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Newsletter of the International Pacific Research Center

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

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Cover photo: Black-crowned Night Heron at the lily pond of the former Pineapple Research Institute at the University of Hawai'i Mānoa campus. Photo credit Gisela Speidel.

Research

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

South Pacific Rainfall in a Warming Climate

Image courtesy of NOAA

The main source of rainfall for the South Pacific island nations during austral summer is the largest rainband in the Southern Hemisphere, the South Pacific Convergence Zone (SPCZ). This rainband supplies water for agriculture in Northern Australia and drinking water for the many South Pacific islands. Because the overall amount of rainfall varies greatly over short distances, small shifts in the location of the rainband could have severe consequences for the vulnerable island nations already having to adapt to sea level rise.

Despite its importance, scientists know very little about how this 8,000-km-long rainband will respond to greenhouse warming. One reason why projections are so elusive is that state-of-the-art coupled general circulation models (GCMs), used for climate projections and assessments by the Intergovernmental Panel on Climate Change (IPCC), have trouble realistically simulating this hydroclimate phenomenon under present-day climate conditions.

Two years ago, an international team of scientists around IPRC's **Matthew Widlansky**, **Axel Timmermann**, and **Niklas Schneider** set out to explore why the rainfall response to greenhouse warming is so uncertain in the South Pacific island region—some climate models simulate more rainfall by the end of the 21st century, while others suggest much drier future conditions.

The impetus for this study then came during a workshop in the small island nation of Samoa where Widlansky and Timmermann, along with oceanographers **Matthieu Lengaigne** (L'Institut de recherche pour le développement, France) and **Wenju Cai** (Commonwealth Scientific and Industrial Research Organisation, Australia), discussed the uncertainty of rainfall projections for the region.

"It was at the Samoa meeting," Widlansky recalls, "that we realized just how little we know about climate change in the South Pacific, and that we have such fundamental questions as, why does the SPCZ exist?"

Storms in the South Pacific on 8 February 2012. Image courtesy of Digital Typhoon, National Institute of Informatics.

Back in Honolulu, the IPRC scientists invited **Matthew England**, co-director of the Climate Change Research Centre at the University of New South Wales (UNSW, Australia) and **Shayne McGregor**, a former IPRC postdoctoral fellow and now at UNSW. Together the team laid out a plan for a sequence of experiments to explore some of the unknowns about the SPCZ response to climate change (see 'Visiting Scholars' in *IPRC Climate,* vol. 11, no. 2, 2011).

The first step, the scientists decided, was to understand why climate models have difficulty simulating the present-day South Pacific rainfall. Since each coupled ocean-atmosphere GCM simulates unique sea surface temperatures (SSTs), which often deviate sharply from the observed SST pattern, the scientists thought removing SST errors might improve the climate simulations.

Their hunch was right. Forcing a hierarchy of atmospheric models with the observed SST pattern always yielded a diagonal rainband in the South Pacific, consistent with observations. Their model-simulated rainbands, moreover, were free of many errors typical of more complex coupled GCMs. For example, in their bias-corrected experiments, the so-called 'double-Intertropical Convergence Zone (ITCZ)' problem mostly disappeared.

Karl Stein, an oceanography doctoral student at the University of Hawai'i at Mānoa, then tested the effects of SST bias on the SPCZ's response to greenhouse-gas increases and also on the projected 21st century SST increase. Specifically, Stein conducted control and climate change experiments with a radiative flux corrected coupled GCM (CCSM3) to achieve more realistic present-day coupled SST patterns and

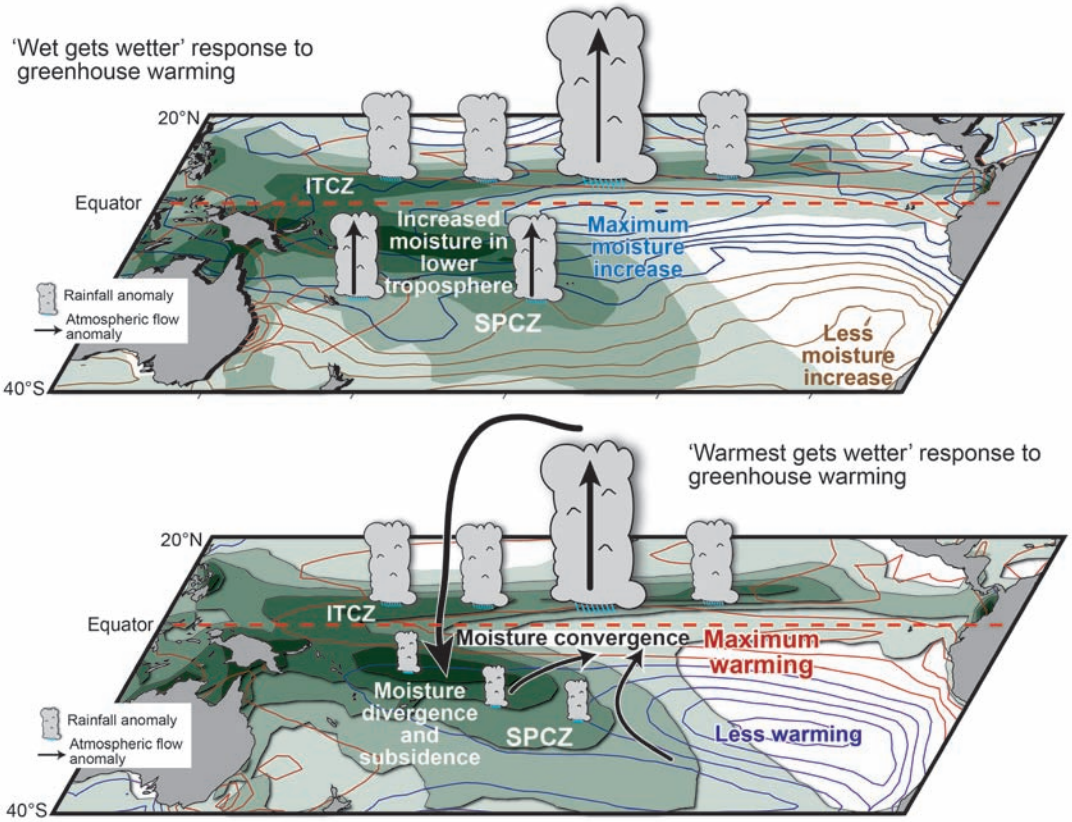


Figure 1. Illustration of the two opposing mechanisms that can impact rainfall rate in the South Pacific Convergence Zone (SPCZ), given the projected 21st century greenhouse warming. *Green shading* depicts the observed average rainfall during austral summer over the last 30 years (heavier rainfall indicated by *darker shading*).

Top: Rising tropical temperatures will lead to more water vapor in the atmosphere (*blue and brown contours*) which could bring about heavier rainfall in regions of converging winds such as the SPCZ. Some studies refer to this thermodynamic effect as the 'wet gets wetter' climate change mechanism.

Bottom: Most model simulations of climate change suggest the equatorial Pacific will warm faster (*red contours*) than the SPCZ region (*blue contours*). Such uneven warming is likely to pull the rainband away from its normal position, causing drying in the Southwest Pacific and more equatorial rainfall. This is a dynamic effect referred to as the 'warmest gets wetter' mechanism.

then compared the projected warming pattern to the standard CCSM3 greenhouse warming experiment. Both sets of experiments simulated a greater rise in SST along the equator than off the equator (a warming pattern noted in many studies, including the IPCC Fourth Assessment Report). This uneven heating between the SPCZ region and the equator, as the scientists later learned, is pivotal in determining how the rainband responds to greenhouse warming. Most importantly, Stein's experiments demonstrated that the warming pattern is robust, even when improvements are made to the coupled model's SST climatology.

In further experiments with corrected SST biases, the team identified two competing mechanisms impacting future rainfall trends in the South Pacific: an increase due to overall warming and a decrease due to changes in atmospheric water transport associated with the projected warming pattern.

"We have known for some time that rising tropical temperatures will lead to more water vapor in the atmosphere," says Timmermann. "Abundant moisture tends to bring about heavier rainfall in regions of converging winds such as the SPCZ." Some studies refer to this as the 'wet gets wetter' climate change mechanism (i.e., a thermodynamic effect illustrated in Figure 1, *top*).

"Nearly all climate-change model simulations suggest that warming will not be uniform, but rather that the equatorial Pacific is likely to warm faster than the SPCZ region. This warming pattern is likely to pull the rainband away from its normal position, causing drying in the Southwest Pacific and more equatorial rainfall," Timmerman explains. Climate scientists refer to this as the 'warmest gets wetter' mechanism (i.e., a dynamic effect illustrated in Figure 1, *bottom*).

Widlansky adds, "When we evaluated the latest climate change experiments being conducted by international climate modeling groups for the forthcoming IPCC Fifth Assessment Report, we saw that these competing mechanisms cause the different SPCZ rainfall projections among models."

Depending upon the degree of tropical warming expected this century, the scientists found that one or the other mechanism is more likely to win out (Figure 2). With moderate warming, weaker SST gradients are likely to shift the rainband towards the equator, potentially causing drying during summer for most Southwest Pacific island nations. For much higher warming possible by the end of this century, the net effect of the opposing mechanisms is likely a shift towards more rainfall for the South Pacific islands.

"To be more definite in our projections, however, we need more extensive observations on the formation of clouds and rainfall in the South Pacific and their response to such climate phenomena as El Niño. Before we have more confidence in our calculations of the delicate balance between the two climate change mechanisms, we need to be able to simulate cloud formations more realistically," says Timmermann.

This story is based on

Widlansky, M.J., A. Timmermann, K. Stein, S. McGregor, N. Schneider, M.H. England, M. Lengaigne, W. Cai, 2012: Changes in South Pacific rainfall bands in a warming climate. *Nature Clim. Change*, doi:10.1038/NCLIMATE1726. IPRC-923.

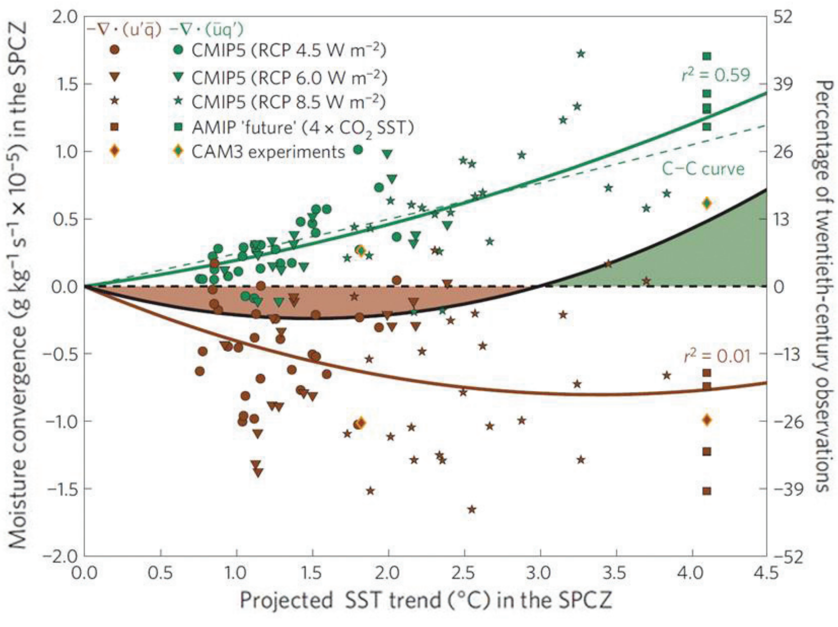
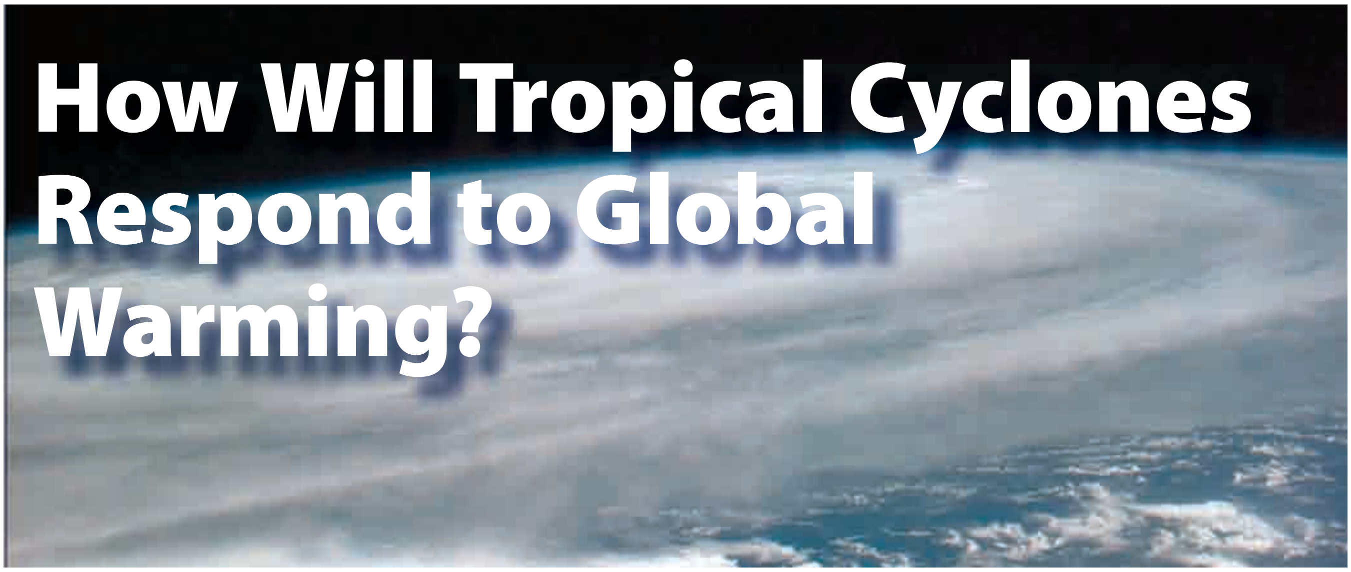


Figure 2. Projected net moisture flux convergence in the SPCZ as a function of SST increase. Green and brown curves represent the best fit, using a 2nd order polynomial, for each model's thermodynamic and dynamic moisture flux effects, respectively. The *shaded curve* represents the sum of the *green* and *brown curves* and shows the multi-experiment projection estimate of net moisture flux convergence, which is a good indicator for the difference between rainfall and evaporation (except for eddy contributions).



How Will Tropical Cyclones Respond to Global Warming?

Among the various natural hazards facing humankind, tropical cyclones (TCs) are a leading cause of loss of human life and property. The formation, movement, and intensification of TCs are known to be sensitive to the large-scale weather and climate environment in which they are embedded. Hence, trying to project the anticipated changes in the climatology of TCs in response to global warming has been of great interest. One critical limitation in this endeavor has been the relatively coarse horizontal resolution (typically 100 km or more) in the coupled global climate models generally used for long-term climate projections.

A major advance in this field was made around 2005 by **Akio Kitoh** and his group at the Japanese Meteorological Research Institute (MRI). Kitoh ran 10-year and 20-year "time-slice" experiments with the MRI atmospheric general circulation model at 20-km horizontal resolution using prescribed sea surface temperatures (SSTs) based on lower resolution coupled model results. The demanding computations were conducted on the JAMSTEC Earth Simulator and produced the first global-climate projection in which TCs could be reasonably well-resolved. However, this early version of the fine-resolution MRI model displayed some biases in the simulated distribution of TC numbers, locations, and intensities when run for present-day conditions.

IPRC Postdoctoral Fellow **Hiroyuki Murakami** and Faculty Member **Yuqing Wang** are collaborating with Kitoh and other colleagues on analysis of a new version of the MRI model (AGCM_3.2), one that produces a much better simulation of the present-day TC climatology.

"Improvements in TCs in the new version are the result of improved large-scale vorticity and vertical velocity fields," notes Murakami. "Above all, the new model is able to simulate extremely intense TCs. It is the first model that has successfully simulated the distribution and frequency of category 4 and 5 TCs over several decades. This ability comes from the model's new cumulus convection scheme" (Figure 1: compare panels a and b).

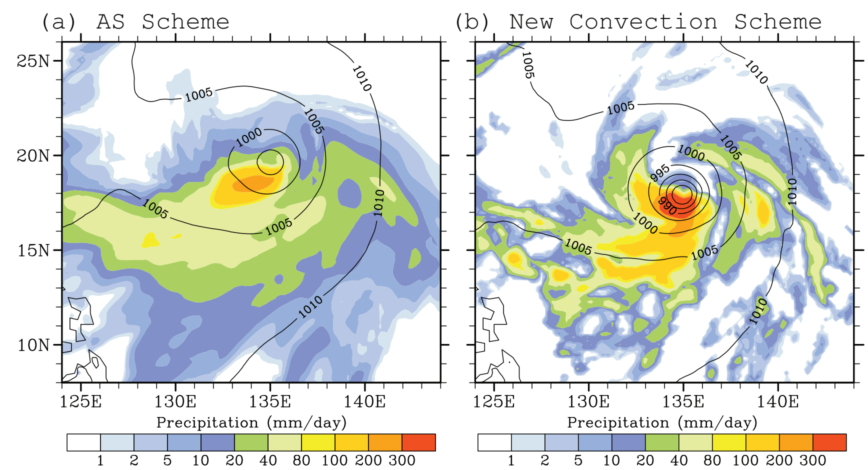


Figure 1. Snapshots of 48-h simulations initialized under the same initial conditions and generated using (a) the Arakawa–Schubert cumulus convection scheme in version 3.1 and (b) the new cumulus scheme, based on the Tiedtke (1989) scheme in version 3.2. Colors indicate 1-h mean precipitation (mm/day), and contours indicate instantaneous sea level pressure (hPa).

Since the model simulates present TC activity so well (see Figure 2), Murakami and his colleagues used it for global warming projections. They drove the model with the mean SST simulated by 18 models of the Coupled Model Intercomparison Project 3, which had been forced with increases in greenhouse gas concentrations described by the A1B future scenario of the Intergovernmental Panel on Climate Change. The model projections for the last quarter of this century are shown in Figure 2 and briefly described below.

Frequency. According to the model, the annual global number of tropical cyclones will drop 25%, with a somewhat greater decrease in the Southern than the Northern Hemisphere. This finding is generally consistent with projections reported earlier. Regional analyses, furthermore, show that the decrease is broad: all major ocean basins, except the eastern North Pacific, will see a drop in the annual number of tropical storms.

Intensity. In all ocean basins, except in the South Pacific Ocean, the model projections show that the average maximum wind speed is to increase (Figure 3) by 6.6% in the North Indian Ocean to 10% in the North Atlantic.

Formation Region. The model projects several shifts in the formation region of tropical cyclones. In the Northern Hemisphere, the formation regions tend to shift to higher latitudes: in the North Atlantic, they shift westward into the Caribbean; and in the Indian Ocean, northward in the Arabian Sea. In the western North Pacific, the formation region is projected to shift eastward toward the central Pacific.

Frequency of Landfall. Of greatest concern is how tropical cyclones will impact the safety of people and property in the future. Will the frequency of tropical storms approaching shorelines and making landfall go up? In line with the overall reduction of tropical cyclones globally and in individual ocean basins, the average global number of storm days per year within 200 km of a coastline drops. Regionally, however, the picture is more complicated, especially when considered together with storm intensity near coastlines. For example, in the Northwest

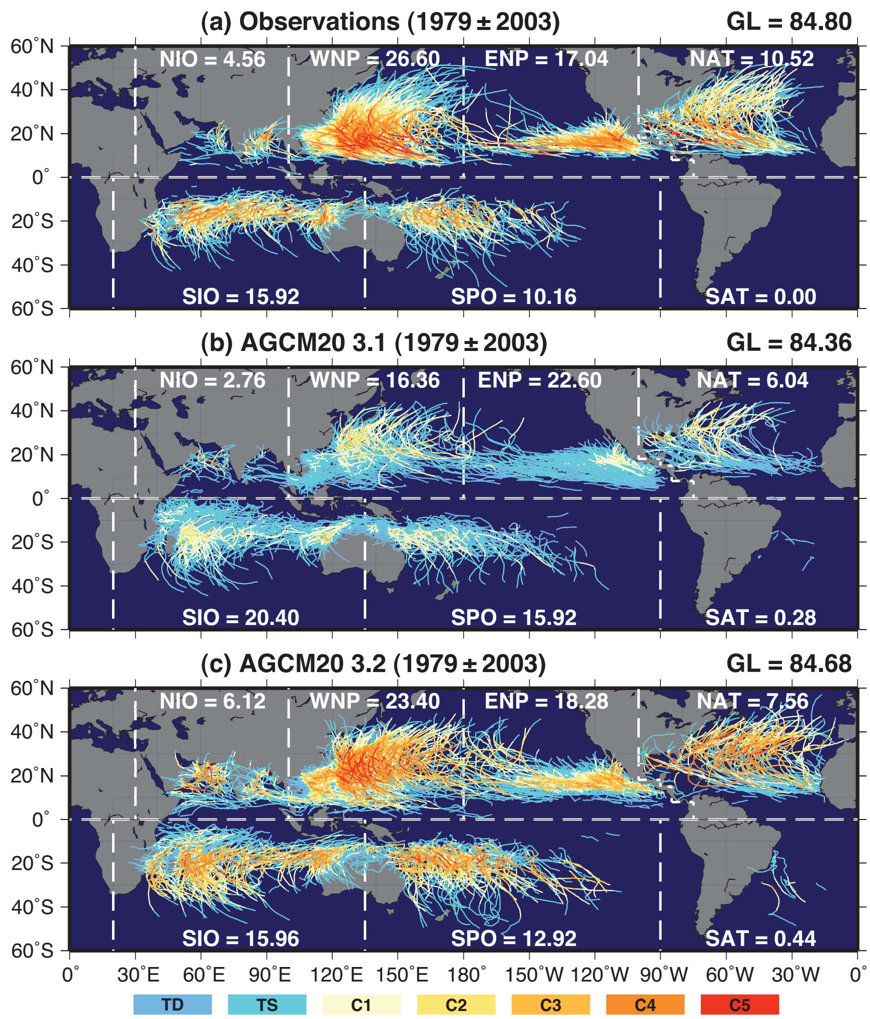


Figure 2. Global distribution of TC tracks during all seasons for (a) observations (1979 – 2003), (b), AGCM20_3.2 (1979–2003), (c), GW projection in AGCM20_3.2. The numbers for each basin show the annual mean number of TCs. TC tracks are colored according to the intensities of the TCs as categorized by the Saffir–Simpson hurricane wind scale [e.g., tropical depression (TD), tropical storms (TSs), and C1–C5] Ocean basins: NIO=North Indian Ocean, SIO=South Indian Ocean, WNP=Western North Pacific, ENP=Eastern North Pacific, SPO=South Pacific Ocean, NAT=North Atlantic and SAT=South Atlantic.

Pacific, the maximum wind speed attained by tropical cyclones within 200 km of coastlines is projected to rise by 6% on average.

"Studying the dynamical and thermodynamical mechanisms responsible in the model for the impacts of global warming on tropical cyclones, we found that the projected changes in TC activity can be attributed to changes both in the tropical overturning circulation and in the local and remote effects of sea surface temperature," explains Murakami.

"For example," says Murakami, "the tendency for tropical storms to shift towards the central North Pacific is due to a slowdown of the Walker Circulation, which itself is due to a shift of the maximum surface temperature towards the central Pacific in response to global warming. Both the rising motion at 500 hPa in the ascending branch of the Walker Circulation in the western North Pacific and the downward motion in the descending branch in the central Pacific are weaker in the global warming run. Consistent with this change, the high cyclonic vorticity region at 850 mb shifts to the central Pacific in the model."

"We are confident in our finding that the yearly number of global and hemispheric tropical cyclones will on average diminish with global warming as this finding is independent of model physics in our study and has also been noted by other scientists. We are much less certain, however, about our projections for local characteristics and intensity," cautions Yuqing Wang. He adds, "A remaining, challenging issue is how global warming will impact the interannual variability of tropical cyclone activity."

This story is based on

Murakami, H., Y. Wang, et al., 2012: Future Changes in Tropical Cyclone Activity Projected by the New High-Resolution MRI-AGCM. *J. Climate*, **25**, 3237–3260. IPRC-847

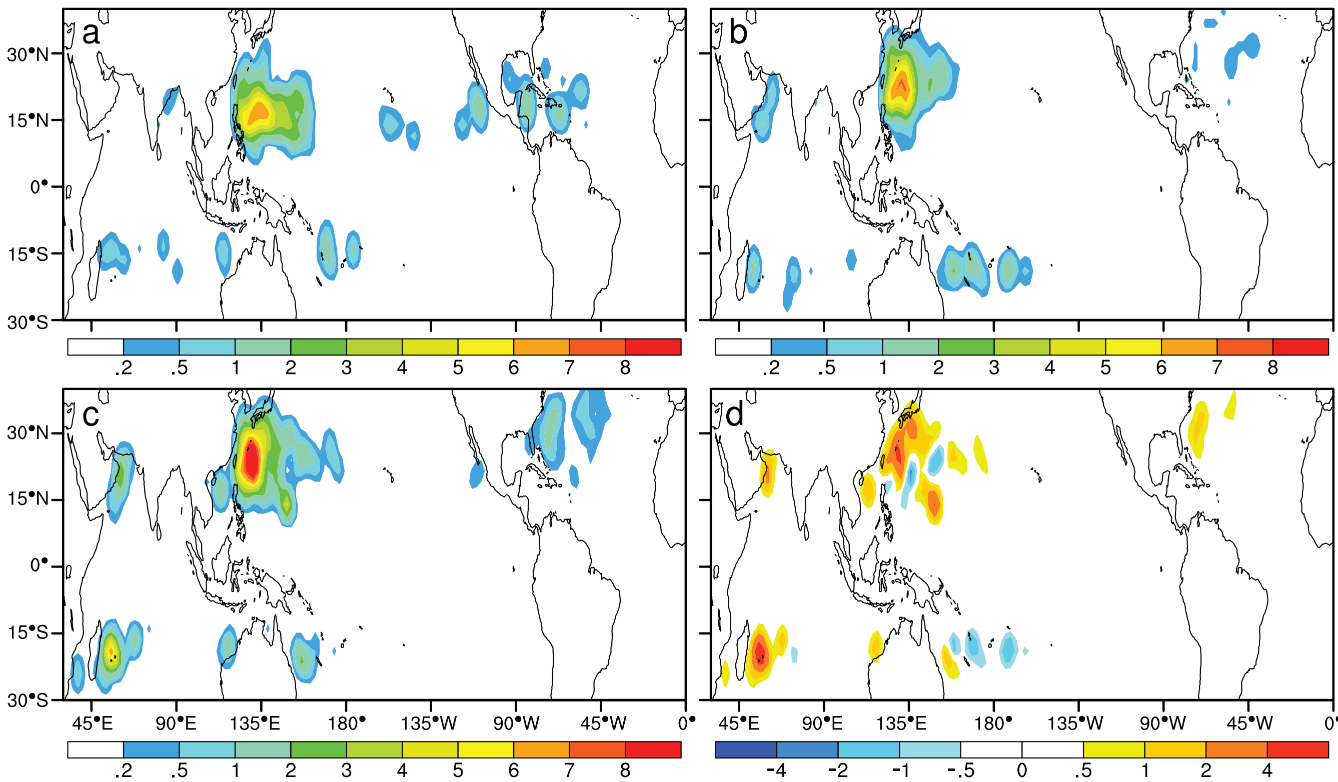
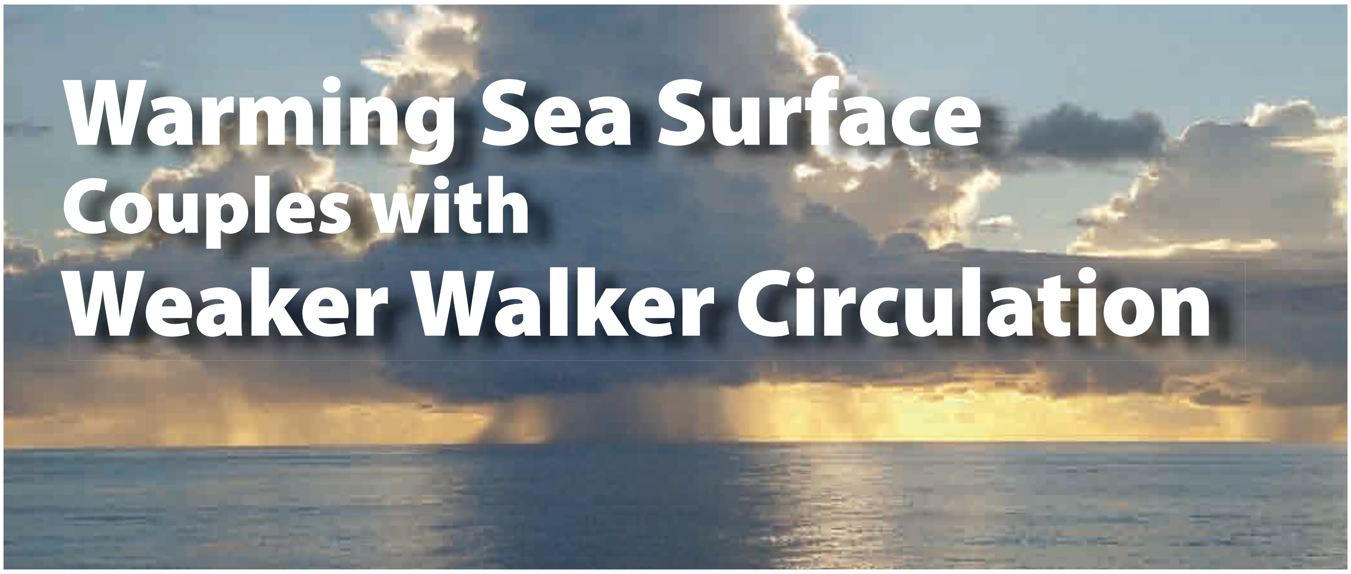


Figure 3. Category 5 TC frequency (unit = number per 25 years per 2.5° x 2.5°): from 1979 to 2003 in (a) observations and (b) simulation; (c) projected 2075–2099, and (d) difference between present-day and projected simulation.



Warming Sea Surface Couples with Weaker Walker Circulation

Photo courtesy of Y. Kashino, JAMSTEC

The Walker circulation determines much of the tropical Indo-Pacific climate and has global impact as seen in the floods and droughts spawned by the El Niño-Southern Oscillation. Climate scientists, however, have been uncertain about the recent long-term trends of this important circulation, and projections of how it will respond to global warming have, therefore, remained unclear.

In the last *IPRC Climate* issue, IPRC's Assistant Researcher **Hiroki Tokinaga** and his colleagues **Shang-Ping Xie** and **Axel Timmermann** at the IPRC and elsewhere provided firm evidence that the Walker circulation had slowed from 1950 to 2010, the trade winds weakening and rainfall shifting eastward toward the central Pacific. Their results were based on analyses of several data sets bias-corrected by Tokinaga.

The immediate cause of this slowdown, however, continued to puzzle climate scientists. They could not reproduce the weakening consistently in global atmospheric models, questioning the ability of climate models to simulate the observed gradual climate change.

At the root of the models' failure, Tokinaga suspected, was the lack of precise sea surface temperature (SST) data used to drive the models. Such observations must show small east-west differences across the tropical Pacific. Differences in the order of 0.1°C can greatly affect wind and rainfall.

Over the 60-year period, the methods used to measure ocean temperature have evolved enormously. Until routine satellite monitoring of SST began in the 1980s, the observational record relied heavily on measurements taken from ships. Such ship records themselves were subject to spurious effects introduced by changing observational techniques. This makes it nearly impossible to have one continuous, unbiased record that goes back for so long.

Tokinaga, who is an expert in analyzing old, archived data sets and at

Historical sampling devices from Folland and Parker (1995).

Polar Operational Environmental Satellite. Courtesy of NOAA.

correcting their biases, found two measures that have been taken from ships over the whole period: the bucket technique, in which the temperature is taken of sea water scooped up in a bucket lowered from a ship, and night-time marine air-temperature.

"Removing observational biases from these measurements was still challenging, but we saw that these quite different ways of measuring sea surface temperature turned out to agree very well over the 60-year span from 1950 to the end of 2009. The results were supported by subsurface ocean temperature observations," explains Tokinaga.

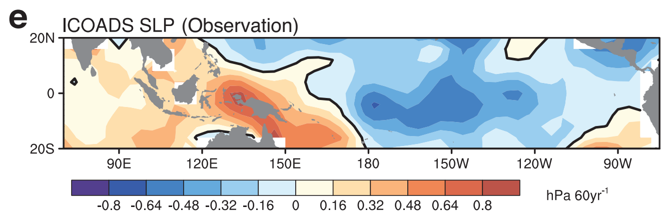
Somewhat unexpected was that the two very different measurements revealed that SST did not rise evenly with global warming across the Indo-Pacific, but rather that the east-west temperature contrast has actually decreased by 0.3–0.4°C, a change similar to what happens during an El Niño.

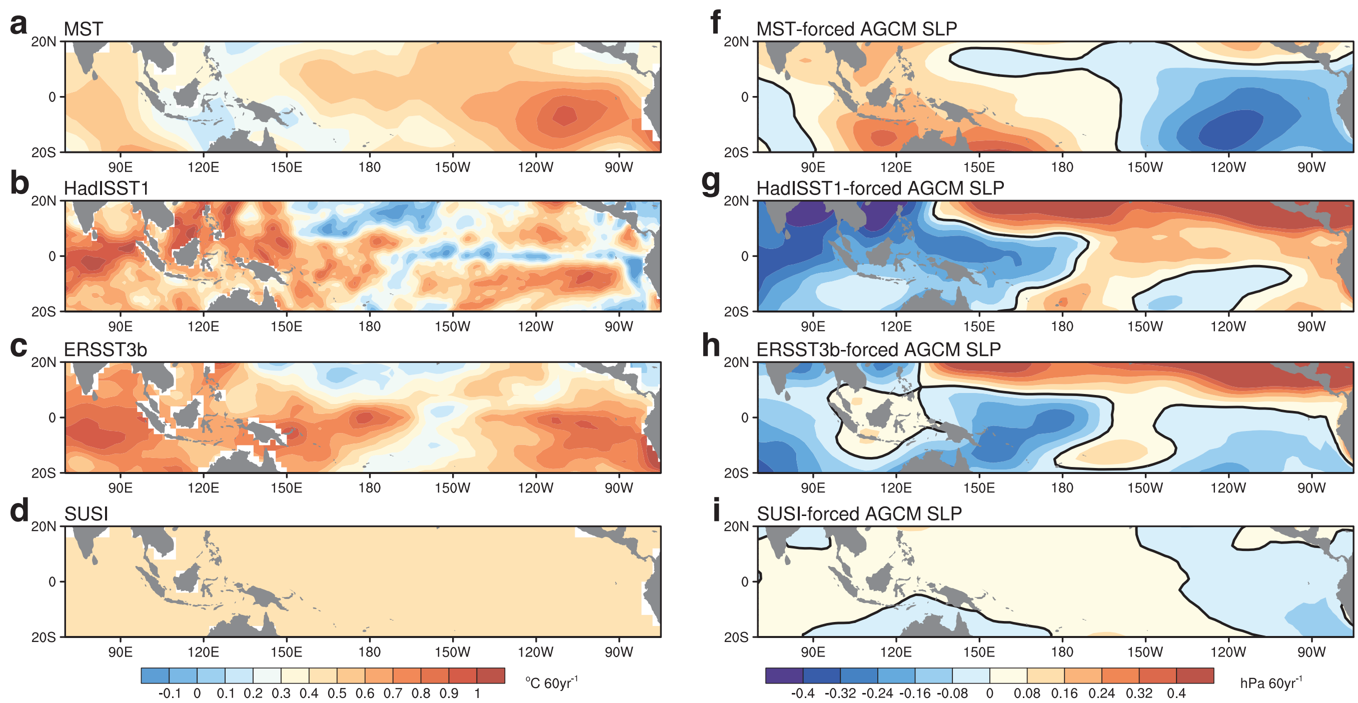
For the experiments that follow, the bucket and the night-time air-temperature data sets were merged (MST). Figure 1 shows SST changes from 1950 to 2009 across the Pacific in Tokinaga's MST product and in two SST products (HadISST1 and ERSST3b) frequently used in climate change studies, as well as a spatially uniform SST increase (SUSI) of ~0.5°C over the 60 years.

Tokinaga's team used these four SST products then to drive four widely used atmospheric models. The four-model ensemble-mean results are shown in the right panels of Figure 1. It can be seen that the unbiased, reconstructed surface temperature data set reproduces quite closely the observed patterns of climate change seen over the 60-year period in the tropical Indo-Pacific, including the slowdown of the Walker circulation (compare panels e and f). When HadISST1 was used, the Walker Circulation actually strengthened (Figure 1, right panel g), whereas when ERSST3b or a uniform rise in SST was used, there was virtually no change. (Figure 1, right panel h and i).

Consistent with the changes in surface wind convergence, observations show that precipitation and cloudiness

Figure 1. Left: 60-yr changes in SST estimated from (a) merged surface temperature (MST), (b) HadISST1, (c) ERSST3b, and (d) spatially-uniform SST increase (SUSI). Right: Observed and simulated 60-yr changes in sea level pressure (SLP) from (e) ICOADS, (f) MST-forced experiment,(g) HadISST1-forced experiment, (h) ERSST3b-forced experiment, (i) SUSI-forced experiment. The basin averages (40°E–70°W, 20°S–20°N) of SLP changes are removed.





have shifted from the Maritime Continent to the central tropical Pacific (Figures 2a-b). The MST-forced experiments simulate these patterns of cloud, precipitation, and surface wind changes quite well, albeit at reduced magnitudes (Figs. 2c-d). The simulated convection changes closely follow the spatial patterns of SST warming, consistent with the "warmer-get-wetter" mechanism and agree with climate model projections and satellite observations for the past three decades. The SUSI experiments (not shown), on the other hand, simulated increasing precipitation/cloudiness over the Maritime Continent, differing from observations.

"Our experiments show that the main driver of the change in the Walker circulation over the last six decades is the gradual change that has taken place in the surface temperature pattern toward a more El Niño-like state rather than the hydrological cycle response to uniform warming. We don't have enough data yet to say to what degree the slowdown over the last 60 years is due to a rise in man-made greenhouse gases or to natural cycles in the climate," explains Tokinaga.

"Short-term fluctuations in the strength of the Walker circulation happen every few years: during La Niña the circulation strengthens, during El Niño it weakens," adds co-author Shang-Ping Xie. "The Walker circulation affects tropical convection, and the global impacts of a temporary slowdown during an El Niño are well known, resulting in extreme floods or droughts in North America and other regions of the world. How the gradual slowdown observed in this study impacts global climate still needs to be investigated."

This story is based on

Tokinaga, H., S.-P. Xie, C. Deser, Y. Kosaka, Y.M. Okumura, 2012: Slowdown of the Walker circulation driven by tropical Indo-Pacific warming. *Nature*, **491**, 439–443, doi:10.1038/nature11576. IPRC-935.

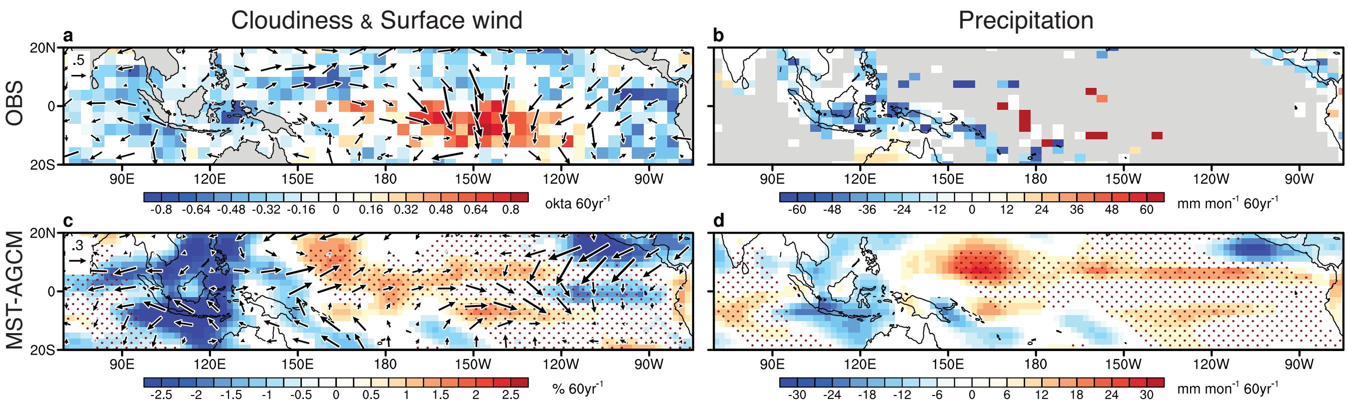


Figure 2. Changes over 60 years: in observed (a) cloudiness, surface wind (m/s per 60 years), and (b) in precipitation from ICOADS, WASWind, and rain-gauges; in (c) and (d) MST-forced experiment. Stippling in (c) and (d) indicates regions of the MST warming trend above the tropical mean.

Mysterious Rotten-egg Smell of Lake Kauhako

A strange rotten-egg smell is coming out of Kauhako Crater Lake on Molokai's Kalaupapa Peninsula. Residents first noticed the smell in September 2011. When park rangers investigated, they found the usual green color of the lake had turned into a milky brew. The rangers concluded that an "overturning" had happened.

To get a first-hand look at this mysterious phenomenon, IPRC's **Axel Timmermann** and **Niklas Schneider** fly to Molokai in May 2012. They take along IPRC postdoctoral fellows **Pedro DiNezio** and **Malte Heinemann** and lots of equipment to study the lake's water characteristics.

A former central vent of Kauhako volcano, the tiny pond-like lake is very deep…over 240 meters. With a surface area of less than an acre, it is the lake with the largest depth-to-surface-area ratio in the world.

"Our hydrographic measurements from 2006 and 2010 have revealed a brackish oxygenated layer about several meters thick floating on top of saline anoxic water with a salinity similar to the nearby ocean," explains Timmermann. "At depth, sulfate reducing bacteria transform the sulfate of seawater into hydrogen sulfide. Something must have happened that September to make the deep layer come to the surface, belching hydrogen sulfide and turning the lake into the milky brew."

Arriving at the crater rim, the IPRC team is disappointed—not a whiff of a foul smell, and the lake glows in its usual emerald hue. Helped by ropes, they climb down the steep crater walls. It takes a good hour with all their equipment. At the lake's shore they set up their computer to record the data to be transmitted via a cable from the CTD, an instrument measuring conductivity (salinity), temperature, density, oxygen and the chlorophyll concentration. To collect data with this instrument, DiNezio and Heinemann paddle to the middle of the lake in a little rubber dingy. Lowering the more than 20-pound heavy CTD to collect systematic samples is a nearly impossible feat. The soft sides of the dingy just crumble under the heavy weight, and the vessel is leaking air. In spite of these less than optimal circumstances, they make several successful deep CTD casts.

That evening back in Kalaupapa settlement, the group sits together and studies their first data graphs on the computer screen. The data is noisy, yet they can detect a less dense, oxygenated layer of water above a colder anaerobic layer (see figure).

Next morning, heading out to the lake again, they smell from afar hydrogen sulfide…An overturning happened over night! The lake is crystal clear, but stinks hellishly. At higher concentrations, hydrogen sulfide is deadly, but undetectable to the human sense of smell. They must rely on a sensor that should beep once concentrations get poisonous.

Lowering the CTD today is much easier: **Eric Brown**, marine ecologist for the National Park Service at Kalaupapa, brought down a sturdy ocean kayak for them and a pulley system from which they lower and raise the CTD without much effort. While collecting the CTD data and taking water samples, DiNezio notices that a part of the lake is taking on a

Milky film is starting to form over the lake.

whitish, opaque hue. It's where the sunlight hits the lake. With time, the whole lake is in the sun and is turning from its crystal-clear morning state into the milky brew.

Schneider explains the events as follows: Usually, frequent rains on Lake Kauhako create a freshwater lens, several meters deep, floating on a salty layer. Because freshwater is lighter than salty water, it does not mix with the salty layer but acts as a lid. During that state, no traces of hydrogen sulfide are found at the lake's surface, and shrimp and other fresh water animals live happily in the oxygen rich lens.

During 2011, however, Kalaupapa was experiencing a very severe drought. The freshwater layer thus was not replenished but evaporated gradually. With time the surface layer became salty until its salinity differed little from the layer below. What probably began to happen last fall, when the rotten-egg smell was first noticed, was that the lid had evaporated away and the very clear, rich hydrogen sulfide water could rise to the surface, killing the creatures and filling the air with the rotten-egg smell.

Why does the overturning continue to happen particularly during nighttime? The density of water changes not only with salinity, but also with temperature. Warm water is light and floats, while cool water is heavy and sinks. With hardly a difference in salinity, small changes in temperature due to heating during the day and cooling at night alter the density of the surface waters. This means that a lid of lighter water forms during the day and erodes with night-time cooling. The hydrogen sulfide from the interior of the lake can then come to the surface, giving the smell and crystal-clear appearance. The lid starts to form again with warming during the day, cutting off the exchange with the interior of the lake. The daylight then allows sulfur-oxidizing bacteria to break down the hydrogen sulfide near the surface and form crystalline sulfur – the substance that turns the lake milky.

The IPRC team is eager to go back to Lake Kauhako to install a continuous monitoring system that would help predict future hydrogen sulfide belching.

Story by Gisela E. Speidel based on interview with Malte Heinemann and email correspondence with Niklas Schneider, Axel Timmermann, and Pedro DiNezio.

Photos by Pedro DiNezio.

From left, Pedro DiNezio, Malte Heinemann, Axel Timmermann, Niklas Schneider, and Eric Brown.

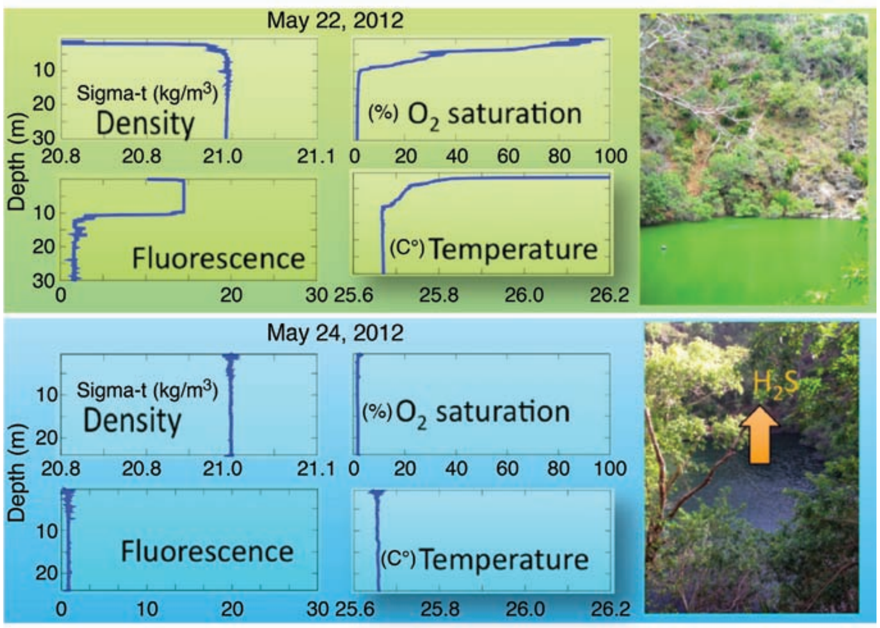


Figure. Changes in Lake Kauhako from May 22 to May 24, 2012. Green panel (May 22): vertical profiles of density, oxygen saturation, temperature and fluorescence on the day before the overturning event; photo shows green color of lake, indicating high plankton concentrations. Blue panel (May 24): same vertical profiles after the nightly overturning event. The stratification in the lake collapsed, plankton concentrations becoming very low and the lake emitting H_2S gas. (Courtesy of Axel Timmermann and Pedro DiNezio)

Tsunami Debris on Kaho'olawe?

It is early morning at the small Kihei boat harbor on Maui. We, the members of the IPRC marine and tsunami debris project (**Nikolai Maximenko**, **Jan Hafner**, and **Gisela Speidel**) are with the Hawai'i State International Coastal Cleanup Coordinator **Chris Woolaway** and with a Japanese team from NHK television network: **Jun Matsuda** (Program Director of NHK's News Features Production Center), **Tsuyoshi Namekawa** (camera man) and **Yasue Drabble** (project coordinator). The NHK team is here to film a documentary on marine and tsunami debris with the explanation: "Hawai'i is the last place for the marine debris, which floats around the Pacific Ocean, to end up, and in the future, a lot of debris from the March 2011 Tohoku tsunami will arrive here."

We are all going to the tiny volcanic island of Kaho'olawe. The island was once a military training ground that has only partly been cleared of un-

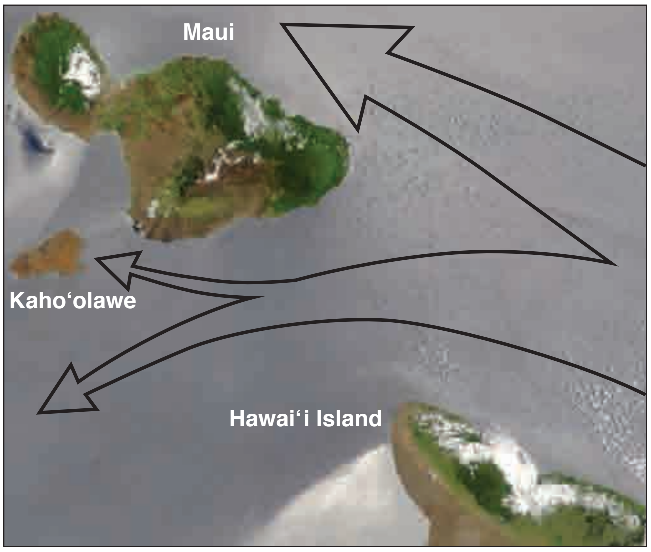
exploded ordinance. Now as a Native Hawaiian cultural heritage site, the island can be visited by special permission only. We are meeting **Michael Naho'opi'i**, Executive Director of the Kaho'olawe Island Restoration Commission (KIRC). Less than a year ago, 15 tons of marine debris were airlifted off Kanapou beach, the beach to which we are going. New debris is already accumulating, and Naho'opi'i, concerned about marine debris on this special island, is giving us the opportunity to study its accumulation in Kanapou Bay.

IPRC's marine debris project leader, Senior Scientist Nikolai Maximenko, was at first surprised to hear that Kaho'olawe gets much marine debris as it lies in the wind shadow of Maui. The Hawaiian Islands collect marine debris mostly along their windward-facing beaches.

We travel to the island on the KIRC boat, a flat-bottomed, 40-foot-long landing craft with a rectangular bow that can be lowered to drop people and cargo off in the water. After a high-speed trip of some 30–40 minutes out of Kihei, we approach Kanapou Bay. The vertical cliffs look forbidding and inaccessible. But finally a narrow, mud-brown strip of sand appears wedged between the sheer cliffs.

Some 100 yards from shore, the bow is lowered. We must jump into the deep water and swim to shore with our gear. Already as we step on to the sand, a thick rim of debris greets us above the waterline. It is hard to believe that the beach was cleaned by KIRC volunteers less than a year ago!


DANGER
KEEP AWAY - KAPU
BOMBS IN LAND & WATER
PROPERTY OF
U.S. COAST GUARD



Likely path of wind-driven debris.

Why does this beach, which appears to be protected by Maui to the windward and which has no visitors except for the occasional KIRC volunteers, collect so much debris? "The combined funneling of the northeast trade winds and prevailing currents choke the five miles of the Bay with debris from the ocean," explains the KIRC brochure.

In addition to heaps of tangled, derelict fishing nets and gear, much intact debris is strewn across the beach: blue barrels, about 3-5 feet tall, different-colored crates and buckets, lots of fins, and hard hats, and even a child's baseball bat and ball. US Coast Guard and Navy buoys are scattered in the sand.

Much of the debris is still usable. Even though some objects have Japanese, Korean, or Chinese characters printed on them, the pieces are astonishingly free of barnacles, which commonly cling to objects on their long ocean voyages. Maximenko says that on no other Hawaiian beach did he ever see such large debris with so little wear and tear, not even on remote Kamilo Bay on the southwest corner of the Big Island. These items, he concludes, must be local debris, and because of the prevailing currents, the debris must have come from Maui and Hawaiʻi Island, or have been lost from boats navigating near these two islands (see map).

The typical international marine debris that accumulates on the beaches of the Hawaiian Islands is also here: the hag fish traps and the oyster spacers from Asia. Also typical of other wind-facing beaches is the large amount of microplastic, the end condition of plastic objects that have either chemically disintegrated or have been ground into tiny pieces by machines, water or sand. **Jennifer Vander Veur**, the KIRC ocean specialist, has studied the accumulation of these tiny plastic pieces on the beach here. It collects further up on the beach, and she says that when she dug deeper down, the amount seemed to increase with depth, something that Maximenko has also noticed on other beaches, such as the rocky beach near South Point (*IPRC Climate*, vol.12, no. 1) .

Most intriguing are two large, red light bulbs with Japanese characters. Such bulbs have recently been found on Hawaiian shores and are thought to come from Japanese fishing boats lost in the tsunami. A further hint of the tsunami is a huge oyster buoy that lies only a few feet from the water's edge. Numerous oyster buoys have washed up on the Washington State coastline and are thought to be from the tsunami. How long has this buoy been here? We do know that it arrived after the last cleanup in 2011. Does it mean tsunami debris has arrived here, as on other islands?

Suddenly we are told to pack up. The boat is back, the captain is impatient, urging us to the boat. "Never stay till after noon!" It is nearly noon and the wind is picking up. If the waves get any higher, we'll have trouble swimming out to the boat and might get stranded on the beach.

Reflecting on what he has observed, Maximenko thinks that a marine debris monitoring site at Kanapou Bay on Kahoʻolawe would have great advantages: it would allow gathering systematic information about the nature of marine debris accumulation free from outside influence other than wind, ocean currents and waves, and the shape and structure of the bay and beach. The type of objects we saw suggests moreover that the beach would be ideal to study the footprint of local debris, produced by ocean activities around the Hawaiian Islands, as well as debris from the whole North Pacific subtropical gyre.

Story and photos by Gisela E. Speidel.

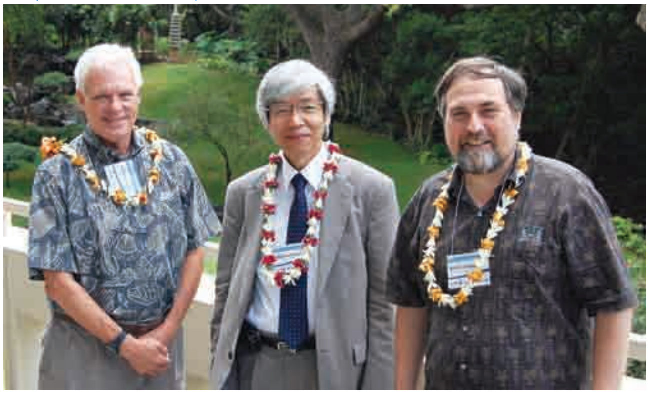
MEETINGS

Joint Symposium with the University of Tokyo

The University of Hawai'i's School of Ocean and Earth Sciences and Technology (SOEST) has long-standing links with the University of Tokyo's principal ocean and atmospheric research units: the Ocean Research Institute (ORI) and the Center for Climate System Research (CCSR). ORI and CCSR were combined in 2010 into the Atmosphere and Ocean Research Institute (AORI) with facilities located on the new University of Tokyo Kashiwa campus. Since its earliest days, the IPRC has had close relations with CCSR, ORI, and now with AORI. Former CCSR Director **Akimasa Sumi** was one of the original supporters of the IPRC in Japan and has been a frequent visitor over the years. CCSR professor (and now AORI Vice Director) **Masahide Kimoto** was a long-serving member of the IPRC Science Advisory Committee. In the last three years, IPRC faculty members **Yuqing Wang** and **Niklas Schneider** have each spent a sabbatical term at AORI. Therefore, when AORI Director **Hiroshi Niino** proposed a 2012 joint workshop with SOEST scientists, IPRC was very pleased to act as host and organizer in partnership with SOEST's Sea Grant Program.

The *Joint Symposium on Ocean, Coastal, and Atmospheric Sciences* was held June 13–15, 2012, in the Keoni Auditorium of the East-West Center, with 27 participants from the University of Tokyo and 31 from SOEST. The meeting featured two days of lectures and one day of informal small-group interactions between the AORI scientists and their SOEST counterparts. IPRC presentations at the meeting were as follows: **Kelvin Richards** discussed interactions between small-scale ocean mixing and the larger-scale atmosphere-ocean circulation in the tropics; **Niklas Schneider** described his work on decadal variability of the North Pacific circulation; **Nikolai Maximenko** spoke on ocean surface currents in the western North Pacific; and **Axel Timmermann** and **Oliver Elison Timm** discussed paleoclimate research being conducted at IPRC. IPRC postdoctoral fellows **Ali Belmadani** and **Malte Heinemann** gave poster presentations.

Sea Grant Associate Director **Darren Lerner**, AORI Associate Professor **Susumu Hyodo** and IPRC Director **Kevin Hamilton** organized the meeting. The workshop program and abstracts of all the oral and poster presentations are at tinyurl.com/IPRCjoint.



From left, Gordon Grau (UH Sea Grant Director), Hiroshi Niino (AORI Director), and Kevin Hamilton (IPRC Director).

Participants of the Joint Symposium on Ocean, Coastal, and Atmospheric Sciences.

US-Japan Workshop on the Tropical Upper Troposphere

Planning for a Golden Era of Tropical Pacific Measurements

Above the equator, the coldest air is generally found near 17-km altitude, the "cold-point tropopause." However, the region spanning roughly 14–17 km typically displays a higher vertical stability than does the atmosphere lower down, and most deep tropical convection detrains below about 14 km. Within the tropical troposphere, the upper few km are rather distinct in composition and dynamics from the lower part, and also from the overlying stratosphere. This special region is called the "tropical tropopause layer (TTL)." The TTL is notable for some of the coldest temperatures observed anywhere in the atmosphere and for the presence of very cold cirrus clouds that are important in maintaining the global radiative energy balance. Almost all the air entering the stratosphere is believed to pass through the TTL, making this a key region for determining stratospheric composition. The TTL is also thought to mark the boundary between large-scale net radiative cooling below and net radiative heating above (Figure 1).

A whole new generation of observations has transformed the study of the TTL in the last decade. One development has been the start of regular extended in situ observational programs, notably the Japanese-led Soundings of Ozone and Water in the Equatorial Region (SOWER) program and the US-led Southern Hemisphere Additional Ozonesonde (SHADOZ) program. SOWER has been running since 1998 on a campaign basis, improving our knowledge of the ozone and water vapor distributions in the tropical Pacific region by making coordinated radiosonde observations at three equatorial sites: the Galapagos Islands, Christmas Island, and Indonesia. Led by NASA and NOAA, in partnership with various national meteorological services, SHADOZ, also initiated in 1998 coordinated balloon soundings of the atmosphere at a number of Southern Hemisphere tropical and subtropical stations. Great advances have also occurred in space-based and ground-based remote-sensing observations. Notable are the research satellites deployed in the first decade of this century, such as those in the NASA "A-train" and the COSMIC array of radio occultation satellites, which have provided unprecedented high-resolution observations of temperatures, trace gases, and clouds in the upper troposphere and lower stratosphere.

Inspired by the significant progress made over the last decade and the prospect of several new field campaigns in the western Pacific region in the next few years, Hokkaido University Professor **Fumio Hasebe** conceived a US–Japan workshop on the tropical upper troposphere to review key science issues and help coordinate mission planning. Joining Hasebe's initiative were US scientists **Andrew Gettelman**

Participants at the NSF US-Japan Workshop.

(NCAR), **Gary Morris** (Valparaiso University), **Henry Selkirk** (NASA) and IPRC's **Kevin Hamilton**.

The US National Science Foundation sponsored the bilateral workshop through its Catalyzing New International Collaborations program. The IPRC was very pleased to host this important US–Japan meeting. The *NSF U.S.-Japan Workshop on the Tropical Tropopause Layer: State of Current Science and Future Observational Needs* was held October 15–19, 2012, at the East-West Center. Eighteen Japanese scientists and graduate students joined about 25 US participants from NASA, NOAA, NCAR and various universities.

The organizing committee from left, Gary Morris, Andrew Gettelman, Kevin Hamilton, Henry Selkirk, and Fumio Hasebe.

The workshop participants discussed open questions in understanding the dynamics and chemistry of the TTL. They found these questions mainly related to one or more key areas: effects of the large-scale atmospheric circulation including the summer monsoon, effects of deep convection, cirrus-cloud dynamics and microphysics, atmospheric wave processes, and long-term trends.

The next few years promise to be an exciting "golden era" for observations of the TTL as the ongoing regular balloon sampling and satellite observations will be supplemented by a series of aircraft campaigns mainly focused on the western Pacific region. These major field campaigns are planned to begin in the summer of 2013 with the Southeast Asia Composition Cloud and Climate Coupling Regional Study (SEAC^{4}RS), which will include observations by two NASA research aircraft (DC8 and ER2) based in Singapore, and will continue over the 2013–2015 period with more campaigns featuring multiple aircraft based in Guam and northern Australia. The workshop participants worked to coordinate the planning of these major initiatives with an eye to reducing the key uncertainties in our knowledge of the tropical upper troposphere.

With the help of Valparaiso University librarian **Jon Bull**, a special effort was made to record completely the workshop presentations and discussions and to document fully the proceedings. All interested colleagues are invited to visit the unusually detailed workshop archive at scholar.valpo.edu/ttlworkshop/2012_proceedings/. A detailed article on the meeting has been published and is at tinyurl.com/IPRClayer.

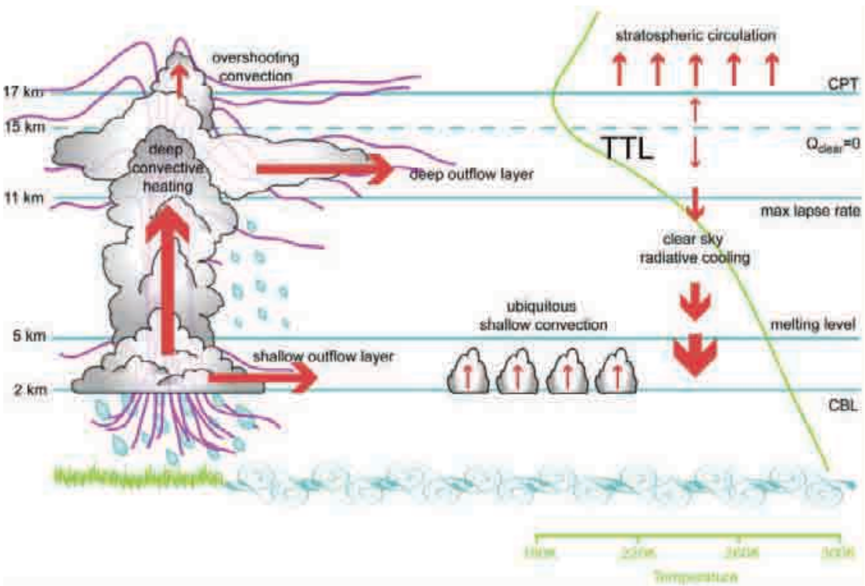


Figure 1. Schematic diagram showing some key processes in the tropical atmosphere (adapted by Laura Pan, NCAR, from an original prepared by Diane Pendlebury and the SPARC office).

Kazuyuki Miyazaki at the IPRC.

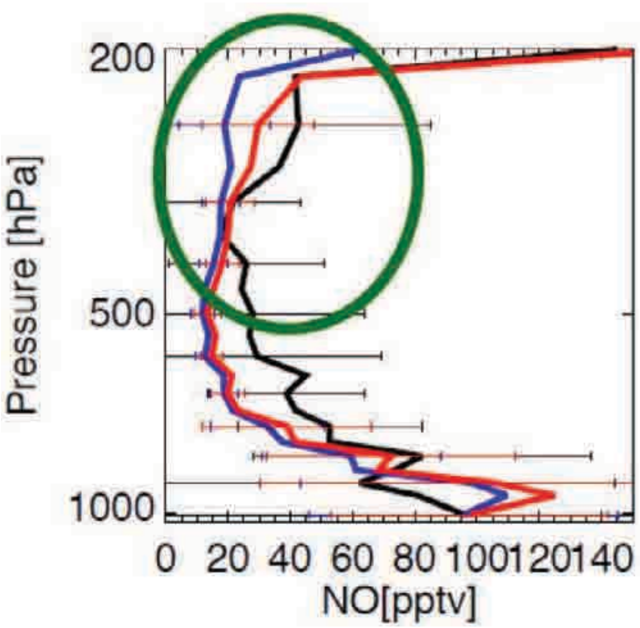


Figure 2. Concentration (parts per trillion) of nitric oxide in the atmosphere over a tropical location in direct observations (black) and in two global assimilation data sets (red and blue). The red curve is for an assimilation that includes input of satellite observations of atmospheric composition.

Putting Chemistry into Global Analyses

The tropical upper troposphere is a region with relatively sparse in situ observations. Making the best use of the available satellite data, including satellite observations of atmospheric composition, is important for advancing our knowledge of this region. JAMSTEC's **Kazuyuki Miyazaki** is a leader in assimilating chemical data into sophisticated global analyses using dynamical-chemical atmospheric models. The *Tropical Tropopause* workshop occurred during Miyazaki's six-month visit to the IPRC. In his invited tutorial talk at the workshop, he reviewed the emerging field of chemical data-assimilation for global analyses and discussed results from a major Japanese initiative.

"The Japan Meteorological Agency's Meteorological Research Institute (MRI), the National Institute for Environmental Studies (NIES), JAMSTEC, and Tohoku University have developed chemical data assimilation systems for monitoring the atmospheric environment in East Asia and over the whole globe. The data assimilation systems developed by the four research institutes use the ensemble Kalman filter scheme. The approach allows simultaneous optimization of forecast variables (i.e., concentrations of particular chemicals) and other parameters, notably emission rates into the atmosphere," said Miyazaki.

One result that shows promise for obtaining a more complete picture of the circulation and chemistry of the TTL is given in Figure 2. The figure compares the atmospheric profile of nitric oxide (NO) concentration at a tropical location determined in a special aircraft observation campaign (black curve) and the predictions of a chemical model-run with atmospheric circulation from analyses with (red), and without (blue), assimilation of chemical observations. The improvement in the model's upper troposphere that includes assimilated satellite chemical measurements is quite significant, despite the fact that observations of NO were not actually used in the assimilation.

Ocean Mixing Group Meets Again

From left, Ryo Furue, Yanli Yia, Niklas Schneider, Bruce Cornuelle, Kelvin Richards, Peter Hacker, Armin Köhl, Nidia Martinez Allevaneda, Jennifer MacKinnon and Detlef Stammer.

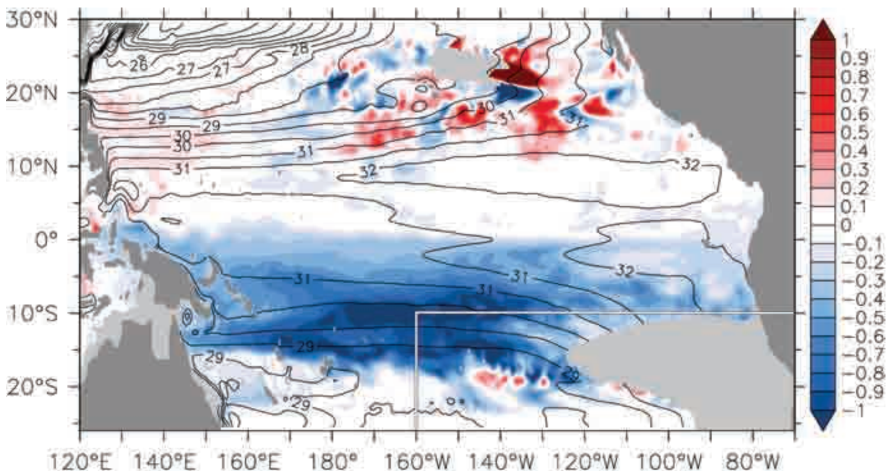
Ocean models in climate research have greatly advanced in recent years. A major challenge, however, remains: representing realistically ocean mixing, which significantly impacts the large-scale ocean circulation and surface fluxes.

"The processes directly responsible for mixing occur at such small spatial and temporal scales that they must be parameterized by representing small-scale effects on large scales in terms of large-scale variables," wrote IPRC's assistant researcher **Ryo Furue** after an IPRC miniworkshop on ocean mixing in March 2009 (*IPRC Climate,* vol. 9, no. 1).

From that meeting emerged a project, funded by NASA, to investigate ocean-mixing processes more closely, and the group has been meeting annually since then. The latest meeting was held September 10–11 at the IPRC to review progress and to plan further research.

This year's group consisted of Ryo Furue, **Yanli Jia**, **Kelvin Richards**, and **Niklas Schneider** from the IPRC; **Bruce Cornuelle** and **Nidia Martinez Allevaneda** from Scripps Institution of Oceanography; **Armin Köhl** and **Detlef Stammer** from the University of Hamburg; and **Peter Müller** from the University of Hawai'i at Mānoa (UHM).

The participants reported major progress in understanding the following issues: (1) the modifications needed to mixing parameters for data assimilation and the reasons for these modifications; (2) the reasons why, and the ways in which diapycnal diffusivity affects the upper tropical Pacific Ocean; and (3) the difficulty of using Green's function to optimize diapycnal diffusivity because it results in overfitting and negative (unrealistic) diapycnal diffusivity values.



Results of an experiment in which vertical diffusivity is increased from the sea surface to the sea bottom in the box in the figure (south of 10°S and east of 160°W). This increase results in a negative temperature anomaly (blue) that is advected on isopycnal surfaces to the equator, where it changes the temperature of the thermocline and the sea surface.

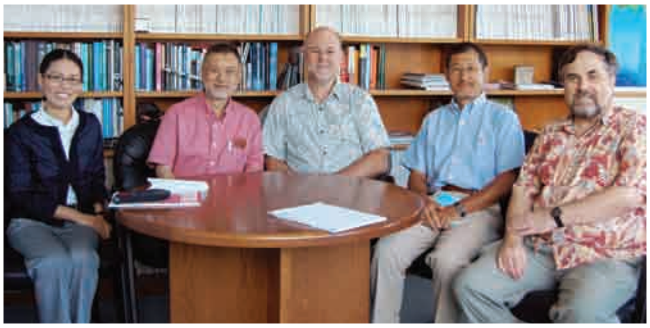
To learn more about the complexities of diapycnal diffusivity and to help plan future possible extensions to the project, the group had invited to the meeting **Jennifer MacKinnon**, Scripps Institution of Oceanography, who summarized the work of the US CLIVAR Climate Process Team (CPT) on ocean diapycnal mixing; and **Thomas Decloedt** (UHM Oceanography Department), who reviewed various parameterizations of diapycnal mixing used in ocean general circulation models. They had also invited **Peter Hacker** from NASA headquarters to hear more about the research directions NASA plans to pursue.

On the basis of these presentations and discussions, the group is considering to focus on diapycnal diffusivity near the equator, which would complement CPT's work, which does not concentrate on this region.

IPRC NEWS

JAMSTEC Executive Director Visits

JAMSTEC Executive Director **Yoshihisa Shirayama** visited the IPRC on August 30–31 to discuss future collaborations between the IPRC and JAMSTEC. Accompanying Shirayama were **Yukio Masumoto**, Program Director in JAMSTEC's Research Institute for Global Change (RIGC), and **Chihiro Baba** from JAMSTEC's International Affairs Division.



From left, Chihiro Baba, Yoshihisa Shirayama, SOEST Dean Brian Taylor, Yukio Masumoto and IPRC Director Kevin Hamilton.

Hiroki Tokinaga Awarded the Yamamoto-Shyono Medal

IPRC Assistant Researcher **Hiroki Tokinaga** was awarded the prestigious Yamamoto-Shyono Medal by the Meteorological Society of Japan at the society's Fall meeting in Sapporo, Hokkaido. Each year the society selects two top papers written by young scientists for the award. Tokinaga, who received the medal for his work on the detection of regional patterns of tropical Indo-Pacific climate change over the past six decades, gave a lecture at the meeting on this topic.

Hiroki Tokinaga receives the Yamamoto-Shyono Medal from Hiroshi Niino, president of the Meteorological Society of Japan.

IPRC Model Used by Japanese Research Groups

The field of numerical simulation of atmospheric and oceanic circulation has come to be dominated by a limited number of global and regional models developed by large national centers or large consortia. In this environment it is remarkable that IPRC's locally-developed regional atmospheric model (iRAM) and coupled ocean-atmosphere regional model (iROAM) are in demand for use by colleagues internationally. These models, developed by IPRC faculty member **Yuqing Wang**, have features that make them attractive for many investigations, and they have been shown to produce quite good simulations when applied to individual regions stretching from East Asia to the eastern Pacific.

Over the last decade, IPRC scientists have benefitted enormously from the model development at JAMSTEC (e.g. the AFES, OFES, CFES, and NICAM models). Thus, it is particularly gratifying when our JAMSTEC colleagues use an IPRC model in their research. For example, **Toru Miyama**, research scientist with the Climate Variation Predictability and Applicability Research Program of the Research Institute for Global Change (RIGC), recently led a team of JAMSTEC scientists in applying iRAM to a case study of the formation of an unusual narrow rainband over the East China Sea. This work was published in October in the journal *Tellus A*.

Another recent Japanese study, this one led by **Shunya Koseki** of Hokkaido University, used iRAM, together with reanalysis data and satellite observations, to investigate the formation of low-level clouds in summer over the Okhotsk Sea. This study appeared in the January 2012 *Journal of Geophysical Research*.

Students from Japan's Super Science High School Project Visit IPRC

Student presenting Masuda High School mascot to Ryo Furue. Images courtesy of Masuda High School.

To strengthen mathematics and natural science education, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) funds the "Super Science High School (SSH)" project for designated high schools. With these funds the schools can send students for short visits to overseas universities and research institutions. Such a Super Science High School is Masuda High School, the alma mater of IPRC's Assistant Researcher **Ryo Furue**. The school sent a group of students to Hawai'i in October to visit the Base Facility of the Subaru Telescope on the Big Island of Hawai'i. The students and their teachers then came to O'ahu to visit the IPRC.

Furue welcomed the students and teachers in the IPRC conference room, where they honored Furue with a gift of the school's mascot, a mask for a dance representing a famous story about the Chinese Emperor Xuanzong of the Tang Dynasty, who recovered from a serious illness after he dreamed he was rescued by Zhong-Kui, the king of the ghost world.

The two-day program for the students included lectures by **Jan Hafner** on the debris released into the ocean by the March 2011 tsunami, and by Furue, who spoke about observing and predicting the atmospheric and oceanic circulation, and about the nature and culture of Hawai'i. One of the students presented the results of his science project on river-water quality. Furue also took the students on a field trip to the eastern side of O'ahu to look at weather systems, ocean waves, geology, and plants.

Students from Masuda High School, during their visit to the IPRC.

Pacific Land Grant Association Workshop

The Pacific Land Grant Association (PLGA) connects across the American-affiliated Pacific region those post-secondary educational institutions that have academic programs in agriculture. Members are University of Hawai'i Mānoa, University of Alaska Fairbanks, University of Guam, College of Micronesia, Northern Marianas College, and American Samoa Community College. In October the PLGA sponsored a workshop in Honolulu on the implications of projected climate change for regional agriculture. IPRC Director **Kevin Hamilton** was invited to present IPRC's work on climate projections for Hawai'i and other Pacific Islands. The meeting brought together scientists and administrators from the PLGA colleges along with other officials and educators interested in this important issue.

IPRC's Kevin Hamilton with Dan Aga, Dean of Community and Natural Resources, American Samoa Community College, at the PLGA workshop.

IPRC Participates in Two NOAA Conservation Panels

NOAA has important responsibilities for nature conservation in the Pacific and earlier this year hosted two workshops in Honolulu on urgent conservation issues. IPRC Director **Kevin Hamilton** was invited as a panelist in both workshops to provide expert input on regional climate change.

The workshop in early June was entitled *Managing Papahānaumokuākea in the Context of Climate Change*. Papahānaumokuākea Marine National Monument was created by presidential proclamation in 2006 to protect the extraordinary natural and cultural resources of the Northwestern Hawaiian Islands. The site, encompassing 140,000 square miles, is the largest conservation area in the United States and among the largest marine protected areas in the world. In 2010 Papahānaumokuākea was designated a UNESCO World Heritage site for its outstanding natural and cultural features. As discussed at the workshop, the wildlife and other natural and cultural resources are threatened in many ways by the consequences of global warming. Rising sea level, rising air temperatures, and changing rainfall patterns may directly affect the habitability of the islands by many bird species; rising ocean temperatures and ocean acidification may affect coral reefs and other aspects of the marine ecosystem.

Black-footed Albatross on Midway. This species breeds in the Northwestern Hawaiian Islands. They are very heat-sensitive, building their nests in sand, and large kills occur during unusually warm weather, questioning their viability in a significantly warmer climate. Image courtesy of James Lloyd.

At the second workshop, June 18, an invited science panel reviewed NOAA's draft-response to a petition from the non-profit Center for Biological Diversity, which had asked the Federal Government to list 82 coral species as threatened or endangered under the Endangered Species Act. This petition may set a groundbreaking legal precedent for application of the Endangered Species Act, because human-induced global climate change is the main driver of potential extinction for the coral species.

At both workshops Hamilton presented the preliminary results of high-resolution regional climate projections conducted at the IPRC in collaboration with **Yuqing Wang**, **Chunxi Zhang** and **Axel Lauer**.

Pacific Islands Climate Science Center Inaugural Lecture

The Pacific Islands Climate Science Center (PICSC) is a new collaborative initiative of the US Department of Interior, the University of Hawai'i at Mānoa, the University of Hawai'i at Hilo and the University of Guam. The PICSC is one of a network of 8 regional climate science centers recently established by the Department of Interior. The centers are to serve the scientific needs of managers as they deal with wildlife habitats and ecosystems in a changing climate. The IPRC is playing a key role in this federally funded climate initiative in the Pacific islands: IPRC Director **Kevin Hamilton** is also serving as the University Director for the PICSC, and IPRC scientists are providing much of the PICSC research on the climate drivers for anticipated ecological changes in the Pacific region. Among the recently funded PICSC projects, for instance, are two that are spearheaded by IPRC scientists: "Climate Change Research in Support of Hawaiian Ecosystem Management: An Integrated Approach," led by **Oliver Elison Timm**, and "21st Century High-Resolution Climate Projections for Guam and American Samoa," led by **Yuqing Wang**.

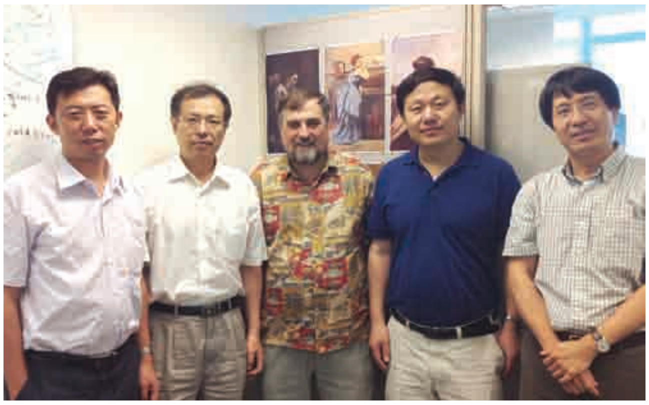
On October 26 an inaugural lecture was held on the Mānoa Campus to mark the public rollout of the PICSC. The lecture by **Loyal Mehrhoff**, field supervisor at the U.S. Fish and Wildlife Service, and **Deanna Spooner**, coordinator of the Pacific Islands Climate Change Cooperative, was titled "Navigating Change: Climate Science and Collaboration in the Pacific."

The lecture was preceded by brief remarks from University of Hawai'i at Hilo Chancellor **Donald Straney**, University of Guam Assistant Vice President **John Peterson**, PICSC Federal Interim Director **Cynthia Kolar**, University of Hawai'i at Mānoa Associate Vice Chancellor **Vassilis Syrmos,** and by Kevin Hamilton.

From left, John Peterson, Donald Straney, Kevin Hamilton, Loyal Mehrhoff, Deanna Spooner, Cynthia Kolar, and Vassilis Syrmos.

Ocean University of China Delegation Visits

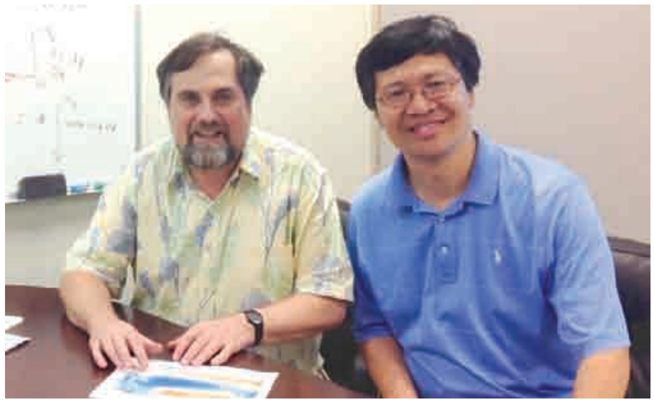
Faculty and officials from the Ocean University of China (OUC) visited the IPRC on August 7. The delegation was led by OUC Vice President **Hua Jun Li** and included **Dai Hua**, Director of the OUC International Office, and **Peiqing Guo**, professor in the OUC School of Law and Political Science. Located in Qingdao, OUC is the largest university for ocean sciences and related fields in China. The visitors met with several IPRC researchers as well as with scientists from the Oceanography Department, University of Hawai‘i at Mānoa.



From left, Peiqing Guo, Dai Hua, Kevin Hamilton, Hua Jun Li, and Bo Qiu (UH).

Texas Climate Center Director Visits

Zong-Liang Yang, Director of the Center for Integrated Earth System Science and John A. and Katherine G. Jackson Professor at the University of Texas, visited the IPRC in June. His center is leading advances in satellite analysis and numerical modeling work on climate-relevant land-surface processes. He presented a seminar titled "Achievements, Challenges and Opportunities in Modeling Land Surface Processes." In his talk Yang volunteered that he wants his center, as it grows, to take IPRC as a role model for scientific achievement in climate diagnostic and simulation work.



Kevin Hamilton with Zong-Liang Yang.

Japan-Hawai‘i Workshop on Disaster Risks

On August 14, the University of Hawai‘i Asia Pacific Initiative hosted a meeting on disaster risk management that was co-sponsored by the International Research Institute of Disaster Science (IRIDeS) of Tohoku University in Sendai, Japan, and the United Nations University (UNU) Tokyo campus. IRIDeS was founded at Tohoku University after the great March 2011 earthquake and tsunami. Deputy Director of IRIDeS, **Fumihiko Imamura**, described the mission and research activities of his new institute. **Brendan Barrett** of UNU discussed relevant educational programs, particularly an Asia-Pacific initiative led by UNU to teach college students about environmental planning using climate change as a cross-cutting theme. **Nikolai Maximenko** and **Kevin Hamilton**, who represented the IPRC at the meeting, took the opportunity to talk with IRIDeS tsunami modeling experts about the prospects of developing a simulation that shows the distribution of debris deposits from major tsunami wave inundations.

IRIDeS Deputy Director Fumihiko Imamura at the workshop.

Wide Interest in the IPRC and its Scientists

The IPRC reputation as an exciting international research center in the exotic Hawaiian Islands is spreading beyond the science community! In 2010 the IPRC was featured in a textbook designed to teach Japanese to Chinese speakers as an example of a workplace with a very international group of young workers (tinyurl.com/IPRCjn2010, p. 4, bottom right), and Senior Scientist **Nikolai Maximenko** appeared in the documentary on *America before Christopher Columbus: Who really discovered the new world?* aired on the US History Channel. In 2011, IPRC professor **Shang-Ping Xie** served as a tour guide for a Japanese television documentary about the rainiest spot on earth, Mt. Waiʻaleʻale on Kauai.

This past October, a French television production company documented the experiences of two of our French-speaking young scientists for a French travel documentary on the Hawaiian Islands. The television crew followed IPRC postdoctoral fellows **Ali Belmadani** and **François Ascani** around for an "ordinary" day in Honolulu. After an early surfing session at Kewalo Basin near Ala Moana beach park, the two young scientists went to their University of Hawaiʻi at Mānoa offices. Belmadani described his theoretical work on wind-forced beta-plumes and their application to deep currents found below the Hawaiian Lee Countercurrent. Together with IPRC Scientific Computer Programmer **Jan Hafner**, he showed the French reporters the now famous animations of the tsunami debris dispersion that followed the Great Tohoku Earthquake of March 11, 2011. The animations were derived from Maximenko's and Hafner's Surface Currents from Diagnostic (SCuD) model and are accessible on the IPRC website (tinyurl.com/IPRCdebrisnews). The prime-time documentary *Echappées Belles (France 5* tv channel), featuring the two postdoctoral fellows, was broadcast on November 3 and again on November 11, 2012.

Ali Belmadani being filmed for French TV documentary.

IPRC Scientists Active in the Research Community

Yu Kosaka was invited this fall to become an editor of *Science Online Letters on the Atmosphere* (SOLA), a Web-based research letter, which rapidly distributes scientific discoveries and advances the understanding in the atmospheric and related sciences. The pronunciation of "SOLA" is similar to the Japanese *sora* which means *atmosphere*. SOLA is published by the Meteorological Society of Japan.

Yuqing Wang will become an editor of the AMS journal *Weather and Forecasting* beginning January 1, 2013. He has served as associate editor for the past 3 years.

IPRC's **Ali Belmadani**, **Ryo Furue** and **Nikolai Maximenko** convened a session on "Mesoscale Ocean Processes" at the 2012 American Geophysical Union Fall Meeting in San Francisco. Mesoscale processes such as eddies, waves, fronts, and jets contribute significantly to the transport of momentum, heat, and mass as they interact with the ocean circulation at larger and smaller scales. With over 50 papers presented in three 2-hour oral sessions and a 4-hour poster session, the meeting was a great success. The conveners intend to organize this session every year at the AGU Fall Meeting.

Continuing the Hokkaido University Exchange Program

IPRC's meteorology professor **Yuqing Wang** continued the long-standing partnership with Hokkaido University that was organized by Hokkaido professor **Youichi Tanimoto**. Wang gave a series of lectures over three days and one seminar at Hokkaido University in September 2012. His lectures focused on dynamical downscaling and its applications. The Hokkaido lecture series began in Spring 2008 with **Shang-Ping Xie**. More recent lectures series were given by IPRC's **Jay McCreary**, **Kelvin Richards**, and **Axel Timmermann**.

IPRC Scientists in the News

Tropical Indo-Pacific Climate Shifts to a More El Niño like State

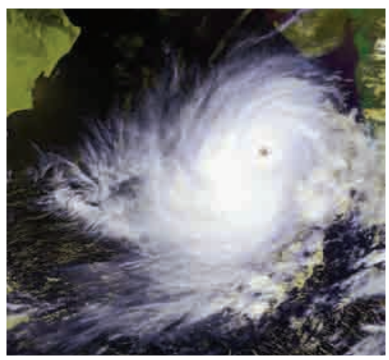
IPRC's **Hiroki Tokinaga** and **Shang-Ping Xie** and their colleagues published in the November 15 issue of *Nature* their successful simulation of the slowdown of the Walker circulation over the last 60 years, a change that atmospheric models had difficulty simulating. The study shows that changes in the sea surface temperature pattern across the Indo-Pacific are the drivers of the slowdown. The photo on the right by **Y. Kashino,** RIGC/JAMSTEC, was featured on the National Science Foundation home-page banner, with a link to the story. The study results were picked up by many online news outlets, such as *Science Newsline, Science Daily,* and the Australian Government's *Climate Science.org*. Tokinaga's work was also featured in Honolulu's *Star-Advertiser* in a special tabloid insert on innovations at the University of Hawai'i.

Why Rainfall Projections for South Pacific Islands Are Uncertain

An international team of scientists around IPRC's **Mathew Widlansky** and **Axel Timmermann** found that with global warming rainfall in the South Pacific islands depends on two competing effects: overall warming should increase rainfall, while changes in atmospheric water transport could decrease rainfall. The uncertainty of which effect wins out makes for highly uncertain rainfall projections. Published in the 28 October online issue of *Nature Climate Change*, the study was featured on the magazine's homepage and widely in such news media as *Science Newsline, Phys. Org., Science Daily, Raising Islands*.

Earlier Monsoon Onset Impacts Tropical Cyclones in Arabian Sea

The tropical cyclones in the Arabian Sea during the pre-monsoon season (May–June) have intensified since 1997 compared to 1979–1997. IPRC'S **Bin Wang** spearheaded a study showing that this change is due to decreased vertical wind shear, resulting from an earlier occurrence of tropical cyclones and an earlier monsoon onset. Published in "Brief Communications Arising" in *Nature* (Sept. 20), the study was featured in many online news sites in the US and in the developing world.



Marine Debris Continues to Fascinate the Media

Nikolai Maximenko's and **Jan Hafner's** expanded version of the IPRC Tsunami Debris model has been featured again in the media, among them the *Star-Advertiser* (August 8, 2012), and *Deep Sea News*. When the news that a blue bin, the first confirmed tsunami debris in Hawai'i, had arrived, the model animation was shown on *CBS News* (Sept. 21), *KITV4* (Sept. 22), *USA Today* (Sept. 22) and other outlets. Another flurry for interview requests came when a huge orange cylinder beached on the Island of Hawai'i. The scientists' work has also been featured in the *Natural History Magazine,* the *Frenchtribune.com,* Japan's *NHK,* and other foreign language sites.

Atmospheric Resonance and Hawai'i Climate

Kevin Hamilton was involved in one of the year's top science stories: NASA's mission of the Curiosity rover on Mars. The atmospheric pressure data from the rover confirmed Hamilton's prediction from over 20 years ago of an extremely large diurnal cycle due to a natural resonance of the Martian atmosphere. This confirmation of a fundamental aspect of atmospheric dynamics theory was reported in online media including *Popular Science* and *Space Daily*, and featured in the American Meteorological Society's *News You Can Use* and foreign language sites.

The IPRC was also featured in the August 2012 issue of *Alaska Airlines Magazine*. The story is based in part on an interview given by Hamilton about present-day climate conditions and IPRC scientists' projections for climate in the late 21st century.

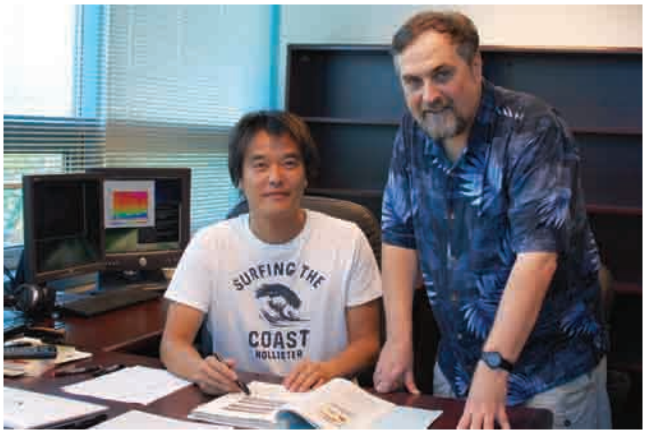
Climate Change and the South Asian Summer Monsoon

The vagaries of South Asian summer monsoon rainfall impact the lives of more than one billion people. Based on an extensive review of recent research, IPRC's **H. Annamalai** and **A. G. Turner** from the University of Reading, UK, conclude that with continued rise in CO_2 the region can expect generally more rainfall. Regional projections for devastating droughts and floods, however, are still beyond the reach of current climate models. Their review appeared in the June 24 edition of *Nature Climate Change* and was featured in many online media, such as the *New York Times environment blog, Science Daily, India's Daily News and Analysis,* and *UzbekistanNews.Net*.

VISITING SCHOLARS

Modeling the Stratosphere

Yoshio Kawatani, senior scientist with the Global Change Projection Research Program of JAMSTEC's Research Institute for Global Change (RIGC), visited IPRC for several weeks in August and then again in October. Kawatani is collaborating with IPRC Director **Kevin Hamilton** on projects that involve modeling of the dynamics and composition of the stratosphere. The focus in these recent visits was on modeling the stratospheric response to global warming and on the question of whether observations support their model simulations of long-term stratospheric climate trends.



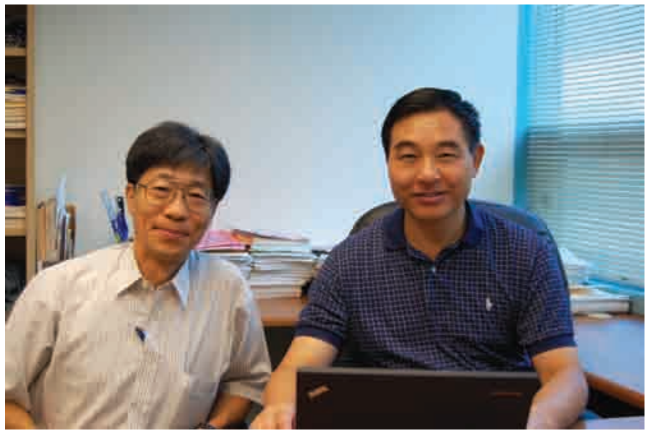
Yoshio Kawatani with Kevin Hamilton.

Tokyo Storm Runoff Model

Akira Kawamura of the Tokyo Metropolitan University, Japan, visited the IPRC from August 22 to September 14, 2012. Hosted by IPRC's **Yuqing Wang**, Kawamura had extensive discussions with IPRC scientists on the hydrometeorology of rainstorms. In urban areas such events often lead to disastrous floods. The scientists also explored possible collaborative research in the areas of hydrometeorology and water resources in Asia and Pacific regions.

During his visit, Kawamura gave an IPRC seminar on urban floods entitled "Introduction of the distributed urban storm-runoff model [Tokyo Storm Runoff – (TSR) model] with an advanced GIS (geographical information system) catchment delineation." In his presentation, he introduced the comprehensive flood-control measures being taken in Tokyo. The measures include both structural and non-structural approaches. He explained details of the TSR model proposed by his research group. The TSR model precisely describes the spatial characteristics of an urban catchment that traces with precision the rainfall runoff and inundation processes.

Kawamura's visit to IPRC was funded by the Tokyo Metropolitan Government, Japan, under the research project "Solutions for the water-related problems in Asian Metropolitan areas" with Kawamura as the representative.


Akira Kawamura with Yuqing Wang.

Astronomical Theory of Climate

In June, IPRC's paleoclimate research team, led by **Axel Timmermann,** welcomed **André Berger**, Université Catholique de Louvain, Belgium, and his colleague **Quizhen Yin**. Berger is well known for his pioneering work on the Astronomical Theory of Paleoclimate and the impact of solar insolation on the ice-age cycles during the last 2.5 million years. While at the IPRC, he gave a public lecture entitled "Astronomical Theory of Climate: A Review."

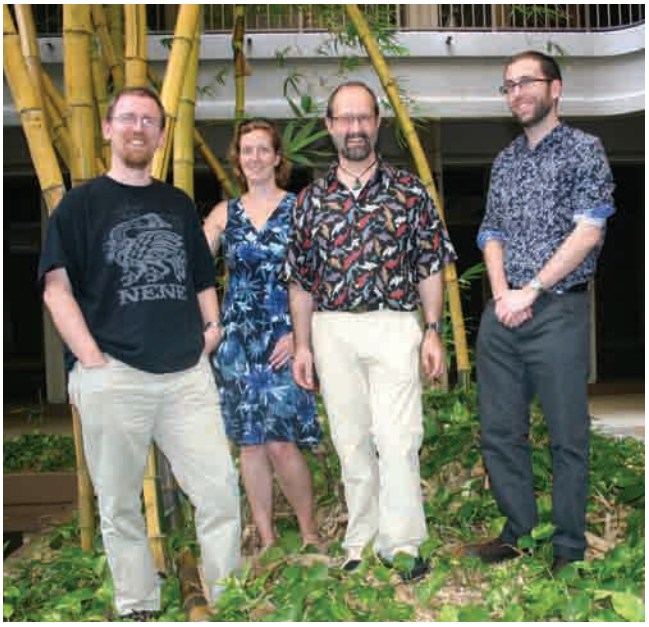
Berger discussed with the paleoclimate team the latest developments in numerical Earth-System-modeling on the beginning and termination of ice ages. Berger and Yin are currently working on the puzzling question why Antarctic ice-core records show cooler interglacial periods in the earlier parts of the 800,000-year-long proxy records than in the more recent interglacial periods. Discussions also centered around the latest developments in IPRC's paleoclimate model LOVECLIM, which now includes interactively coupled 3-dimensional thermomechanical ice-sheets for the Northern Hemisphere and Antarctica.

Berger also met individually with Postdoctoral Fellow **Tobias Friedrich**, JAMSTEC visitor **Megumi Chikamoto,** and PhD student **Michelle Tigchelaar,** exchanging ideas and results on marine carbon-cycle dynamics and Antarctic ice-sheet-ocean interactions. Both processes are fundamental active components of the Earth Climate System that translate the astronomical forcing into changes in the hydrological and carbon cycles on land and in the ocean.

André Berger and Axel Timmermann.

Past Ocean Climates

In late November, the paleoclimate group welcomed several scholars working in the areas of past ocean climates and ice-core-sediment data archives. **Tom Russon**, University of Edinburgh, gave a seminar titled "The extent of unforced ENSO changes over the last millennium." Gerhard Kuhn from the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, is a co-author with IPRC's **Axel Timmermann** and **Tobias Friedrich** and IPRC's JAMSTEC visitor **Megumi Chikamoto** on an article dealing with the millennial-scale variability of the Antarctic Ice Sheet throughout the last deglaciation. **Nathalie Dubois** (Woods Hole Oceanographic Institute) also has research interests in paleoceanography and in climate-related changes in the ocean circulation and their impact on marine ecosystems.



From left, Axel Timmermann, Natalie Woods, Gerhard Kuhn, and Tom Russon.

New Black Sea Climatology

IPRC's Senior Scientist **Nikolai Maximenko** is working with **Gleb Panteleev** (International Arctic Research Center, University of Alaska, Fairbanks) and with scientists from the P.P. Shirshov Institute of Oceanology in Moscow on a project that synthesizes the wealth of satellite and in situ observations in a data-assimilating numerical model of the Black Sea. The project will provide the first high-quality estimate of the mean state of the Black Sea, including a three-dimensional climatology with dynamically consistent fields of temperature, salinity, and currents. The new climatology will be available on the APDRC website and is expected to have multiple scientific, operational, and managerial applications.

Funding for the project comes from the US Civil Research & Development Foundation and the Russian Foundation for Basic Research.

Nikolai Maximenko with Gleb Panteleev.

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