the Gulf Stream and the Kuroshio, and tall coast lines are regions favorable to high winds. The maps, the first of their kind, are important for such things as selecting shipping routes and oil rig placement, and for such scientific purposes as charting air–sea fluxes.

Nikolai Maximenko authored with **Oleg Melnichenko** at IPRC, **Peter Niiler** at Scripps, and **Hideharu Sasaki** at the Earth Simulator Center "Stationary mesoscale jet-like features in the ocean," which describes mysterious currents, flowing in an alternating east–west pattern. These currents were detected in a combined analysis of direct ocean observations, satellite images, and computer simulations. The study created a sensation in the media before it was even published in the April issue of *Geophysical Research Letters*. It was cited in such newspapers as *The Scotsman*, *die Welt*, *Oceanographers.cu*, *South Asia News*, and in the prominent science news magazines *New Scientist*, and *ScienceNOW*.



Kevin Hamilton and his colleague **Wataru Ohfuchi**, group leader at the JAMSTEC Earth Simulator Center in Yokohama, published in January with Springer Verlag their edited volume *High Resolution Numerical Modelling of the Atmosphere and Ocean*. The book presents exciting developments in simulation of atmospheric and oceanic flows with very fine-resolution computer models. The findings are applicable to daily weather forecasting and to simulation of longer-period climate variations.

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NEW IPRC STAFF

Hae-Kyung Lee Drbohlav

Hae-Kyung Lee Drbohlav joined the IPRC as postdoctoral fellow in January 2008. She became interested in meteorology because Earth science, particularly atmospheric science, was the most tangible of all the science subjects taught in high school: "The weather is something I live with every day, and this is what led me to study meteorology at university."

Originally from Korea, Drbohlav received both her MS (1997) and PhD (2002) from the Meteorology Department at the University of Hawai'i. For her dissertation she investigated the initiation of the intraseasonal oscillation in the South Asian monsoon and its northward propagation. Wishing to see whether the eastward propagating Kelvin–Rossby wave packet was critical to the northward propagation, she excluded this wave packet in her model experiment. The model still simulated the northward propagation. The model showed that when strong convection develops under the easterly vertical shear in the seasonal mean background winds, the rising motion at the center of convection advects the seasonal mean background winds vertically, inducing barotropic westerly winds. The Coriolis effect on these strong westerly flows generates the barotropic divergence (equivalent to the tropospheric divergence) that results in boundary-layer moisture convergence north of the precipitation.

Drbohlav continued her research as postdoctoral fellow first with **Antonio Navarra**'s group in Bologna, Italy, and then at the Center for Ocean-Land-Atmosphere Studies in Maryland. Throughout, her goal has been to identify and verify the processes that produce variations in the intraseasonal monsoon oscillation, the Indian Ocean dipole mode, and the South Asian summer monsoon by analyzing observations and model outputs of these climate phenomena.

At the IPRC, she is working with **H. Annamalai** on the project "Future projections of the Asian summer monsoon and Indian Ocean climate systems." She will be studying the monsoon response to global warming scenarios in simulations with coupled general circulation models.

Hironori Fudeyasu

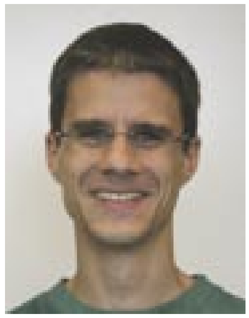
Hironori "Hiro" Fudeyasu joined the IPRC in January 2008 as a postdoctoral fellow. His research interests are tropical cyclones. During his studies for his master's and doctoral degrees, he became fascinated by the mysterious pressure dip, the rapid decrease and subsequent increase in surface pressure occasionally observed in Japan during a tropical cyclone that can cause unusually severe damage. Though the phenomenon has been known for over 50 years, the formation and structure of pressure dips have remained poorly understood. Fudeyasu, therefore, decided to focus his dissertation research on the pressure dip and tropical cyclones. He received his PhD from Kyoto University in 2003.

He then worked at Japan's National Research Institute for Earth Science and Disaster Prevention as a postdoctoral fellow and continued to study the pressure dip and the impacts of El Niño and the monsoon on tropical cyclones.

Joining the JAMSTEC Institute of Observational Research for Global Change in 2006, he became a member of the group that studied the stable oxygen and hydrogen isotopes and other meteorological data of tropical cyclones. Observations of these isotopes can be used to yield information on the atmospheric moisture cycle in tropical cyclones and to get clues to the intensity of the storm. His group succeeded in recording the stable isotope ratios in rainfall and water vapor during the passage of a tropical cyclone on a small island in subtropical Japan. The project yielded the first realistic record of the isotope ratios in water vapor, and thus of the water cycle inside the eye wall.

"To understand the link between the atmospheric moisture cycle and the intensification of tropical cyclones over the ocean," Fudeyasu says, "is the captivating subject of my work at the IPRC with Dr. **Yuqing Wang**."

Axel Lauer joined the IPRC as a postdoctoral fellow in September 2007. He recalls, "I've always been fascinated by the weather and climate and especially by the question whether meteorological observations of recent years could still be considered normal. My interest in climate change, the Antarctic ozone hole, and air pollution made me decide to go into meteorology instead of generic physics." After obtaining a master's degree in meteorology at the University of Munich, Germany, Lauer started his dissertation on global aerosol modeling at the German Aerospace Center (DLR) and received his PhD from the Free University of Berlin in 2005.



Axel Lauer

He continued at DLR as a postdoctoral fellow in the young investigators group SeaKLIM, where he studied the impact of ship emissions on aerosols, clouds, and Earth's radiation budget. The group found that emissions from international shipping have a much larger impact on the shortwave cloud forcing and therefore on climate than previously thought. Model results suggested that this kind of anthropogenic emission increased considerably the number of cloud condensation nuclei in low maritime stratus clouds.

At the IPRC, Lauer is working with **Kevin Hamilton**, **Yuqing Wang**, and **Vaughan Phillips** (UH Meteorology) on cloud modeling. Using the IPRC Regional Atmospheric Model, they are studying maritime stratocumulus clouds in the eastern Pacific and the indirect aerosol effect on these clouds.

Yoshinori Sasaki joined the IPRC as a postdoctoral fellow in April 2008 after receiving his PhD from the Graduate School of Science at Hokkaido University, Japan. He recalls, "When I started out at university, I wanted to study meteorology. But then I attended lectures by Shoshiro Minobe at the Graduate School of Science, and he was so interesting and had such a pleasant personality, that I decided to join his laboratory and study physical oceanography and climate instead."

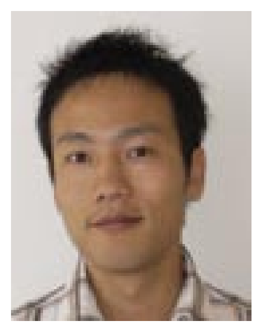
Yoshinori Sasaki

Sasaki conducted his dissertation research on interannual sea-ice variability in the Bering and Okhotsk Seas and decadal sea-level variability in the South Pacific. In the Bering Sea, he found that surface-wind fluctuations are related to large-scale atmospheric circulation variations associated with the Aleutian Low and with local atmospheric fluctuations over Alaska. Regarding the Okhotsk Sea, Sasaki found that late-autumn atmospheric conditions still affect sea–ice extent 4 months later, in late winter, through heat stored in the sea ice and the ocean. Previous studies had suggested that atmospheric conditions affect sea ice for only one month.

Regarding the South Pacific, Sasaki statistically investigated sea-level variability and related oceanic changes in a hindcast of the Ocean General Circulation Model for the Earth Simulator (OFES). He found that the trend in sea-level rise after 1992 in the central and western South Pacific, which attracted much attention in association with global warming, is not part of a continuous long-term trend but due to decadal ups and downs. The sea-level fluctuations accompany decadal changes in the subtropical gyre, the western boundary current, and eddy activity. Moreover, in OFES, the corresponding atmospheric variations are associated with decadal variations in the El Niño–Southern Oscillation.

At the IPRC, Sasaki is working with research team leader **Niklas Schneider** on low-frequency processes and air-sea interaction in the Kuroshio Extension.

Hiroki Tokinaga joined the IPRC as a postdoctoral fellow in October 2007. He focused his dissertation research at Hokkaido University on the air–sea interactions in the Kuroshio Extension and the Brazil-Malvinas Confluence regions, which are both remarkable sea-surface temperature fronts in the extratropics. He took part in the winter 2003–2004 and summer 2005 cruises in the Kuroshio Extension that were conducted by a partnership among Hokkaido University, The University of Tokyo, and the IPRC. The atmospheric soundings with GPS radiosondes, which Tokinaga helped to take, showed that the sea-surface temperature front created by the warm current affects the atmospheric boundary layer, impacting the structure of the



Hiroki Tokinaga

marine-atmosphere boundary layer as well as the formation of low-level clouds and sea fog.

Regarding the Brazil-Malvinas Confluence, his analyses of high-resolution satellite data and in situ observations support the notion that the near-surface atmospheric stability associated with the Brazil-Malvinas Confluence affects surface-wind variability on seasonal to interannual timescales.

After receiving his PhD from Hokkaido University in 2005, Tokinaga joined the JAMSTEC Institute of Observational Research for Global Change as a postdoctoral fellow to analyze the surface heat-flux variability in the Kuroshio Extension. In 2007, he participated in the winter cruise of *R/V Mirai* to deploy the JAMSTEC Kuroshio Extension Observatory (JKEO) mooring buoy, a cooperative project with the NOAA Pacific Marine Environmental Laboratory. Together with a second buoy, the JKEO is expected to yield in situ surface heat-flux data for the Kuroshio Extension.

Working now with IPRC's **Shang-Ping Xie**, Tokinaga is analyzing satellite data and in situ observations to gain a better understanding of tropical and extratropical air–sea interactions and how global warming may affect these interactions.


Shengjun Zhang

Shengjun Zhang joined the IPRC as a postdoctoral fellow in January 2008. He received his PhD in 2002 from the Chinese Academy of Meteorological Sciences (CAMS), where he continued doing research until coming to Hawai'i.

He believes that his studying meteorology was arranged by fate. As a high school student, he had been interested in astronomy, but when he started his studies at Nanjing Institute of Meteorology (now the Nanjing University of Information Science & Technology), he was attracted to lectures on weather and soon came to love meteorology.

For his dissertation, Zhang analyzed the dynamics of typhoons that follow two different tracks: typhoons that move westward toward the South China Sea and then turn northward, and typhoons that move northward toward the East China Sea and then turn westward. Based on dynamical differences between the typhoons taking these different tracks, he devised a new "bogus" typhoon initialization scheme for a typhoon-track prediction model. The scheme resulted in simulating more realistic tracks than previous schemes. At CAMS, he also studied the assimilation of wind-profiler data and its effect on numerical simulation of typhoon tracks. This research showed him the need for remote sensing data in determining such things as the structure, track, and intensity of tropical cyclones. He is therefore now working on assimilating satellite data into models in order to improve the numerical simulation and forecasting of typhoons.

At the IPRC, Shengjun Zhang is working with **Tim Li** on 4D-variational satellite data assimilation. He believes this focus will help him to understand better the evolution of typhoons.

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IPRC Bids Sayonara!

Postdoctoral Fellow **Yan Du**, who joined the IPRC in 2004, has returned as research scientist to the South China Sea Institute of Oceanology in Guangzhou. Visiting Researcher **Richard "Justin" Small**, who joined the IPRC as postdoctoral fellow in 2001, took a position in February with the Naval Research Laboratory (NRL), Stennis Space Center, Mississippi. One of three NRLs., the Stennis laboratory specializes in oceanography and modeling. Postdoctoral fellow **Yang "Ed" Yang**, who joined the IPRC in 2006, took a position with the National Institute of Water & Atmospheric Research in New Zealand. Atmospheric Specialist **Yongsheng Zhang**, who joined the IPRC as postdoctoral fellow in 1999, took a position in January 2008 with the Satellite Oceanography Group at the National Oceanographic Data Center in Silver Springs, Maryland. Data Assimilation Specialist **Xin Zhang**, who joined the IPRC as postdoctoral fellow in 2004, took a position in February 2008 as Software Engineer with the Data Assimilation Group at NCAR, where he develops and maintains the WRF 3D/4D-Var system.

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A publication of the
International Pacific Research Center
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Printer Hagadone Printing Company, Honolulu, Hawai'i

June 2008

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The IPRC is a climate research program funded by agencies in Japan and the United States and by the University of Hawai'i.