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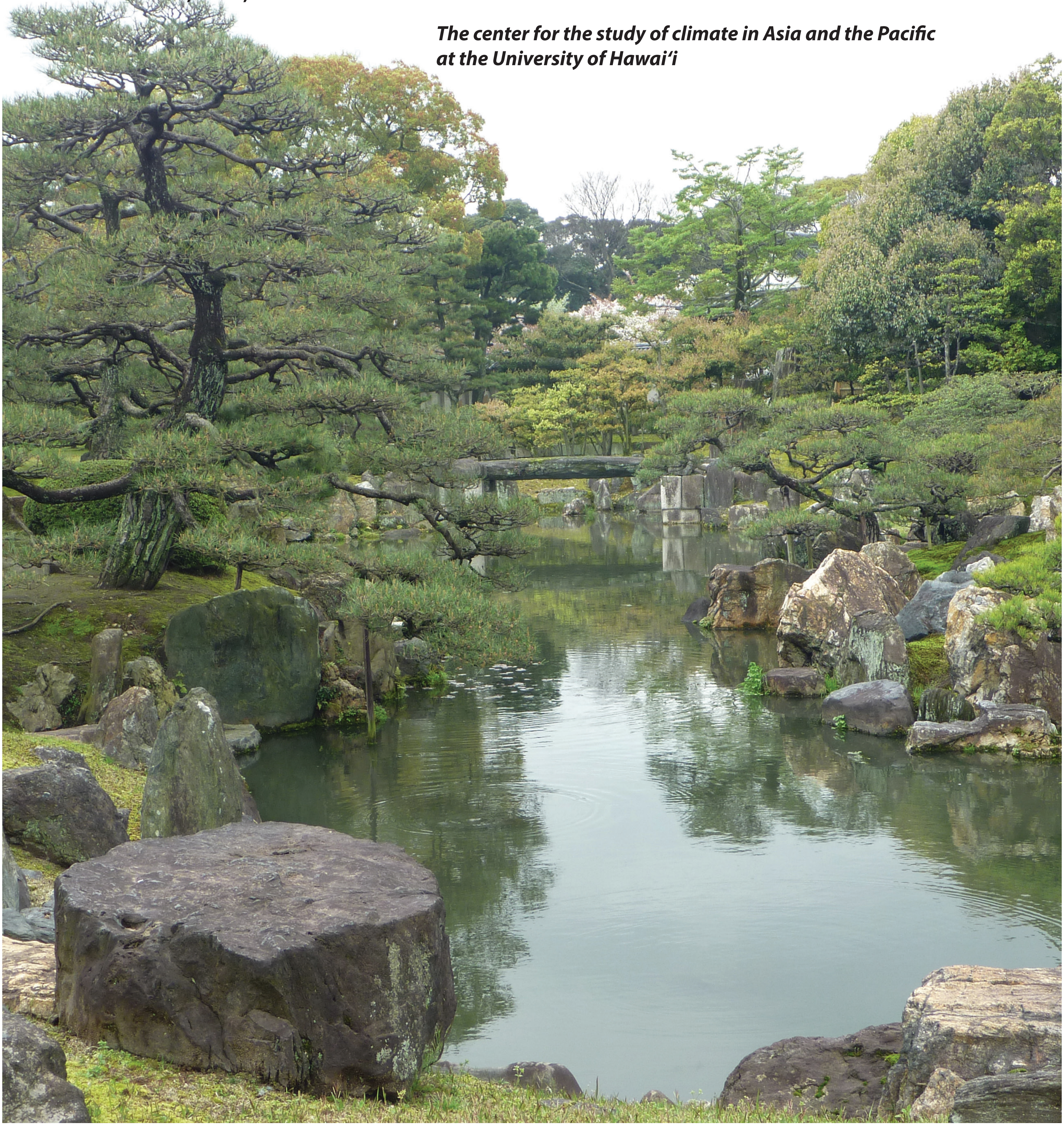
Newsletter of the International Pacific Research Center

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



Vol. 14, No. 1, 2014 **Newsletter of the International Pacific Research Center**

Cover photo: The pond in the Ninomaru Garden on the grounds of Nijo Castle in Kyoto, Japan. With the recent signing of a new co-operative agreement, IPRC will continue as a Japan–US partnership at least to 2017 (see story page 22). Photo credit: Gisela Speidel.

Research

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

Projecting Climate Change in Hawai‘i

Image courtesy of Ben Isabel.

By **Kevin Hamilton**

Human effects on the global climate system, principally through altering the atmospheric concentrations of carbon dioxide and other greenhouse gases, are expected to lead to significant warming and other associated changes in the climate worldwide. Human-induced climate changes are likely already observable in the global mean temperature and, over the next century, can be expected to significantly disrupt the varied habitats and environments in Hawai‘i.

Isolated islands such as those of the Hawaiian archipelago are especially vulnerable. The unique landscape of plants and wildlife in Hawai‘i is already under stress as native species compete with recently introduced invasive species. While the state of Hawai‘i has only 0.2% of the land mass of the USA, fully 25% of the species on the US government's official endangered list are found only in Hawai‘i. Climate change in Hawai‘i will threaten habitats and perturb island ecosystems, not only on land, but also along the coastline and in the surrounding ocean. The latter will be further stressed by ocean acidification.

The systems that directly support the human population—including those producing the state's energy and food supply—are particularly vulnerable to disruption due to Hawai‘i's isolated location, especially if patterns of extreme weather events change. As on all isolated islands, the continued supply of fresh water is an ever-present concern in Hawai‘i. Given the prohibitive cost of alternative fresh water sources (importation or desalination), each island in Hawai‘i must rely on its own rainfall to supply the fresh water needs of a modern economy. On O‘ahu nearly 1 million inhabitants and visitors must rely on watersheds that total only 1550 km^2 in area. Finally, many aspects of the unique indigenous culture in Hawai‘i could be further stressed by significant changes in the local environment.

Climate change is a prominent concern among the general public in Hawai‘i and also has received significant official attention. The state wishes to be a leader in conservation, clean energy and climate adaptation, and the legislature has passed a number of relevant laws in recent years (see box).

> *Climate changes will likely impose major, but not fully understood, costs and other impacts on Hawai‘i's people and the natural capital we depend upon to support our lives in the middle of the Pacific Ocean. Nowhere is it more obvious than in remote island chains like Hawai‘i that our lives and the economy are intertwined with the health and function of the natural world around us.… Now is the time.… to plan for the inevitable effects of climate change.*
>
> – Preamble to Act 73 of the Hawai‘i Legislature (2010)

Until recently, the intense public and official interest in climate change in Hawaiʻi perhaps was not matched by the activity of the climate research community. The physical science working group contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2007 included only a single paragraph discussing the special issues for small Pacific islands. Last year's Fifth IPCC Assessment Report is more generous, with ten paragraphs devoted to Pacific islands, mainly discussing projected shifts in regional rainfall patterns, but not touching on the small-scale variations that may occur within individual islands.

Over the last few years, however, the effort in the science community devoted to Hawaiʻi climate change has intensified. One driving force behind this increasing activity has been the local implementation of US Federal Government initiatives on regional climate research. The US Department of Interior (DOI) has recently created regional partnerships with academic institutions as part of a strategy to consider the effects of climate variation and change in its mission to protect the nation's natural and cultural resources. Eight regional DOI Climate Science Centers were created across the nation. Hawaiʻi and the US affiliated Pacific islands are served by the Pacific Islands Climate Science Center (PICSC) established in 2011 as a partnership between the United States Geological Survey (USGS) and a consortium of academic institutions led by the University of Hawaiʻi (UH).

The US Department of Commerce through its National Oceanic and Atmospheric Administration (NOAA) has established a Regional Integrated Sciences & Assessments (RISA) program that supports regional research teams contributing to the capacity of communities to prepare for climate variability and change. In 2010, NOAA approved a joint proposal between UH and the East-West Center that has led to the creation of the RISA-funded Climate Adaptation Partnership for the Pacific (CAPP) focused on climate change and fresh water resources in Hawaiʻi and the insular Pacific.

IPRC has been deeply involved in both PICSC and CAPP. I serve as the inaugural University Director of the PICSC as well as IPRC Director here at UH, and I serve as one of five co-PIs in CAPP.

The new efforts on climate change research for Hawaiʻi and the broader insular Pacific are driven by the concerns of a variety of stakeholders and involve contributions from ecologists and social scientists as well as physical climate scientists. IPRC is the region's leader in climate modeling and diagnostics and has stepped up to spearhead the physical climate projections needed as part of this broader focus. Here I will review IPRC's continuing work on island-scale climate change projections and briefly describe some of the efforts of our partners who will use our projections as input to their own assessment of various impacts of long-term climate trends in Hawaiʻi.

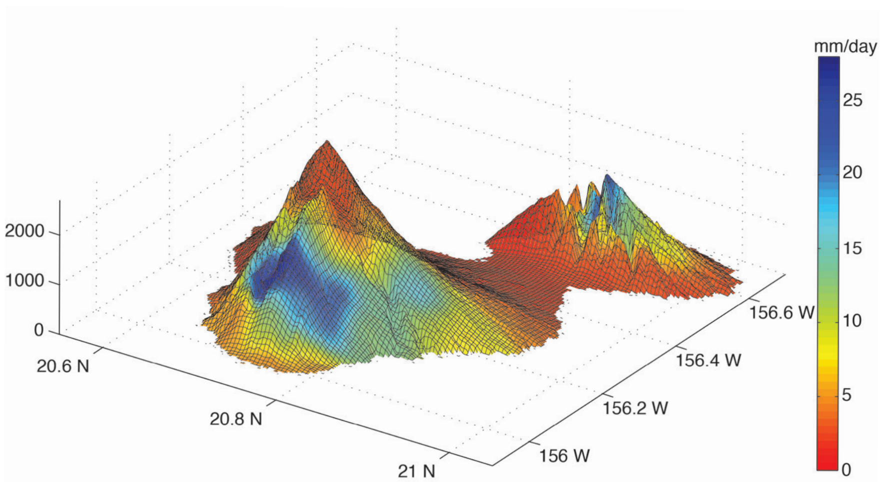


Figure 1. Observed annual mean rainfall rate (mm/day) during 1990–2009 on Maui.

Island-scale Atmospheric Simulation

The currently available climate change projections from global coupled atmosphere/ocean models, as summarized for example in the recent IPCC assessment reports, have very limited direct application to Hawaiʻi or other Pacific islands. Such model projections have been performed with atmospheric models with effective horizontal grid-spacing typically ~100 km or more. State-of-the-art global models may represent all the Hawaiian Islands as just a handful of land grid-boxes or even ignore the presence of the Hawaiian landmasses entirely! Without a representation of the high and steep topographic relief characteristic of Hawaiʻi, such models cannot simulate even basic features of the winds, temperature and rainfall over the Hawaiian Islands.

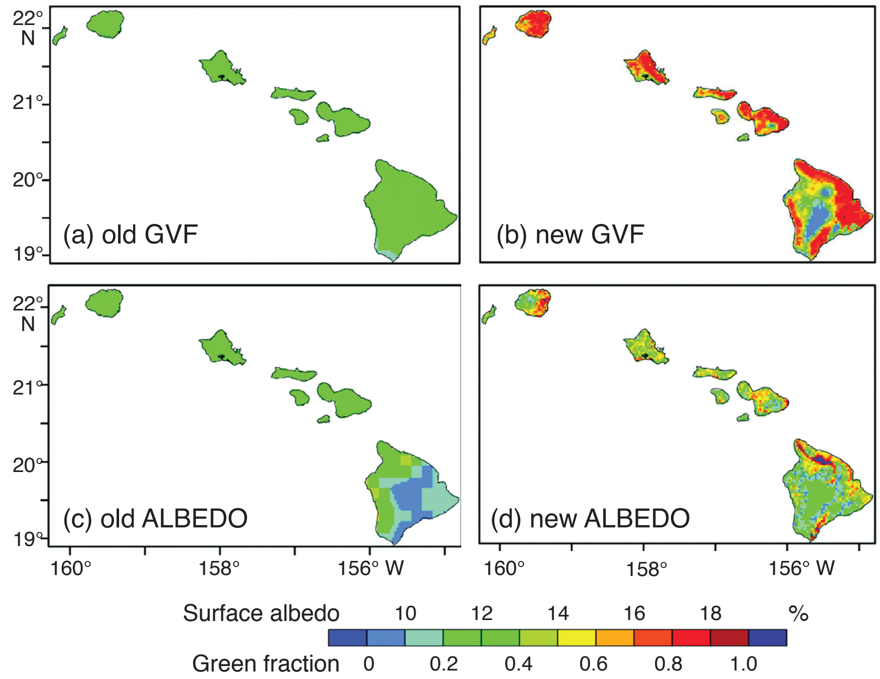


Figure 2. Comparison of green-vegetation fraction in the land cover of the Hawaiian Islands as represented in the standard WRF model (a) and in IPRC's modified version (b). Same comparison for surface albedo in the original WRF (c) and in the modified WRF version (d).

An example of the topographic control of climate in Hawai'i and the remarkably large horizontal gradients in climate elements is displayed in Figure 1. This very high-resolution representation of the topography of the island of Maui shows the observed 20-year mean rainfall for 1990–2009 in colored shading. East Maui is dominated by Haleakalā volcano (peak elevation 3055 m), and the rainfall is concentrated on the slopes facing the prevailing northwest surface trade winds. The summit is generally quite dry since it is well above the usual trade wind inversion. West Maui is dominated by the much eroded volcano known as Mauna Kahalawai (peak elevation 1,764 m), and in this area the highest mean rainfall rates are near the summits, which are often in the trade wind cloud layer. The rainfall rates plotted in Figure 1, interpolated from a large number of individual rain gauges, are similar to results shown by Giambelluca et al. (2013) in their more sophisticated spatial analysis of 30 years of station data.

For the last few years IPRC's regional climate modeling experts, led by faculty member **Yuqing Wang**, have been working on ultra-fine resolution climate projections for Hawai'i including the anticipated greenhouse gas climate forcing through the remainder of the 21st century. The modeling group has included two of IPRC's more junior researchers **Chunxi Zhang** and **Axel Lauer** (now at the Institute for Advanced Sustainability Studies in Germany) as well as myself.

The main effort has been on developing a triply nested version of the community Weather Research and Forecasting (WRF) model and applying it to extended simulations of the climate around Hawai'i. The WRF model was chosen as the basis for our work due to its community support and its well-developed capacity to handle nonhydrostatic equations and multiply nested grids. Nevertheless the standard "off-the-shelf" community WRF model required several modifications to the convection and cloud physics parameterizations as well as more accurate specification of surface properties. We call our WRF version the "Hawai'i Regional Climate Model" (HRCM). Figure 2 shows examples of the changes in surface characteristics introduced into the WRF to derive HRCM. Details on the basis for these and other surface specification modifications in HRCM are presented in Zhang et al. (2012). Given the relatively small area of the islands, the land surface characteristics were not expected to have a large effect on climate simulations, but Zhang et al. (2012) show that the more realistic surface characteristics in HRCM do improve slightly the simulated diurnal temperature ranges and surface wind speeds.

The model initial and lateral boundary conditions for the atmosphere in the "present day" climate simulation were obtained from standard atmospheric reanalysis products.

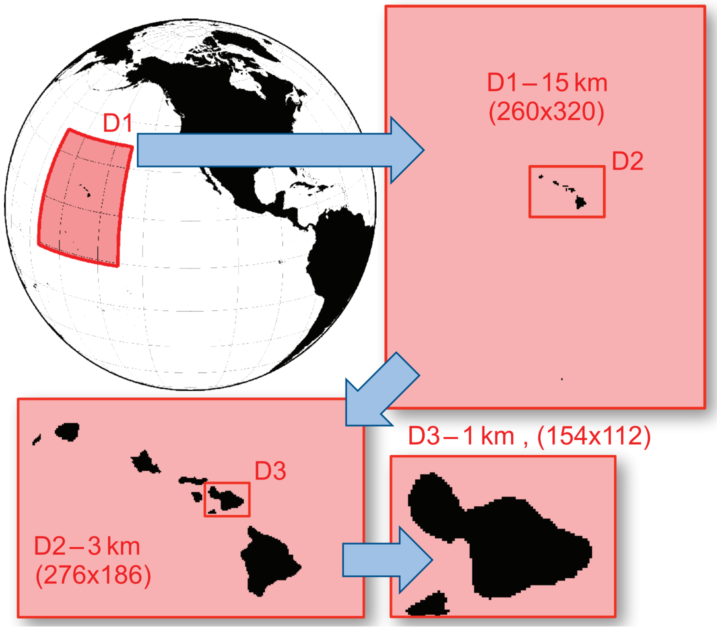


Figure 3. The configuration of the nested grids for the study with the Hawai'i Regional Climate model focused on Maui.

The sea surface temperature (SST) specified in the HRCM runs was updated daily using NOAA global observational analysis. In addition, a diurnal SST variation was included based on the surface energy budget. Figure 3 displays the domain and grid structure for a triply nested version with the inner grid covering Maui and the immediately adjacent ocean. The outer, middle and inner domains have grid spacing of 15, 3 and 1 km, respectively.

Zhang et al. (2012) discuss the formulation of HRCM and examine one year (November 2005 to October 2006) of retrospective simulation in a doubly nested version with finest horizontal resolution of 3 km. Since then our group has completed 20 years (1990–2009) of retrospective simulation (1990–2009) and a 20-year simulation driven with projected future conditions at the end of the current century (2081–2099). These new model integrations used a version of HRCM that included the 1-km grid over Maui. Here I will present just a preliminary sampling of the results, focusing on the long-term means.

The present-day simulations have been compared with a large variety of observations. The most complete surface station observations are at the aviation weather (METAR) stations at Lihue (Kaua'i), Honolulu (O'ahu), Kahului (Maui), and Hilo (Hawai'i Island) Airports. Figure 4 shows the 1990–2009 mean rainfall at these stations for each month of the year compared with the HRCM simulation results at the nearest grid point. The model captures the basic features of the annual cycle of rainfall, temperature and surface wind (not shown). The HRCM realistically simulates the range of variability of the observed trade wind inversion base heights, with a large majority of days having inversion heights between about 1.2 and 2.5 km, with the most frequently occurring heights around 1700–2000 m. The model simulation can be compared in detail with observed data from twice daily balloon soundings at both Lihue and Hilo, and at both stations, the model displays an overall low bias of about 200 m in the inversion height.

Simulating the geographical rainfall distribution over the individual islands is a particular challenge for a comprehensive model. The overall pattern of wet windward slopes and relatively dry leeward areas on each major

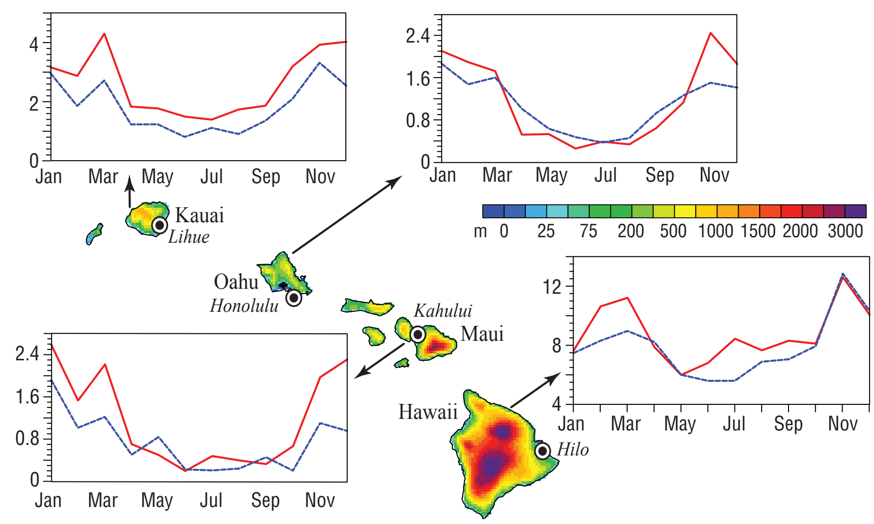


Figure 4. The long-term mean rainfall rate (mm/day) for each month of the year at the four major Hawai'i aviation weather sites. Red curves represent observations, blue the HRCM simulation. The topography of the islands is also shown.

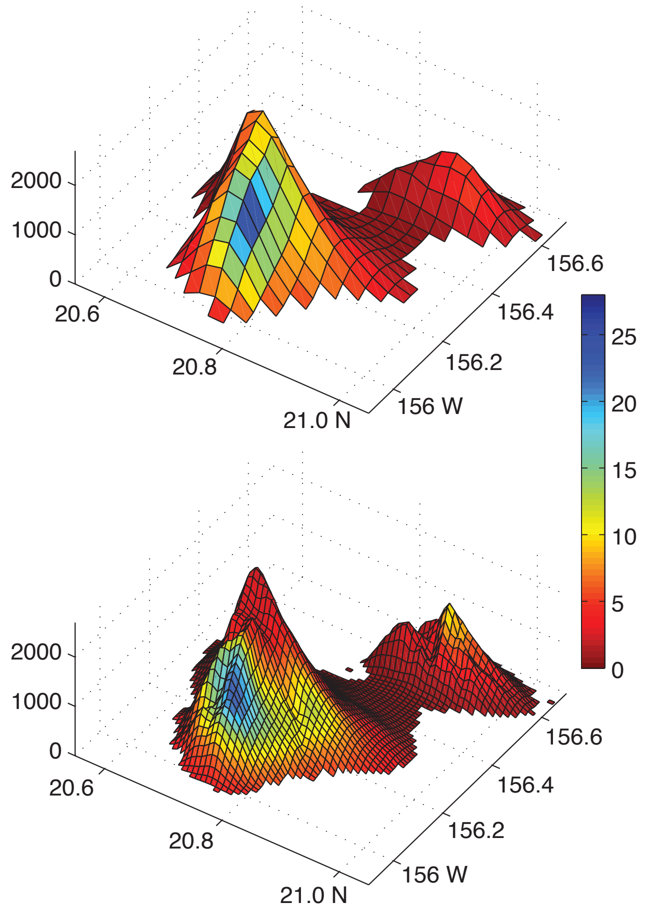


Figure 5. Top: the topography and the 20-year mean rainfall rate (mm/day) over Maui in the 3-km grid doubly nested version of the HRCM. Bottom: in the 1-km triply nested version.

island is captured by the model (not shown) and the spatial correlation coefficient between observed and simulated mean rainfall rate computed on a 3-km grid over all land areas in the state exceeds 0.8. However when examined in detail, some significant problems in the mean rainfall simulation are apparent, particularly on Maui and Oʻahu, the islands with the steepest topographic slopes.

For Maui we can see the improvement when the model grid spacing is reduced to 1 km. Figure 5 compares the 1990–2009 mean rainfall over Maui simulated on the 3-km grid in the doubly nested HRCM (top) with the results from the 1-km grid in the triply nested HRCM (bottom). The topography used in each version is represented and the grid lines show the horizontal resolution of the model. With the summit of Haleakalā noticeably smoothed out, the topography at 3-km resolution is much blander than the actual topography (compare Figure 1). This leads to a simulation with too much rainfall in the highlands of East Maui. With the more realistic topography at 1-km resolution, the rainfall simulation improves dramatically, with the dry uplands on Haleakalā now well represented. Other biases improve as well, notably the peak rainfall on the highlands of West Maui increases along with the topographic height of the summit there.

The good news is that we are able to get a reasonable simulation of the detailed patterns of rainfall gradients, but, at least for Maui, this apparently requires at least a 1-km horizontal resolution. Oʻahu has two very narrow mountain chains and we expect even finer resolution may be needed there. We have begun a HRCM integration with an inner grid over Oʻahu with 800-m horizontal resolution. Although Hawaiʻi Island features the state's two tallest mountains, the typical topographic slopes there are significantly smaller than on Maui or Oʻahu and the rainfall simulation at 3-km resolution appears to be reasonably good.

The HRCM is able to simulate successfully even some fairly subtle aspects of the hydrological cycle. For example, we have compared the HRCM simulation of the diurnal rainfall cycle in Hawaiʻi with observations at 173 rain gauge stations that have hourly data (not shown). On each island the HRCM simulation reproduces the dominant pattern in the observations reasonably well. Notably in both observations and model, the mean rainfall rate tends to peak in the early morning on the windward sides and in the afternoon on the leeward sides.

Island-scale Climate Change Projections

We have completed a 20-year climate change projection experiment appropriate for late 21st century conditions using the triply nested version of HRCM with the inner grid over Maui. The SSTs and lateral boundary conditions for this experiment have been based on multimodel means of the CMIP3 global coupled models using the SRESA1B scenario for the 21st century. Lauer et al. (2013) discuss the details of the "pseudo-global warming" method we employed and show results of some calculations that support using a multimodel mean of global coupled model results to force a regional model such as HRCM. The annual mean of the ocean surface warming imposed in the late 21st HRCM projections is shown in Figure 6 (see next page).

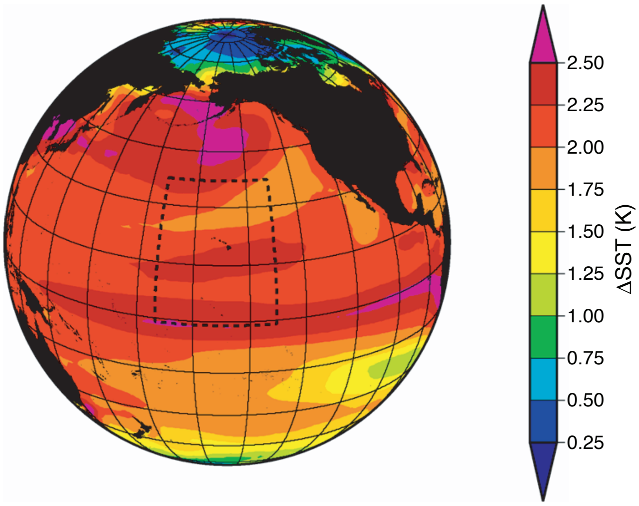


Figure 6. The ocean surface warming in the late 21st century simulation with HRCM.

The model projected annual mean surface air temperature increase (average of 2180–2099 minus 1990–2009) is shown in Figure 7 for Hawaiʻi Island. The view is from the southwest and the two summits are Mauna Loa in the foreground and Mauna Kea in the rear. Near the coast the air temperature increase reflects the imposed surface warming (based on the global model results) of the adjacent ocean. In the interior of the island, a clear pattern of intensified mean warming with topographic height is evident. This is seen in the warming projection for the other islands as well (not shown). It is interesting that the historical surface air temperature rise observed at Hawaiʻi stations over the last few decades has also been found to be intensified at higher altitudes (Giambelluca et al., 2008). The mean warming over 90 years at the summits of Mauna Loa and Mauna Kea is predicted to be close to 3.5°C, equivalent to an upward displacement of the temperature climatology by about 500 m along the mountain. We find that one consequence of the very substantial warming will be the almost complete disappearance of snow from the summits of the mountains on Hawaiʻi Island (see box).

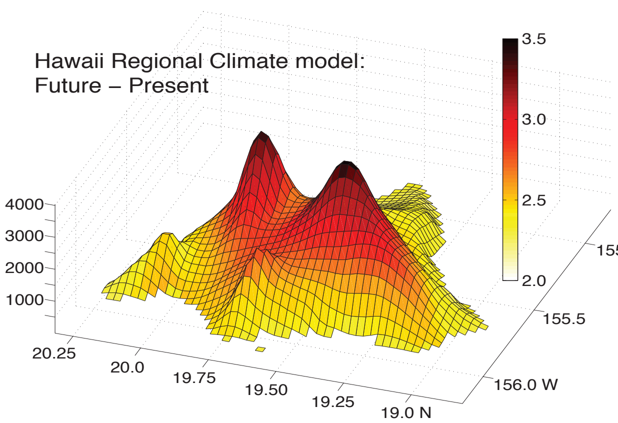


Figure 7. The change in annual mean surface air temperature in the late 21st century HRCM simulation relative to the 1990–2009 simulation (C). Plotted for the Hawaiʻi Island topography as represented at 3-km resolution in the HRCM.

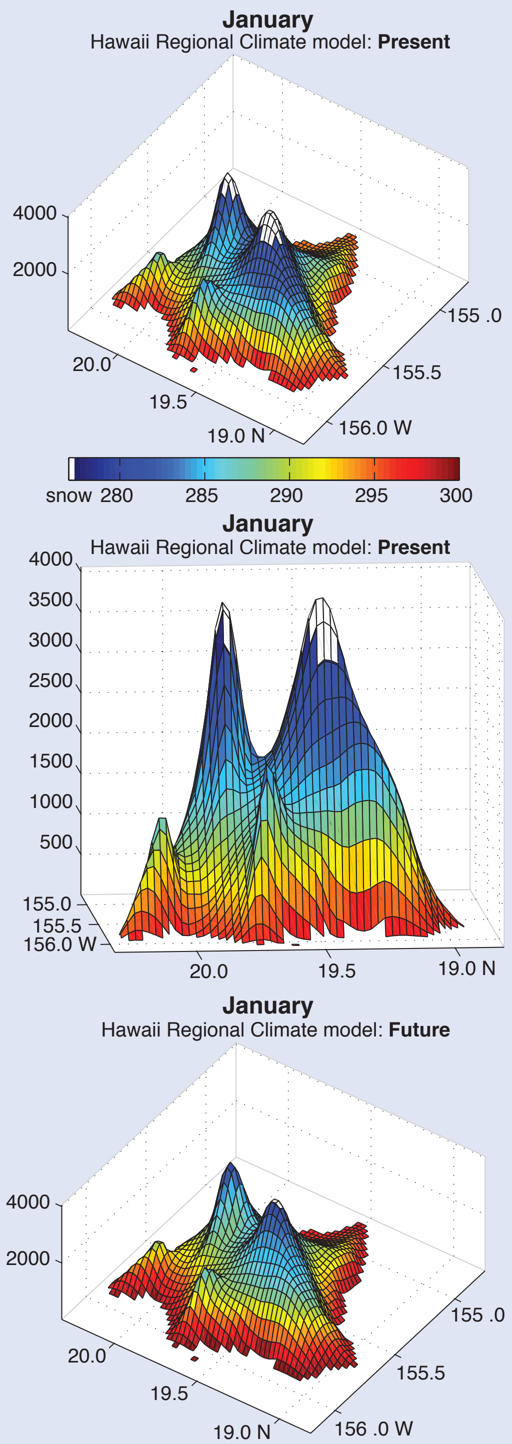
We have also begun to analyze the projected changes in long-term mean rainfall (not shown). The overall pattern is for more rainfall on the windward sides of the islands and less rainfall on the leeward sides. The change in annual mean rainfall in the model projections can be roughly characterized as "wet areas get wetter" and "dry areas get drier." Similar results are apparent in the 1-km simulation over Maui, with enhanced rainfall over the northeast-facing slopes of East Maui and over the highlands of West Maui, but less rainfall in the rain shadow of East Maui (not shown).

The regions where the rainfall is projected to increase are dominated by topographically forced rain during trade wind conditions. The increased rainfall in these regions may, to first order, be a response to increased atmospheric boundary layer moisture in the warmer climate. The normally dry areas in Hawaiʻi generally depend on convective events for their rainfall, and in our model convection is suppressed (on average) in the warmer climate. The fraction of days with a clearly defined trade wind inversion is projected to rise from about 80% in present day to roughly 90% at the end of the century. The projected rise in the fraction of days with trade wind inversions represents a large decrease in the fraction of days during which significant convective rain events have the possibility of forming. Our model results suggest that the increased average stability of the atmosphere under global warming conditions leads to less convective rain, and hence more drying of the already arid rain shadow areas of the islands. Note that increased potential evapotranspiration caused by the higher air temperatures is also projected for almost all areas in Hawaiʻi (not shown), exacerbating the drying trend predicted for the rain-shadow regions.

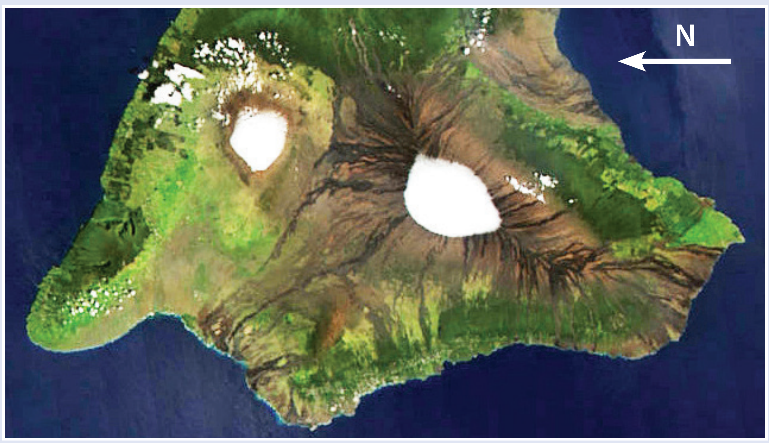
The End of Hawai‘i’s White Mountains?

Lucky visitors to Hawai‘i Island in winter time may enjoy the lovely sight of the snow covered peaks of Hawai‘i’s two tallest mountains: Mauna Loa (4169 m) in the south and Mauna Kea (4207 m) in the north. Mauna Kea, which means “white mountain” in Hawaiian, is believed to be the home of **Poli‘ahu**, the Hawaiian deity of snow. Though the summits of these mountains are mostly clear and the clouds keep below an inversion layer around 1500–2500-m height, the typical weather pattern usually breaks down several times each winter, and convective storms blanket the summits in snow. There is little systematic monitoring of snowfall, unfortunately, but large snowstorms can cover the mountains down to about 3500 m.

The figures at left show results of the Hawai‘i Regional Climate Model simulations for “present day” (1990–2009) and the late 21st century. The white coloring denotes areas where the 20-year mean snowfall for January is greater than 5 cm (5 mm liquid water equivalent). The model results suggest that by the end of the present century the significant snow cover of the mountains on Hawai‘i Island may disappear.



The 20-year January mean surface air temperature and snowfall climatology from the HRCM simulations. The white areas are those that receive at least two inches of snowfall over the month on average. Top: present day looking northeastward; middle: looking eastward; bottom: late 21st century.



Satellite image of Hawai‘i Island on February 28, 2002, showing snowcaps on Mauna Kea and Mauna Loa.

Photo of snow-capped Mauna Kea taken off the east coast of Hawai‘i Island. Credit Ben Isabel, Hawai‘i Island resident.

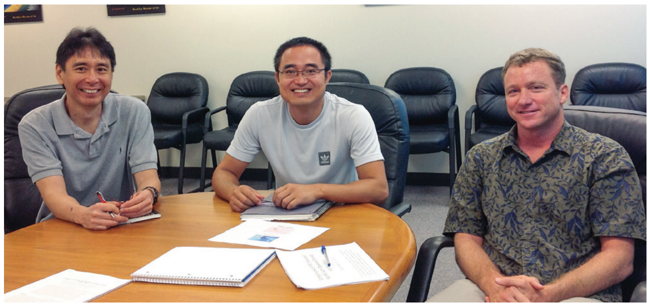
What Will Be the Practical Impacts?

The climate changes expected by century's end in Hawai'i will not have a great direct impact on human comfort or human health, as we expect Hawai'i to still enjoy an exceptionally moderate and pleasant climate (at least in the areas with substantial population). However, climate change will significantly impact the islands through its effects on both the natural and manmade environment. Our IPRC group is now at the center of a busy network of researchers (some based in Hawai'i and some elsewhere) who are using their expertise to study the impacts of our projected climate changes. We have interacted so far with at least 8 research groups who have begun to use our data or have concrete plans to do so. The issues being investigated are those of obvious interest to Hawai'i residents, including fresh water availability, geographical distributions of naturally occurring plant species, carbon storage in the biosphere, agricultural practices, and the viability of native bird species. I will very briefly introduce three of these studies below. In all cases the analyses by our partners are still ongoing and we anticipate they will present their results in future publications.

Fresh Water on Maui

The focus on Maui for our first triply nested simulations was motivated by our participation in a major effort to inform stakeholders on Maui about the implications of climate change for fresh water sustainability. This project is coordinated by the CAPP: researchers at the East-West Center (EWC) are leading the outreach to stakeholders and assessing their concerns. Colleagues at UH's Water Resources Research Center (WRRC) and the USGS Pacific Islands Water Science Center (PIWSC) are modeling the groundwater response to prospective climate changes. Of the main islands, Maui likely presents the most complicated and contested water-use situation, with huge demands from agricultural users, a legacy of extensive water tunnel and aquaduct infrastructure, and a fragmented pattern of ownership and governance (only a small fraction of Maui's water resources are under public control although a larger fraction actually originates as rainfall on public lands).

The CAPP project focuses on the 'Iao Waihe'e watershed in central and west Maui, where CAPP researchers have started to hold meetings with stakeholders to discuss the project's purpose and methods. Over 50 representatives of various Maui water management groups have already made suggestions on how to assess groundwater availability under a changing climate and how to change water management practices accordingly. The basic information the modelers at IPRC have generated on projected climate changes is being used in the IPRC/WWRC/PIWSC/EWC partnership to provide guidance to the large group of stakeholders whose decisions will affect the sustainability of fresh water on Maui.



PIWSC scientists Delwyn Oki (left) and Alan Mair (right) discuss the use of IPRC's climate projections with IPRC's Chunxi Zhang (center).

Avian Malaria and Hawaiian Forest Birds

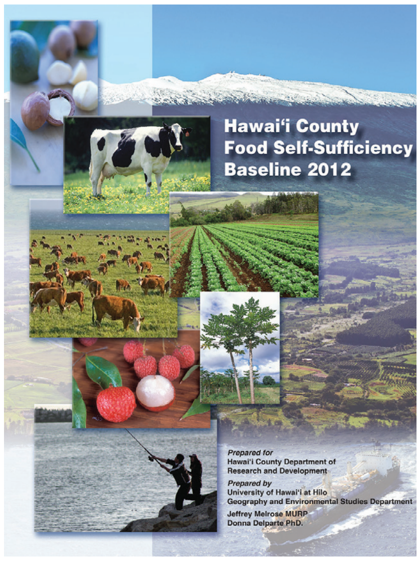
The Hawaiian honeycreeper family (*Drepanididae*) includes 19 extant and at least 10 extinct species. These small colorful birds are all endemic to Hawai'i although they are similar to various finch species in other places. Quoting the classic study of Benning et al. (2002): "[the honeycreepers] represent a dramatic example of anthropogenic extinction. Crop and pasture land has replaced their forest habitat, and human introductions of predators and diseases, particularly of mosquitoes and avian malaria, has eliminated them from the remaining low- and mid-elevation forests. … anthropogenic climate change is likely to combine with past land-use changes and biological invasions to drive several of the remaining species to extinction…"

The effect of avian malaria on native bird populations is particularly serious and is closely coupled to climate change. **Joy Liao**, postdoctoral researcher at the University of Wisconsin, and **Michael Samuel**, a scientist at the USGS National Wildlife Health Center in Wisconsin, are using IPRC's climate forecasts to assess for the first time quantitatively the long-term impact of climate change on bird malaria distribution and on Hawai'i's forest birds. In regions where mosquitoes can thrive and efficiently transmit malaria among birds, almost none of the native forest birds can survive. So the populations of forest birds, including the Hawaiian honeycreepers are largely restricted to higher elevations where the climate is not hospitable for mosquitoes. As the climate warms, however, the region where the birds can avoid malaria will move up in elevation. When this zone is above the remaining forest regions, then the birds will face extinction. Climate change could add another chapter to Hawaiʻi's sad history of extinctions of endemic birds and other native species.

The Common `Amakihi (*Hemignathus virens*) one of the beautiful honeycreeper species found only in Hawaiʻi.

Agriculture in Hawaiʻi

In the middle of the 20th century more than half the food consumed by Hawaiʻi's population was produced in the state. That fraction has now fallen below 12%, but agriculture is still an important component of the state's economy and efforts to improve food security by increasing local production is a priority for Hawaiʻi state and local governments. Agriculture can also support the state's economy, particularly through growing the more successful Hawaiian export crops, notably coffee (*Coffea arabica*) and macadamia nuts (*Macadamia integrifolia*). We can foresee that climate change will complicate agricultural planning in Hawaiʻi. Quantitative projections of how climate change will affect agriculture and agricultural practices in Hawaiʻi are now being pursued by **Jacob Gross**, a graduate student in the Department of Natural Resources and Environmental Management (NREM) in UH's College of Tropical Agriculture and Human Resources. Working with NREM faculty member **Tomoaki Miura**, Gross is first creating a tool that rates the suitability of land in Hawaiʻi for specific crop types under present-day conditions, and then will apply IPRC's temperature and rainfall forecasts to project future suitability for these crops.



A 2012 report prepared for the county government of Hawaiʻi Island.

Conclusion

Regional climate modeling has been one important focus of IPRC's activities from it early days. IPRC's investment in building expertise in this area has allowed us to take the lead over the last few years in projects requiring very fine-resolution modeling of projected climate changes for Hawaiʻi. We find that with fairly "middle of the road" assumptions concerning future emissions scenarios, significant surface warming and rainfall changes can be expected over Hawaiʻi, and that these changes will have significant geographical structure within each island. Even as we here at IPRC work to refine our modeling results, our many partners are already researching how our projected climate changes will affect natural and manmade systems in the islands. As in other places throughout the world, we can expect climate changes over the century to yield some benefits, but likely these will be outweighed by deleterious and disruptive impacts. We hope our efforts, together with those of our partners, will result in the best possible information for adaptation planning.

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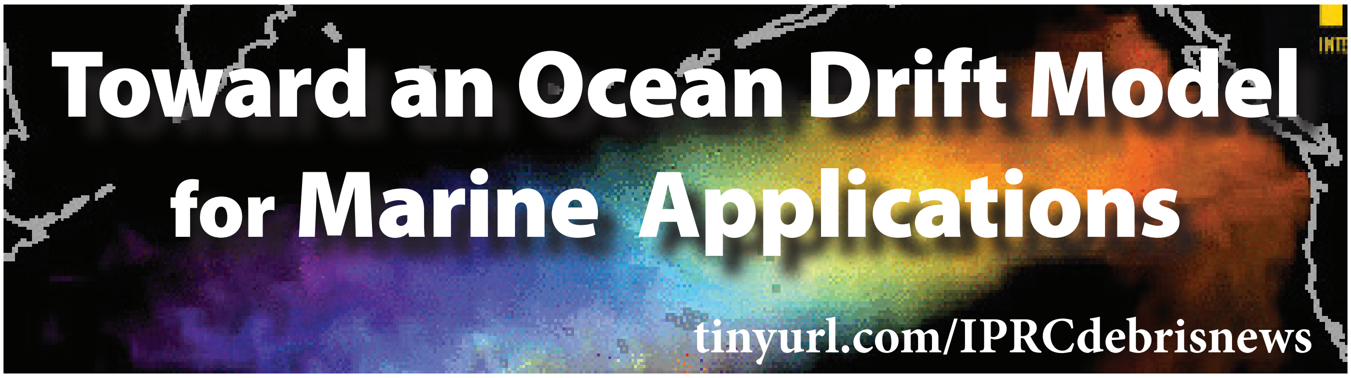
Toward an Ocean Drift Model for Marine Applications



By **Gisela Speidel**

The more than 16,500 drifting buoys deployed in the Global Drifter Program provide a unique opportunity for tracking ocean debris, IPRC Senior Researcher **Nikolai Maximenko** realized. Carried along by ocean currents, the paths taken by these drifters yield information not only of ocean current velocities, but also about areas of accummulation. Where flows diverge, water wells up from the deep bringing rich nutrients to the surface; where flows converge, floating debris can be expected to collect.

An obstacle to developing a computer model from the drifter trajectories was the non-uniform drifter deployment in the World Ocean, each experiment having focused on a specific region. Maximenko dealt with the problem by compiling the actual 5-day movements of each drifter over its life-time into a probabilistic drift model. (For details see *IPRC Climate*, vol. 8, no. 2). As a next step, uniformly distributed tracers were placed into the model and the evolution of their dispersion tracked.

After 10 years, the virtual drifters had mostly collected in five regions in the World Ocean, namely in the centers of the five subtropical gyres (Figure 1). The areas with the strongest convergence and hence largest model drifter collections lie between Hawai'i and California—the Great North Pacific Garbage Patch—and in the South Pacific. Despite its predicted location close to Easter Island, the latter patch was only verified in 2011 by **Jim Mackey**, who explored the area as a ship-of-opportunity following Maximenko's modeling results (See *IPRC Climate,* vol. 9, no. 2). **Marcus Eriksen** explored the area further during a dedicated expedition. Eriksen also collected evidence for the predicted patches in the Southern Indian and Southern Atlantic oceans.

When the tsunami tragedy happened in March 2011 in Japan and aerial images showed thick mats of debris floating in the ocean, Maximenko realized the importance of tracking the driftage. No drifting buoys were floating east of Japan at the time, but running his model with virtual drifters showed that the tsunami debris would drift toward the US - Canada west coast and to Hawai'i. Maximenko presented these results at the 5th International Marine Debris Conference.

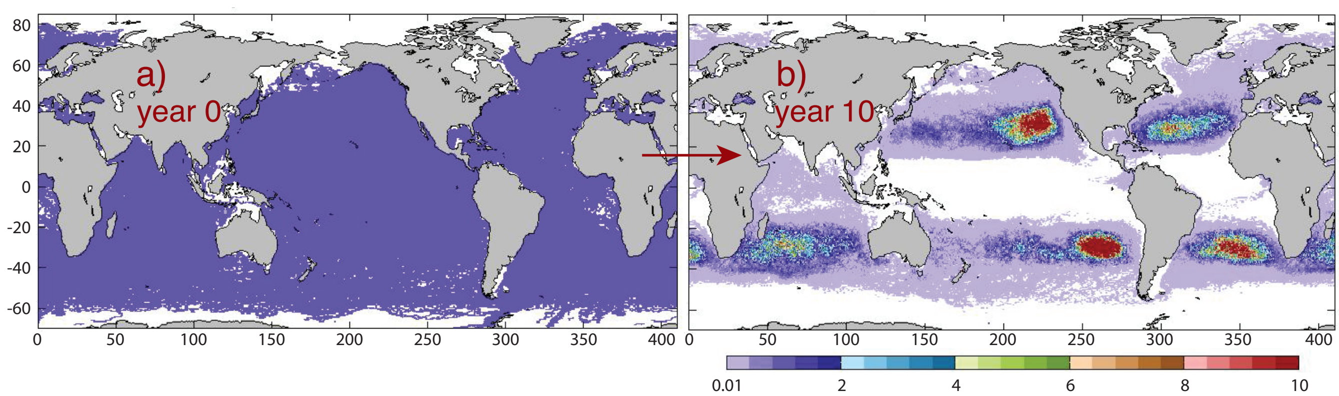


Figure 1. Evolution of density of drifters (or marine debris) from the initially homogeneous state (a) and after 10 years of advection by currents, measured by real drifters (b). Units indicate relative change of the concentration.

Tsunami debris off the Tohoku coast. Photo credit US Navy.

To make the simulations more practical, Maximenko had worked with IPRC Scientific Programmer **Jan Hafner** to develop a real-time drift model. Starting with conditions on the day of the tsunami, March 11, 2011, Hafner placed millions of virtual drifters into the this model off of the Tohoku Coast and ran the model with the daily updates, which were made publicly available. The model showed how the debris dispersed with time.

Maximenko had hoped to track the debris by satellite trackers placed on the floating debris and with airplane surveys. Over the next months he pleaded with NOAA, the Coast Guard, and other federal agencies, but to no avail. By summer 2011 the debris had scattered and vanished.

Public evidence of tsunami driftage resurfaced in fall. The Russian sail-training ship *Pallada* had stopped in Honolulu in September on its trip back to Vladivostok. Maximenko and Hafner took their maps of the tsunami debris field to the captain, who, warned of the danger to his ship, organized on his return trip round-the-clock watches by almost 200 cadets. Just northwest of Midway, consistent with the model's predictions, the sailors observed unusual debris and collected a fishing boat, the first confirmed tsunami driftage found thousands of miles from Japan (Figure 2).

In fall and winter 2011, fear loomed large that the debris would land on the beaches of the Papahānaumokuākea Marine National Monument and destroy habitats of endangered species. Together with **Doug Woodring** of the Ocean Recovery Alliance and **Luca Centurioni** of Scripps Institution of Oceanography Maximenko organized a small sailboat expedition with Jim Mackey (photo page 15) to survey the area northwest of Midway. Only old debris, however, was spotted: An anomalous current associated with a front kept tsunami debris away from the Northwestern Hawaiian Islands, and the model animation showed the core of the debris moving north of Hawaiʻi towards the North American West Coast.

A surprise came when large oyster buoys from aqua farms in Japan started to wash up on Washington coastlines in mid-December 2011, much sooner than the model had projected. The scientists realized that their model, which

Pallada cadets pick up fishing boat lost in tsunami.

simulated the paths of drifters with heavy drogues and intended for charting ocean currents, needed to be rebuilt to include the movements of very buoyant pieces, driven partly by winds like sailboats.

The scientists went back to the drawing board and added wind effects. Obtaining realistic values of windage levels to drive the model was challenging because observations with which to confirm these levels were, and remain, sparse. By August 2012, their expanded model was running with

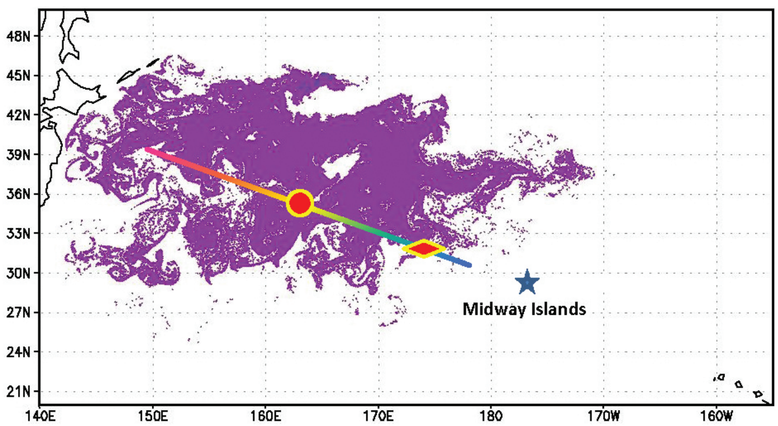


Figure 2. Rhombus shows where Pallada spotted Japanese boat, red circle where maximum debris density was seen, and purple the tsunami debris field in model on September 25, 20111.

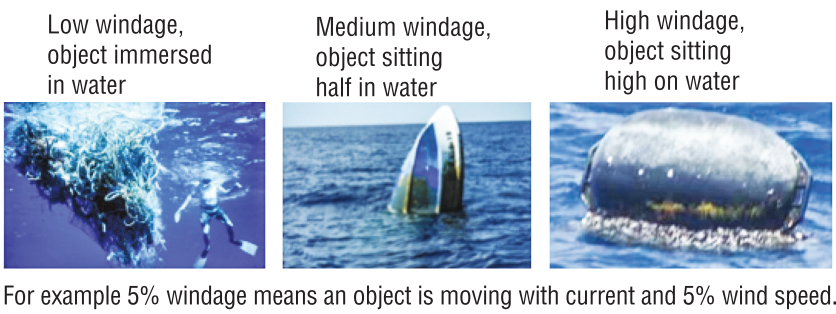


Figure 3. Illustration of different windages.

Oyster buoy found by Carl Berg and Kaua'i Surfrider volunteers.

windage levels from 0 (original version) through 5% (Figure 3) and accommodated objects of different shapes, buoyancies, and amounts of surface exposed to the wind, resulting in different speeds and trajectories.

The updated model was completed just as it showed the front edge of tsunami driftage arriving in Hawai'i and as reports trickled in of unusual driftage washing up on Hawai'i windward-facing shores. In mid-August, **Carl Berg** of the Kaua'i Surfider Foundation sighted off of Kaua'i a black oyster buoy similar to those found on Washington beaches a half year earlier. Large 500-Watt light bulbs with Japanese manufacturer's names and gooseneck barnacles arrived. In mid-September, a blue bin bearing the name of a Japanese company destroyed during the tsunami floated in, followed shortly by an Asahi crate. The first of several fishing skiffs, similar to the one spotted by the *Pallada* sailors, was sighted 700 miles north of Moloka'i; the owner in Japan was found.

As the reports came in, the *Sightings* page listing arrivals of possible tsunami debris was added to the IPRC *Marine and Tsunami Debris News* website. Reports became more numerous. Until summer 2013 most of the driftage consisted of oyster buoys, parts of refrigerators, docks, and fishing skiffs. According to the model these pieces would have drifted with a 4%–5% windage.

In July 2013 the Transpacific Yacht Race, famous for fast downwind sailing with the trade winds, took place. During the 5-day journey from Point Fermin in Southern California to Honolulu, the racing boats reported numerous collisions with floating wood. The IPRC *Sightings* page has the following entries from the race: "Sighted 15′ chunk of floating telephone pole; sighted 35′ floating tree trunk; struck what may have been a 10′ section of telephone pole; large pieces of debris, a couple of pieces of lumber looked like parts of a house."

John Sangmeister, skipper of the winning boat *Lending Club*, reported on CNN: "mid-morning the second day, we were sailing at…about 28 miles an hour, when we encountered a patch of debris…. we hit that telephone pole and struck it mid-way in half like a Ginsu knife …..on days three and four we … encountered similar debris with dramatic consequences and damage to our boat."

Two months later, in September 2013, the large wooden debris started to arrive on Hawai'i shores. Through fall and winter 2013, and into spring 2014 reports came of poles, beams with finely executed mortise and tenon features and atypical US dimensions, and tree trunks. A gabled roof end of a small cabin with metal bracing holding all together was found end of September on Kamilo Point by **Megan Lamson**, **Bill Gilmartin**, and the volunteers of the Hawai'i Wild Life Fund. Carl Berg and his Kaua'i Surfrider Foundation volunteers reported they had never seen so many large wooden pieces washing up on Kaua'i beaches.

Although such pieces of wood do not often wash up on Hawai'i's beaches, are they from the tsunami devastation? To get some confirmation, Maximenko sent wood pictures and samples to **David Stallcop**, a wood export specialist with Vanport International, a lumber company based in Oregon and with worldwide ground support.

Cross-section of very "old" Sugi sample sent for analysis to experts.

James Mackey leaves Honolulu for Midway expedition.

Bill Gilmartin with gabled roof end at Kamilo Point.

Stallcop wrote: "It was easy for me to determine that the samples are definitely Japanese Cedar (Sugi) - *Cryptomeria japonica*. The fresh cross cuts definitely show that it is Sugi… grown in a higher elevation area than the other Sugi samples. The Sugi harvested today grows very quickly. This Sugi is from a very old timber. It could have been precut for a home or building construction 100+ years ago. Very cool." He added "The sizes of the Japanese Cedar samples are definitely indicative of Japanese Post and Beam construction." Morphological analysis of the same samples by **Scott Leavengood** from Oregon State University substantiated the conclusions of Stallcop.

Relevant to the accuracy of the model's simulation are the waves of debris type arriving in Hawai'i. From summer 2012 through spring 2013 oyster buoys and refrigerators were a common sighting, but are hardly seen anymore in spring 2014. Huge wooden beams up to 40-feet long only started to be sighted on their way towards Hawai'i in summer 2013, arriving in Hawai'i in early fall 2013 and becoming more numerous in winter 2013–2014. These waves of debris are broadly consistent with the model, the higher windage items arriving before low windage pieces.

The IPRC Ocean Drift Model is now poised for various applications. For example, the experience with Japanese fishing boats reaching Hawai'i 1½ to 2½ years after the tsunami guided the scientists in using realistic windage parameters to simulate the remarkable 13-month drift of **Jose Salvador Alvarenga**, the San Salvadoran fisherman, from Mexico to Ebon Atoll. The paths of the 16 tracers placed into the model 200 nautical miles southwest of the coastal fishing village Chiapas, Mexico, on December 20, 2012—the time that Alvarenga says he was blown off shore—are consistent with the fisherman's report (Figure 4). The particles are quickly driven offshore by very strong winds and by wind-induced currents. Over the 13 months, some move faster and overshoot Ebon Atoll where Alvarenga was found (red dot indicates approximate place), others have not yet reached the atoll. Given the variability of the daily winds and current that drove the model, the 16 tracers show a remarkably narrow path over this long period of time.

The IPRC scientists are now processing a wealth of further tsunami debris data to improve their ocean drift model. They plan to refine their model with the greatly enlarged drifting-buoy database now available and to broaden their model codes to study, for example, how winds, shapes of coastlines, and currents interact to make some beaches free of marine debris, and others collectors; or what causes the mystery of the vanishing marine debris: millions of tons of debris are washed into the ocean every year, much more than is estimated to be in the 5 "garbage patches."

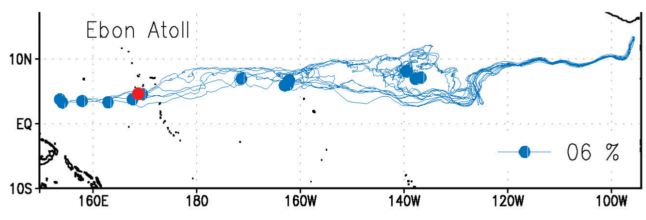


Figure 4. Path of the 16 tracers in the model from December 20, 2012, to February 1, 2014, driven with 06% wind force. Red circle shows Ebon Atoll where Alvarenga was found and blue circles mark positions of the tracers end of January 2014.

The Sea Level Seesaw of El Niño *Taimasa*

During El Niño *Taimasa*, coral tops of Samoa's fringing reefs become exposed to air at low tide. Image courtesy of the National Park of American Samoa.

The huge swings in sea levels linked to the El Niño– Southern Oscillation (ENSO) threaten vulnerable island communities and coastal ecosystems in the tropical western Pacific. Sea level in that region can rise during La Niña and drop during El Niño by up to 20–30 cm. (See 'Klaus Wyrtki and El Niño' in *IPRC Climate*, vol. 6, no. 1, 2006, for a historical perspective of detecting these sea level seesaws.)

The most extreme sea level drops are in the southwestern Pacific, which by exposing the shallow reefs that circle and protect the islands, lead to catastrophic coral and fish die-offs. Samoans refer to very low sea level as '*taimasa*' (pronounced [kai' ma'sa]; translation from Samoan to English is "foul smelling tide" referring to the odor from decaying marine life). **Luafata Simanu-Klutz**, assistant professor of Samoan language and history at the University of Hawai'i, recalls times when the prevailing trade winds changed, sea level would drop, and "you could walk far out on the reefs. During the day, the stench was at times quite unbearable...fish died in the heat."

"Repeated exposure of shallow reefs to air at low tide causes the top portions of coral heads to die off, often creating what are known as micro-atolls on shallow reef flats," explained the managers at the National Marine Sanctuary of American Samoa to **Matthew Widlansky**, IPRC postdoctoral fellow.

"Hearing accounts of flat-top coral heads found throughout the western Pacific coastal reef ecosystem motivated me to further study the associated sea level drops," says Widlansky, who conducts research on tropical climate variability during his postdoctoral studies at the IPRC. "In spite of these ecological and societal impacts of El Niño-related sea level drops on Pacific islands, little is known about their causes, regional manifestations, and what will happen in the future with further climate change."

To explore why these sea level extremes occur and, hopefully, to improve prediction of future events, Widlansky

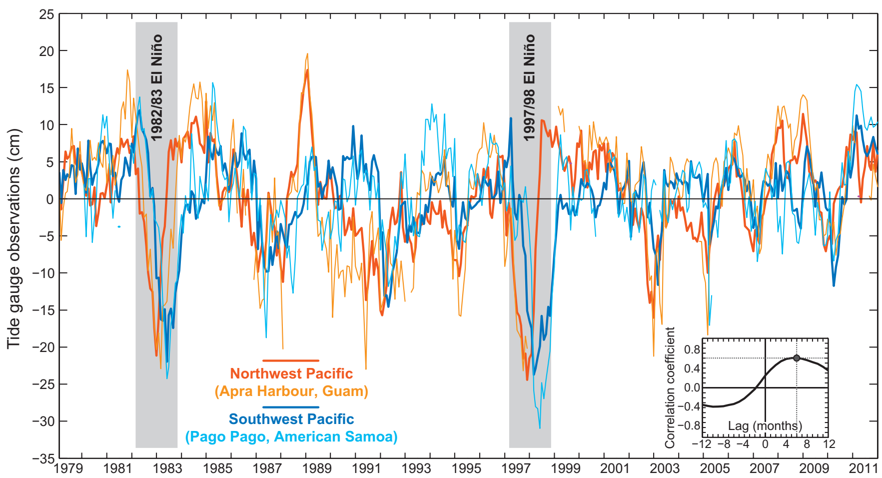


Figure 1. Tide gauge observations in the Northwest Pacific (orange) and Southwest Pacific (blue) with the linear trend in each region removed. Thick lines represent multi-station averages (see Fig. 2 for locations). Observations from Guam and American Samoa are highlighted. Insert shows the correlation coefficient between regions as a function of lag in months (Southwest Pacific lags Northwest Pacific; r = 0.60 at lag 6 months). Grey boxes highlight two strong El Niño events referred to throughout. Data from the University of Hawai'i Sea Level Center.

partnered with IPRC Faculty Member **Axel Timmermann**, and they began collaborations with an international team of climate scientists and oceanographers.

Using tide-gauge records throughout the tropical Pacific compiled by **Mark Merrifield**, director of the University of Hawai'i Sea Level Center, the scientists analyzed past sea level extremes.

"From the tide-gauge network, we saw that sea levels around Guam tend to recover quickly during the end of a very strong El Niño events, but in Samoa the below-normal sea levels persist up to six months longer," explains Timmermann.

The most severe sea level drops, the team noted, took place during the strong El Niño of 1982/83 and 1997/98 (see Figure 1). During both, tide gauge levels initially fell far below normal in the tropical northwestern Pacific but remained near normal around Samoa, creating a steep north-south sea level gradient across the equator (Figure 2a). Focusing on the sea level drops near Samoa, which occurred immediately after the peak of these two El Niño events, the scientists

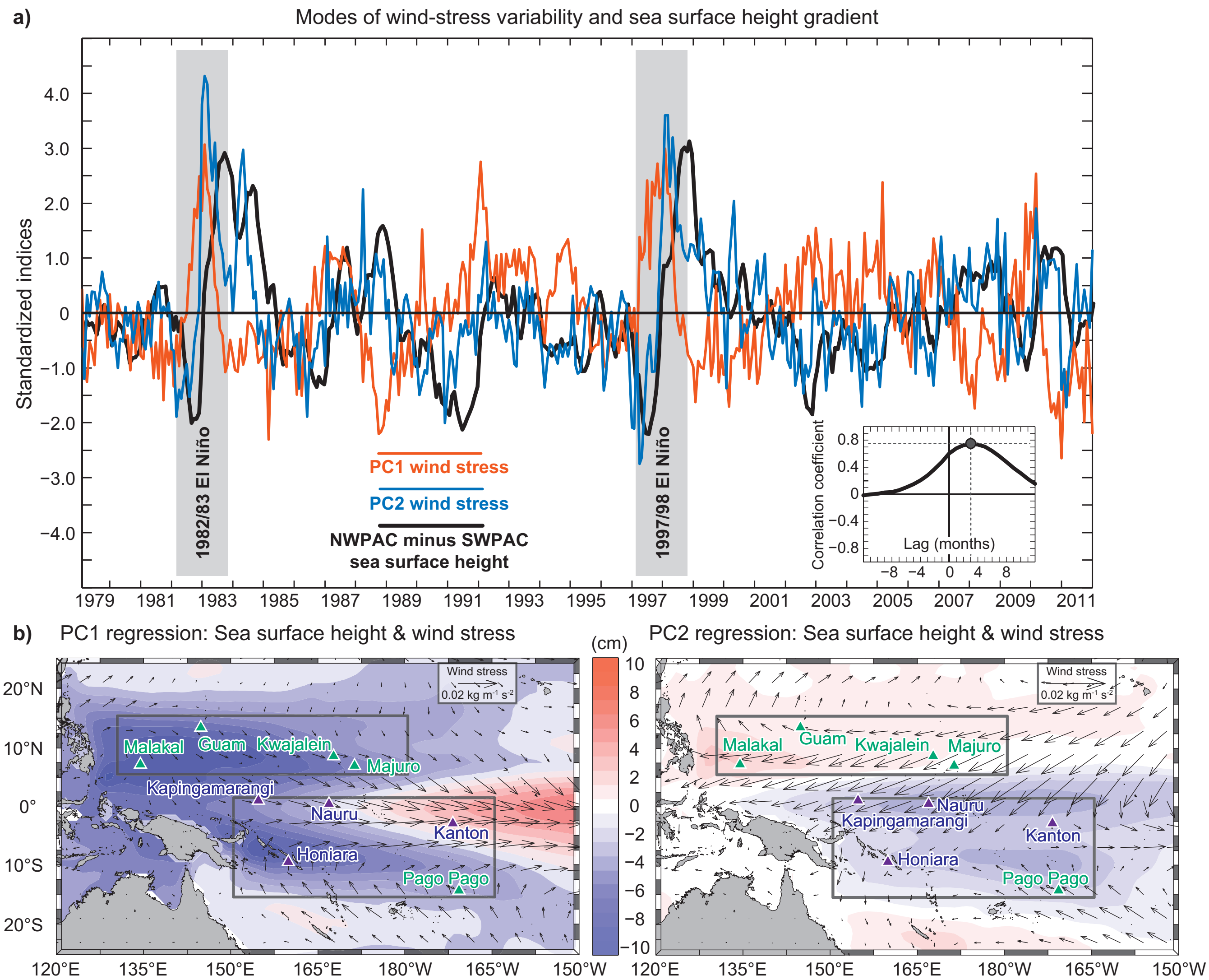


Figure 2. Two principal components (PC1 and PC2) of wind-stress and sea level variability in the tropical western Pacific based on empirical orthogonal function decomposition of the equatorial (10°S–10°N, 100°E–60°W) wind-stress anomaly. (a) PC1 (red) and PC2 (blue) respectively explain 26.3% and 14.9% of the equatorial wind-stress variance. Insert shows correlation between PC2 and Northwest Pacific minus Southwest Pacific sea surface heights (black) as a function of lag in months (sea level gradient lags PC2; r = 0.74 at lag 3 months). (b and c) Linear regressions of sea surface height (cm, shading) and wind stress (Kg m^{-1} s^{-2}, vectors) onto PC1 and PC2. Black boxes represent the Northwest Pacific (5°N–15°N, 130°E–180°W) and Southwest Pacific (15°S–2°N, 150°E–165°W). Triangles indicate tide gauge stations (U.S.-affiliated Pacific Islands green). Wind-stress and sea surface height observations (1979–2011) from respectively the ECMWF interim reanalysis and operational Ocean Reanalysis system 4.

discovered that these were periods when normal trade winds had returned in the North Pacific but remained weak south of the equator (compare Figure 2b-c).

Associated with these sea level and wind changes, is a northeastward shift of the South Pacific Convergence Zone, the largest rainband in the Southern Hemisphere (see *IPRC Climate*, vol. 12, no. 2). Such a shift in the rainband causes droughts south of Samoa and sometimes triggers more frequent tropical cyclones to the east. To describe this climate pattern, the scientists have coined the term El Niño *Taimasa*, a term that captures the damaging effects on shallow reefs around Samoa and nearby regions.

Widlansky collaborated with **Shayne McGregor**, a former IPRC postdoctoral fellow and now at the University of New South Wales, to study how the prolonged low sea level in the South Pacific is linked to the well-known southward shift of weak trade winds (see Figure 2c) that is collocated with the more zonal positioning of the SPCZ. They found this wind shift, associated with ENSO and the seasonal development of the SPCZ, causes the sea level seesaw between the North and South Pacific during the termination of very strong El Niños.

"This interaction—or combination—between ENSO and the annual cycle causes the prolonged sea level drops for Samoa and the abrupt recovery around Guam" explains **Malte Stuecker**, a meteorology doctoral student at the University of Hawai'i at Mānoa, who also participated in the study.

"As the SPCZ and wind response is greatest during the strongest El Niño events," McGregor notes, "we would not expect the extreme sea level drop during weaker El Niño events (including Modoki events) or La Niña."

The ENSO-dependent position of the SPCZ appears to explain the asymmetric sea level response during El Niño *Taimasa*. Timmermann, however, cautions, "A definitive association is limited by the small sample of zonal SPCZ events."

Waves crash on the fringing reef in Uafato, Upolu, Samoa. Image credit Axel Timmermann.

Given the well-established prediction of the seasonal evolution of climate and sea level once a strong El Niño is launched, the scientists think that the long duration of extreme sea level drops at the end of such an El Niño may be highly predictable. Such predictability could warn island communities several seasons in advance and give them the opportunity to adapt at least to some of the detrimental consequences of *taimasa* events.

Widlansky and Timmermann say further observational studies are planned, along with sophisticated hindcast experiments that are being conducted by IPRC Postdoctoral Fellow **Yoshimitsu Chikamoto**, to confirm predictability of future El Niño *Taimasa* impacts.

Though sea levels are likely to gradually rise with global warming, thereby perhaps offsetting somewhat the harm of extreme low sea level periods, recent modeling evidence presented by **Wenju Cai** (Commonwealth Scientific and Industrial Research Organisation, Australia) suggests that strong El Niño events are very likely to occur more often, and thus El Niño *Taimasa* events could also become more frequent.

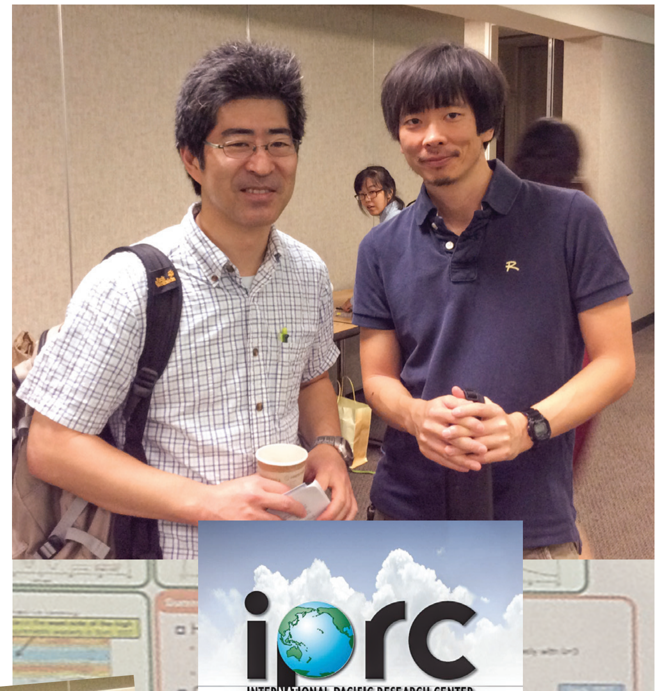
This story is based on

Widlansky, M.J., A. Timmermann, S. McGregor, M.F. Stuecker, and W. Cai, 2014: An interhemispheric tropical sea level seesaw due to El Niño Taimasa. *J. Climate*, **27** (3), 1070–1081, doi:10.1175/JCLI-D-13-00276.1. IPRC-1018

MEETINGS

IPRC Annual Symposium

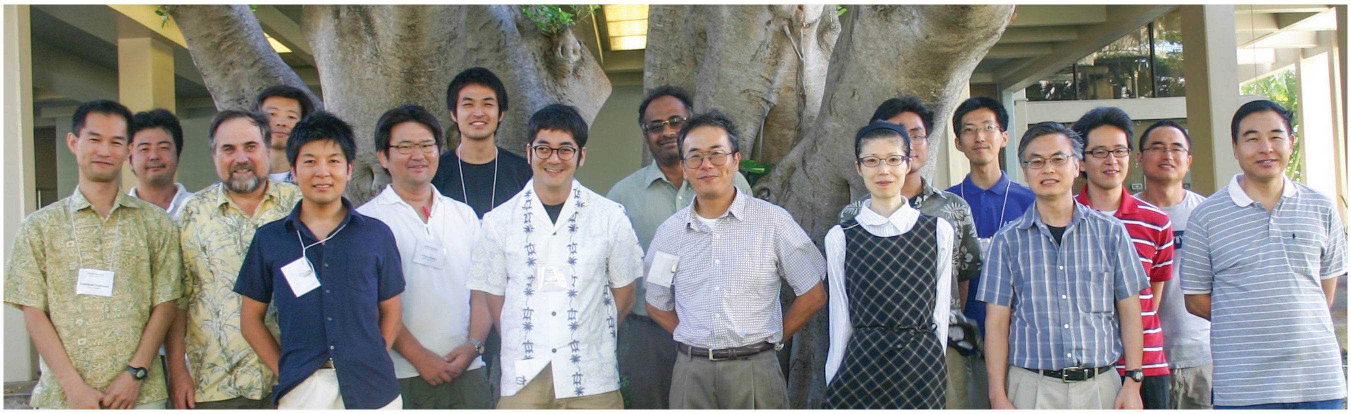
The IPRC held its *13th Annual Symposium* at the East-West Center on December 2, 2013. The "all poster" format of the last several years was adopted again, and IPRC's scientists responded with 29 excellent posters ranging over all the major areas of IPRC research. The staff of the Asia-Pacific Data-Research Center (APDRC) showed off their data products and offered brief tutorials on accessing data through the APDRC web portal. Very special this year was that a number of our JAMSTEC and University of Tokyo colleagues could join us by combining the occasion with their participation in the OFES Workshop (see page 21). The stimulating discussion at the Annual Symposium ended in the early evening with *pupus* and refreshments.



IPRC–JAMSTEC Workshop on High-Resolution Atmospheric Modeling

Over the last decade JAMSTEC has been leading the world in very fine-resolution simulation of the global atmospheric circulation, notably through the development of the Non-hydrostatic Icosahedral global Atmospheric Model (NICAM) in partnership with the University of Tokyo. IPRC's close ties with JAMSTEC have fostered valuable collaborative studies using the NICAM model simulations. From 2007–2014, analysis of NICAM results has been a science priority of the *JAMSTEC–IPRC Initiative* (JII), and it will continue to be a priority in the projects of the upcoming *JAMSTEC–IPRC Collaborative Studies* (JICS) to begin this spring.

In August 2013 IPRC organized and hosted a 2-day workshop to discuss the latest developments in the NICAM model and its applications. Ten Japanese scientists from JAMSTEC, the University of Tokyo and RIKEN presented as well as IPRC scientists **Yuqing Wang**, **Kazuyoshi Kikuchi** and **Xiouhua Fu**. Major themes covered included the challenges in simulating clouds and precipitation in global models, extended range predictability of tropical atmospheric variations, and the detailed modeling of tropical cyclones. The meeting organizers were University of Tokyo Professor **Masaki Satoh** and IPRC Director **Kevin Hamilton**. The full meeting agenda is available at tinyurl.com/IPRCnicam.



Tropical Weather and Climate Dynamics

The *Tropical Weather and Climate Dynamics Workshop* brought together over 80 scientists from Asia, the United States, and Europe in Honolulu from October 9 through 11, 2013. Held at the Pagoda Hotel, the workshop had five major topics: 1) intraseasonal to interdecadal variability, 2) typhoons and high-impact weather, 3) monsoon variability and predictability, 4) climate modeling, prediction and future projection, and 5) the role of ocean and air-sea interaction in climate. The workshop was organized by **Tim Li**, **Bin Wang**, and **Xiouhua Fu**.

Workshop Series on OFES and Computationally Intensive Climate Modeling Continues

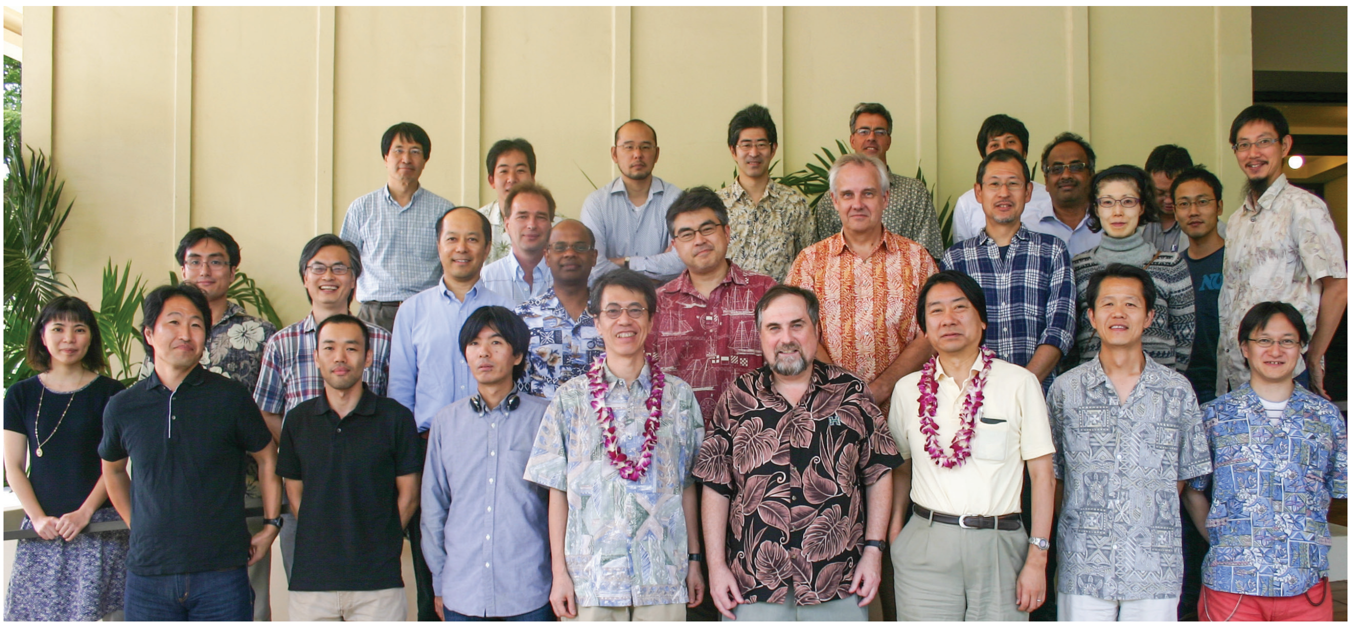
JAMSTEC is an acknowledged world leader in developing and applying very high-resolution models of the climate system. The models developed at JAMSTEC include the Ocean General Circulation Model for the Earth Simulator (OFES), the Atmospheric General Circulation Model for the Earth Simulator (AFES), the Coupled General Circulation Model for the Earth Simulator (CFES), and the Multi-Scale Simulator for the Geoenvironment (MSSG) – all projects led by scientists at the Earth Simulator Center (ESC). For over a decade, IPRC researchers have joined their Japanese colleagues in analysis of simulations from these very high-resolution global models run on the Earth Simulator. IPRC has even partnered with JAMSTEC on serving data from these high-resolution model simulations to the global community.

This close cooperation was recognized when JAMSTEC invited IPRC to cosponsor in August 2008 the first *OFES International Workshop* in Yokohama (see *IPRC Climate* vol. 8, no. 2). Since then, following the suggestion of ESC Director **Kunihiko Watanabe**, the OFES workshops have been held annually and hosted alternately by JAMSTEC facilities in Japan and by IPRC in Honolulu.

The most recent workshop, the *6th OFES International Workshop*, was hosted by IPRC at the East-West Center on December 3 – 4. The meeting featured presentations by 17 colleagues from JAMSTEC and the University of Tokyo, and 14 from the IPRC/UH at Mānoa. In his invited keynote address "Multi-Scale Impacts of the Western Boundary Currents and Associated Frontal Zones on the Atmosphere," University of Tokyo Professor **Hisashi Nakamura** discussed the achievements of the multiyear Japanese "hot spot" project that deals with the effects of the warmer Kuroshio extension on the colder overlying atmosphere.

The OFES workshop series was begun largely to publicize in the international community the achievements of the OFES model and the opportunities for collaborative research using the model and existing simulations. The development and application of OFES are now widely appreciated as one of the great successes of the Earth Simulator enterprise, with scientists in several countries analyzing the very fine-resolution OFES global simulations and yielding important research outcomes. Given these successes, the workshop participants decided to uphold the tradition of joint JAMSTEC–IPRC meetings next year and to broaden the scientific agenda related to climate modeling and diagnostics.

The conveners for the workshop were **Hideharu Sasaki** (JAMSTEC ESC), **Wataru Ohfuchi** (JAMSTEC ESC), **Yukio Masumoto** (University of Tokyo) and **Kevin Hamilton** (IPRC). The complete meeting agenda and presentation abstracts are available at tinyurl.com/IPRCofes6.



IPRC NEWS

UH and JAMSTEC Renew IPRC Scientific Partnership

With the negotiation and signing of a new three-year Cooperative Agreement between the University of Hawai'i at Mānoa (UHM) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the IPRC research partnership with JAMSTEC, which began in 1997, will continue at least through March 2017. JAMSTEC and UHM now envisage their IPRC collaboration within a broader partnership in the study of earth science. This broader framework is outlined in a new five-year (2014–2019) Memorandum of Understanding signed by JAMSTEC President **Asahiko Taira** and UHM Chancellor **Tom Apple**.

Commenting on the new agreements, IPRC Director **Kevin Hamilton** said, "We are very grateful to JAMSTEC for its continued commitment to support IPRC research activities and the unique opportunities our enduring partnership provides for extended and profound scientific collaborations with our JAMSTEC colleagues."

JAMSTEC President Asahiko Taira after signing the JAMSTEC-UHM Memorandum of Understanding in Tokyo on February 7.

New JAMSTEC–IPRC Collaborative Studies Framework

With the updating of the institutional arrangements between IPRC and JAMSTEC in the new Cooperative Agreement, the science goals embodied in the *JAMSTEC–IPRC Initiative* (established in 2007 and revised in 2010) are being replaced with a new series of goals within a framework called the *JAMSTEC–IPRC Collaborative Studies* (JICS). JICS consists of five projects each with JAMSTEC and IPRC leaders, who are listed below together with their projects. The JICS projects will initially be funded for three years by JAMSTEC.

The JICS does not encompass all joint JAMSTEC–IPRC activities, and many IPRC and JAMSTEC scientists are continuing their scientific research partnership in various areas. IPRC and JAMSTEC will also continue to collaborate on data management activities of general interest, notably as partners in operating the Pacific Argo Regional Center, which provides the global community with near real-time, quality-controlled gridded products derived from raw Argo profiling-float observations (tinyurl.com/IPRCparc).

JICS Projects and Leaders

Project 1. Tropical and extratropical climate modes and their variability. Tim Li (IPRC); Swadhin Behera (JAMSTEC)

Project 2. High-resolution atmospheric modeling, diagnosis and applications. Yuqing Wang (IPRC); Tomo Nasuno (JAMSTEC)

Project 3. Midlatitude ocean-atmosphere variability. Niklas Schneider (IPRC); Masami Nonaka (JAMSTEC).

Project 4. Past and future earth system responses to external forcing. Axel Timmermann (IPRC); Naomi Harada and Ayako Abe-Ouchi (JAMSTEC)

Project 5. Unravelling the coupled air-sea interaction processes in CFES. H. Annamalai (IPRC); Bunmei Taguchi (JAMSTEC)

IPRC Welcomes Al Gore

By **Kevin Hamilton**

The IPRC was privileged to host **The Honorable Albert Gore** on the afternoon of April 15. Al Gore has had a remarkably distinguished career in American public life spanning several decades. He has been a US Congressional Representative, a US Senator and was the 45^{th} Vice President of the United States. Gore is a best selling author and a winner of the Nobel Peace Prize, among many other awards. Through his activities in government, and now as a private citizen, Gore has become the world's most famous, and most important, advocate for mankind's concerns about global climate.

Gore was in Honolulu to deliver a public lecture on the evening of April 15 at the University of Hawai'i (UH). I had written to Gore as IPRC Director to invite him to visit us during his time in Honolulu, noting that almost two decades ago Vice President Gore's negotiations with Japan on scientific cooperation in climate research had played a critical role in establishing the IPRC at UH.

Gore graciously accepted the invitation to speak with our scientists. The meeting was deliberately low key and free of news media. Gore met for over an hour in the IPRC conference room with 22 of IPRC's faculty, staff and postdoctoral fellows. Present were also two UH Oceanography faculty members who played key roles in the creation of the IPRC: Professors Emeriti **Lorenz Magaard** and **Roger Lukas**. **Aska Vanroosebeke** of JAMSTEC's International Affairs Division was also present.

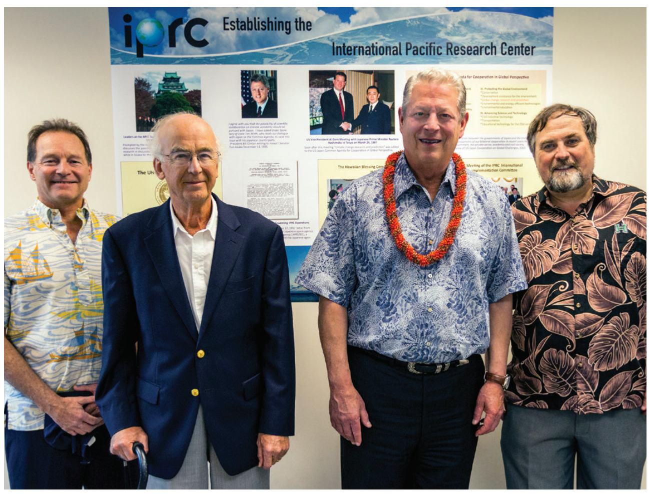
In his opening remarks Gore made clear that he regarded the diplomatic negotiations with Japan that led to the creation of the IPRC as a highlight of his government career, and he expressed his excitement in being able to now visit the mature IPRC. I presented a brief slideshow describing the history of IPRC and highlights of our research accomplishments and contributions to the climate science community. This was followed by a general discussion led off by questions from Gore.

Everyone at the meeting was impressed by Gore's disarming manner and keen interest in climate science. Gore concluded the meeting with a reminder that the work of climate scientists such as those here at IPRC has a great practical importance for dealing with the urgent global climate challenge now facing mankind.

Gore's public lecture in the evening was held in UH's basketball arena and attracted an audience of nearly 7000. Gore took time during his engaging and inspiring talk to express his pleasure in interacting with IPRC scientists earlier in the day. Everyone at IPRC is grateful to Al Gore for his gracious visit and kind words!

IPRC's **Sharon Decarlo**, **Jim Potemra**, **Gisela Speidel**, **Jeanie Ho** and **Aimee Nakajima** deserve special thanks for their help in preparing for the visit and in ensuring a smooth and productive event.

US Vice President Al Gore and Japanese Prime Minister Ryutaro Hashimoto meeting in Tokyo March 24, 1997. The Gore-Hashimoto accord was critical to establishing the IPRC as a Japan–US partnership. (AP news photo).



From left, Roger Lukas, Lorenz Magaard, Al Gore, Kevin Hamilton at the IPRC on April 15, 2014. Photo credit, Colin Macdonald.

JAMSTEC President Visits

IPRC was very pleased to host JAMSTEC President **Asahiko Taira** during his visit to the University of Hawai‘i (UH) where he took part in the 25th Anniversary celebration of the School of Ocean and Earth Sciences and Technology (SOEST) held in mid-April. Taira, a distinguished marine geologist and former professor at the University of Tokyo, joined JAMSTEC as Executive Director in 2002. In April 2012 Taira became the first research scientist ever to be appointed as JAMSTEC President.

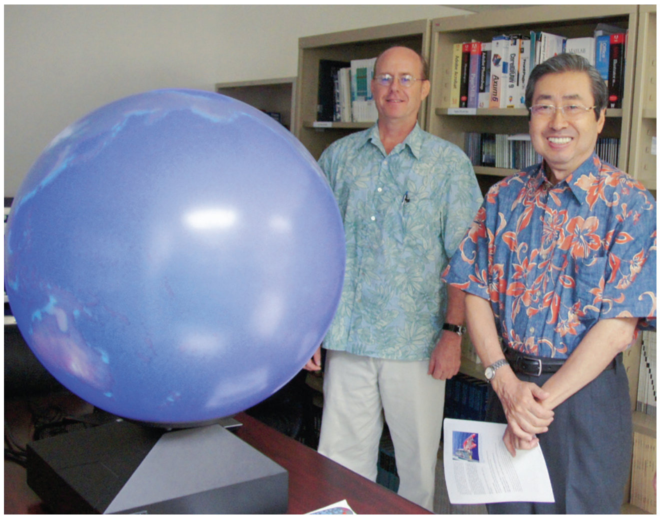
On April 16 UH Interim President **David Lassner** held a meeting to discuss JAMSTEC–UH relations with Taira, IPRC Director **Kevin Hamilton** and UH Geology Professor **Greg Moore**. Then on April 18, Taira spent the day in a very informal workshop with IPRC scientists in the IPRC conference room. In addition to 15 IPRC scientists, the participants included JAMSTEC senior scientist **Yoshio Kawatani**, who was visiting the IPRC.

The workshop with Taira featured talks by the following junior and senior IPRC scientists: Assistant Researcher **Kazuyoshi Kikuchi**, postdoctoral fellow **Kohei Takatama**, Senior Researcher **H. Annamalai**, Scientific Computer Programmer **Jan Hafner** and faculty members **Niklas Schneider**, **Axel Timmermann**, **Jim Potemra** and **Yuqing Wang**. In their presentations, the scientists described research results and plans that focused on collaborations with JAMSTEC colleagues.

In addition to these presentations, Hafner showed Taira a display of marine driftage collected on Hawai‘i beaches and brought to the IPRC, including some that have been identified as coming from the 2011 Japan tsunami. Taira also viewed some animations of global data sets shown on IPRC's "Magic Planet" spherical projection system, including a number of animations of global model results produced by IPRC postdoctoral fellow **Tobias Friedrich**.

Taira remarked on the successes of the IPRC–JAMSTEC partnership. He described a recent report that had shown that UH (mainly IPRC) was second only to the University of Tokyo in terms of the numbers of coauthored papers with JAMSTEC scientists. He noted that IPRC collaborations also accounted for a very large fraction of published papers concerning results obtained with JAMSTEC's "OFES" ocean simulation model.

In his closing remarks, Taira stated that he wanted to encourage the partnership with IPRC despite very severe budget cutbacks at JAMSTEC and that he looked forward to seeing the results of the next three years of joint research. Hamilton echoed these sentiments and expressed IPRC's gratitude for JAMSTEC's continued support and for Taira's participation in the workshop.



IPRC faculty member Jim Potemra (left) and JAMSTEC President Asahiko Taira with IPRC's Magic Planet.

From left, Aska Vanroosebeke (JAMSTEC International Affairs Division), Greg Moore, Asahiko Taira, David Lassner and Kevin Hamilton in front of a mural outside the UH President's office.

IPRC Director to Step Down

IPRC Director **Kevin Hamilton** has announced his intention to step down after more than six years leading the center. Hamilton arrived at the IPRC as a faculty member in 2000 and was appointed Interim Director in April 2008 and Director in April 2010.

Reflecting on the current state of the IPRC, Hamilton said, "In the 17 years since its founding, the IPRC has developed into a powerhouse for climate modeling and diagnostics and now enjoys a global reputation for research achievement. From the beginning IPRC's mission has been broader than just our own research projects, and the climate-science enterprise in the Asia-Pacific region has benefitted from IPRC's multifaceted activities. Through its Asia-Pacific Data-Research Center the IPRC provides valuable climate data services to the research community and the broader public.

"The IPRC has contributed significantly to the professional development of over 100 young scientists, mainly from Japan and other Asian nations, who have come as graduate students, postdoctoral fellows, researchers, other scientific employees or long-term visitors. These IPRC alumni are now populating the universities and research institutes of Asia, the US and elsewhere in the world.

"The IPRC has become the mid-Pacific hub for climate science by serving as the temporary home of a diverse group of scientists and by organizing and hosting numerous international meetings that have brought thousands of researchers to Hawai'i for scientific dialogue.

"The hard-working scientists and support staff at IPRC over the years deserve the credit for IPRC's success. It has been a common experience for me to hear visitors remark with admiration on how much IPRC has accomplished in various areas relative to the number of staff involved."

Regarding IPRC's unique relation with Japan, Hamilton said, "The Japanese connection has been central to IPRC's mission and operations since our inception. The very generous support from Japanese agencies, the extensive partnerships with JAMSTEC scientists, and the opportunity to host outstanding young Japanese scientists have allowed the IPRC to develop into a very special organization. On a personal note, I have enjoyed tremendously the opportunity to collaborate with my JAMSTEC colleagues, first as a researcher and then later also as an administrator, as well as the chance to spend a considerable period in Japan each year."

Looking towards the future, Hamilton said, "With the signing of a new cooperative agreement between UH and JAMSTEC (p. 22) and continued interest from the NOAA National Climatic Data Center in IPRC's data activities, a future path for IPRC is laid out. However, I anticipate in the next few years there will be unprecedented challenges in an ever more competitive environment for research support.

"Despite the challenges clearly on the horizon, I expect in the long term the IPRC will benefit from a continuing broad interest in high-quality climate research that helps inform societal response to global change and that the IPRC will thrive for many years to come."

Tending to IPRC's business in Japan. IPRC Director Kevin Hamilton in February 2012, photographed by a JAMSTEC colleague after a meeting in Tokyo.

Students from a Japan Super Science High School Visit IPRC Again

Super Science High School students visit Ryo Furue (first row, second from left). Jan Hafner (back row, first from left) talked about the tsunami driftage in the IPRC Ocean Drift Model.

Masuda High School, the alma mater of IPRC Researcher **Ryo Furue**, was again selected as a Super Science High School by Japan's Ministry of Education, Culture, Sports, Science and Technology (see *IPRC Climate* vol 12, no. 2). The school used the extra funding from the award again for travel: 9 students from Furue's high school and 3 from neighboring schools, accompanied by 3 teachers, visited the IPRC in January.

Furue had asked the students beforehand to prepare presentations on such global warming issues as "What are other explanations for the global warming trend than anthropogenic greenhouse gases? How likely are those explanations?" and "Suppose that global mean temperature continues to rise. What good and bad changes will happen? Would agricultural production, for example, increase?"

During lively discussions in the IPRC conference room, the students presented in Japanese their answers. Furue said, "I was impressed by their hands-on approach. For example, one student presented results of her science club project on cleaning river water. The students had taken water samples from the river near their school; into some samples they put charcoal to observe whether organic matter is absorbed, and into others they put dish detergent to see if it increases the amount of phytoplankton."

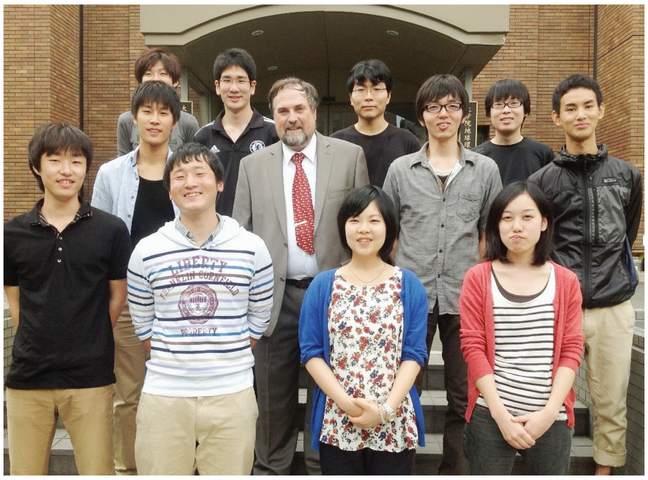
The students also listened attentively to IPRC Scientific Programmer **Jan Hafner** talk in English about the driftage from the 2011 tsunami. Hafner showed pictures and animations from the IPRC Ocean Drift Model (see p. 12), and students questioned him in English about the debris paths.

IPRC Issue of *Blue Earth* Magazine

Six times a year JAMSTEC publishes *Blue Earth*, a glossy magazine for the general public describing JAMSTEC activities in ocean and earth science. In the January 2014 edition, the JAMSTEC–IPRC partnership was the featured cover story, occupying almost the entire issue. Though the bulk of the article was written by professional writers on contract to JAMSTEC, the issue also includes the individual reflections on their IPRC experiences written by JAMSTEC scientists **Masami Nonaka** and **Yoshio Kawatani** as well as former IPRC faculty member **Shang-Ping Xie**, who is now the Roger Revelle Professor of Environmental Science at the Scripps Institution of Oceanography. IPRC Director **Kevin Hamilton** wrote an afterword on the future of the IPRC–JAMSTEC partnership. IPRC appreciates the invaluable assistance of University of Tokyo Professor **Yukio Masumoto** in the conception and execution of this project.

IPRC Partnership with Hokkaido University Continues

Since 2008 Hokkaido University has partnered with IPRC in an exchange program designed to enhance the educational experience for students in the Hokkaido University Graduate School of Environmental Science. Over the years several Hokkaido Ph.D. students have visited IPRC for extended periods. Several IPRC faculty have also contributed by presenting series of guest lectures for Hokkaido University graduate students (see list below).



Kevin Hamilton with Hokkaido University students.

In September 2013 IPRC Director **Kevin Hamilton** continued this tradition and gave several lectures to a group of 19 masters degree program students, introducing the study of the meteorology of the tropical stratosphere and mesosphere. He also presented a seminar for faculty and students of the school entitled "Martian Meteorology from Surface Observations Including from the 2012 Mars Curiosity Rover." This seminar was taped by the Center for Planetary Science (CPS), based at Kobe University in Japan; a video of the lecture is posted on the CPS website (tinyurl.com/IPRCmars).

IPRC Faculty Lecturers

2008 Shang-Ping Xie – Air-sea interaction and tropical climate
2008 Kelvin Richards – Tracers in the ocean and atmosphere
2009 Axel Timmermann – Dynamics of El Nino
2010 Jay McCreary – Large-scale coastal dynamics
2012 Yuqing Wang – Dynamical downscaling of global climate simulations
2013 Kevin Hamilton – Dynamics of the tropical middle atmosphere

IPRC Featured in Newsletter of Japanese Ocean Think Tank

The Ocean Policy Research Foundation (OPRF) published in its newsletter an essay by IPRC Director **Kevin Hamilton** describing IPRC's mission and activities. OPRF, a nongovernmental organization based in Tokyo, has a special consultative status with the Economic and Social Council of the United Nations. The Foundation functions as a think tank for Japan on ocean matters, and its white papers and newsletter are a source of important information for legislators, government officials, and other ocean policy decision makers. Advocating that mankind live harmoniously and sustainably with the ocean, OPRF encourages international collaboration and exchange of views on ocean affairs.

Hamilton's essay focuses on IPRC's strong connections with Japan. He writes that IPRC has "become a crossroads of the Pacific in climate science, contributing significantly to the education and professional development of many young climate scientists, especially from Japan." Reflecting on IPRC's long-term partnership with JAMSTEC, Hamilton writes, "The expertise of IPRC collaborators in diagnostic analysis of the climate system has helped JAMSTEC fully capitalize on its major investments in areas such as high-resolution global computer modeling, ocean sediment coring, oceanographic cruises and participation in international field campaigns."

Hamilton's article was translated into Japanese by the newsletter's Chief Editor, former Dean of Science at the University of Tokyo and current Director of the JAMSTEC Application Laboratory, **Toshio Yamagata**. The article is available in English at www.sof.or.jp/en/news/301-350/317_2.php and in Japanese at www.sof.or.jp/jp/news/301-350/317_1.php .

Toshio Yamagata with Kevin Hamilton.

IPRC in ARTE TV Documentary

In August a film crew from ARTE TV visited the IPRC, seeking help in the production of an episode in their documentary series *Point du Jour: Entre Terre et Ciel*. Series host **Serge Brunier** interviewed IPRC Director **Kevin Hamilton** about predictions of future climate trends. ARTE TV is a publically-funded European educational and cultural television network for French and German speakers.

Kevin Hamilton (left) with program host Serge Brunier.

Tsunami Debris Documentary in the Making

Jennifer Rainsford, an independent filmmaker and artist supported by the Swedish government through a fund for culture and arts, visited the IPRC in November 2103 to interview **Nikolai Maximenko** and **Jan Hafner** about their work on the driftage from the 2011 tsunami in Japan. She is planning a full-length documentary, called "Stories from the Debris" for cinema and TV to be released in 2015. Rainsford was particularly intrigued by the animations of the IPRC Ocean Drift Model featuring the paths taken by tsunami driftage of different shape and boyancy. The work is taking her and her associate to the US West Coast, Hawai‘i and Japan to film and collect stories about the debris.

Nikolai Maximenko during tsunami documentary interview with Jennifer Rainsford.

IPRC Scientists Share Discoveries at AGU Ocean Sciences 2014

The IPRC left its mark at the *Ocean Sciences Meeting 2014* held in Honolulu end of February. Our scientists spoke on topics that ranged from climate predictability (**Yoshimitsu Chikamoto**), to impacts of the continental slope on the deep overturning circulation (**Ryo Furue**), to the seesaw in sea level occurring across the equator in the western Pacific during what has been coined *El Niño Taimasa*, after the wet stench from dying marine life at very low tides in Samoa (**Matthew Widlansky**).

Other presentations featured results from the new Aquarius sea surface salinity products (**Oleg Melnichenko; Peter Hacker**; **Tangdong Qu**). The 3-year story tracking the various kinds of tsunami debris as it flowed from Japan across the Pacific and circulates back towards Hawai‘i using the IPRC Ocean Drift Model was told by **Jan Hafner**. The special two-day session, *Mesoscale ocean processes and their representation in earth system models*, which IPRC's **Nikolai Maximenko** helped to organize, featured 32 talks and 46 posters and attracted at times a standing-room only audience.

RCUH Employees of the Year

At an awards luncheon in February, IPRC's Senior Researcher **Nikolai Maximenko**, Scientific Programmer **Jan Hafner** and Outreach Specialist **Gisela Speidel** were honored as "RCUH 2013 Outstanding Employees of the Year." The award recognized their achievements as a team dealing with the scientific and public outreach aspects of tracking the floating debris following the March 2011 Japan tsunami; their work has produced exciting research results and played an important public service role in providing officials and the public with a realistic assessment of the concerns about the debris issue.

With more than 3000 employees, the Research Corporation of the University of Hawai'i (RCUH) handles over $400,000,000 per year of external funding for the University and other Hawai'i state departments. Over 20 IPRC scientists and support staff are employed through RCUH.

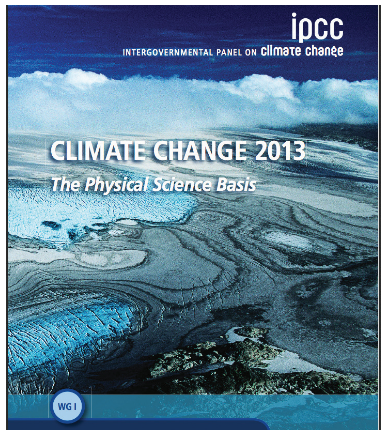
From Left, RCUH Executive Director Michael Hamnett, Nikoklai Maximenko, Gisela Speidel, Jan Hafner, and Kevin Hamilton.

Hawai'i Media Briefing on IPCC Climate Assessment Report

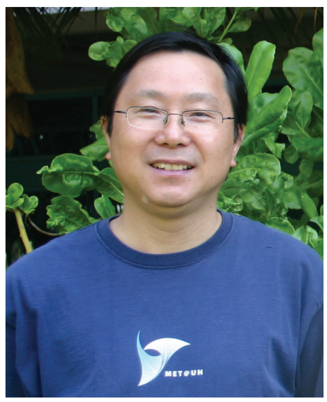
"Human influence on climate is clear." This electrifying statement was released end of September in the "Summary for Policymakers" of the *Scientific Basis of Climate Change* in the Fifth Climate Assessment Report of the Intergovernmental Panel on Climate Change.

Following on the heels of this announcement, two IPCC lead authors at the University of Hawai'i, IPRC's **Axel Timmermann** (Paleoclimate Chapter), and UH Sea Level Center Director, **Mark Merrifield** (Sea Level Chapter), summarized the report's findings to a packed audience of colleagues and students at C-MORE Hale. **David Karl**, Director of the Center for Microbial Oceanography Research and Education (C-MORE) and a lead author of the IPCC companion report "Impacts, Adaptation and Vulnerability", hosted and moderated the special event.

Reporters and cameramen from two television stations and the local newspaper extensively interviewed Timmermann, Merrifield and Karl after the briefing. "UH Mānoa professors say climate change is real & here in Hawai'i," and "`Rise in sea level puts Waikiki, Kakaako at Risk,' researchers say," read the headlines.



Tim Li Appointed Associate Editor

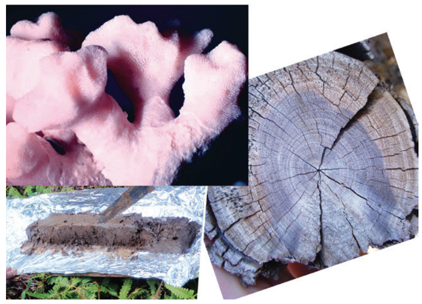


IPRC's **Tim Li** was appointed an associate editor of the Elsevier journal *Dynamics of Atmospheres and Oceans*, an international journal for research related to the dynamical and physical processes governing atmospheres, oceans and climate. The journal publishes papers of theoretical, computational, experimental and observational investigations, particularly those that explore the fundamental nature of dynamical and physical processes at all scales and explore air-sea interactions and the coupling between atmospheres, oceans, and other components of the climate system.

IPRC Research in the News

El Niño is becoming more active

A new approach to analyzing paleoclimate reconstructions of the El Niño – Southern Oscillation (ENSO) resolves disagreements among scientists and reveals that ENSO activity during the 20th century has been unusually high compared to the past 600 years. The study, published in the October 2013 issue of *Climate of the Past*, was authored by **Shayne McGregor** of University of New South Wales, IPRC's **Axel Timmermann**, and scientists at the NOAA Geophysical Fluid Dynamics Laboratory. It was featured in *Nature World News, Colorado News, Honolulu Star-Advertiser*, and on *KITV4 News*.



Increase in greenhouse gases and aerosols has similar effects on rainfall

Although greenhouse gases and aerosols have very distinct properties, their effects on spatial patterns of changes in rainfall with global warming are surprisingly similar, according to new research by IPRC's **Shang-Ping Xie**, currently Roger Revelle Chair in Environmental Science at Scripps Institution of Oceanography, and his colleagues. The study, published in the September 1, 2013, online issue of *Nature Geoscience*, was featured in the *French Tribune.com*, and in the *Honolulu Star-Advertiser*.

Global warming dries up monsoon over India

The *Indian Express*, the Indian English-language daily newspaper read widely across India, published a 400-word story on the changing monsoon rainfall over India, detailing the findings of a study by IPRC's **H. Annamalai**, who is quoted as follows: "Various observations have shown that the Indian monsoon has weakened by around 5-6 per cent over the past few decades. Also, there has been an increase in the instances of rainfall over the west Pacific ocean. In fact, India has not observed any strong rainfall activity… since the monsoon of 1994." The study, "Global warming shifts monsoon circulation, drying South Asia," appeared in the May 2013 issue of *Journal of Climate*.

IPRC Featured in JAMSTEC 2013 Highlight Video

JAMSTEC has created a Youtube video showing five highlights of JAMSTEC research for the year 2013. IPRC is mentioned as JAMSTEC's partner, and one of the highlights featured is a paper by JAMSTEC scientist, **Yoshio Kawatani** and IPRC's Director **Kevin Hamilton** in *Nature*, "Weakened stratospheric quasibiennial oscillation driven by increased tropical mean upwelling." Watch video in English: tinyurl.com/IPRCvideoE; in Japanese:tinyurl.com/IPRCvideoJ.


nature

THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

LETTER

doi:10.1038/nature12140

Weakened stratospheric quasibiennial oscillation driven by increased tropical mean upwelling

Yoshio Kawatani[1] & Kevin Hamilton[2]

The zonal wind in the tropical stratosphere switches between prevailing easterlies and westerlies with a period of about 28 months[1]. In the lowermost stratosphere, the vertical structure of this quasibiennial oscillation (QBO) is linked to the mean upwelling[2–4], which itself is a key factor in determining stratospheric composition. Evidence for changes in the QBO have until now been equivocal, raising questions as to the extent of stratospheric circulation changes in a global warming context. Here we report an analysis of

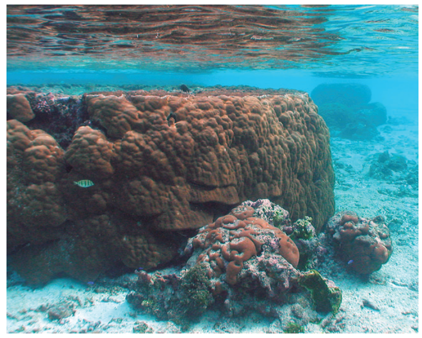
such factors as solar activity or the El Niño/Southern Oscillation (ENSO)[16–21]. There does not seem to be a clear long-term trend in the period of the QBO, and we still lack a detailed explanation of the cycle-to-cycle variability of the QBO period apparent in the observations.

Whereas the variability of the period has been studied extensively, there are apparently no earlier studies on the question of systematic long-term QBO amplitude changes, possibly because a simple inspection of the raw time-series data (Supplementary Fig. 2) indicates that

Nikolai Maximenko talks about tracking debris from 2011 tsunami

On the 3-year anniversary of the tragic tsunami in Japan, **Nikolai Maximenko** was interviewed by a KITV4 reporter about his work on tracking the tsunami driftage in his model and in observations. He described the different types of debris arriving in Hawai‘i during the three years: very boyant objects about 18 months after the tragedy, then refrigerator parts and little boats, and recently pieces sitting deeper in the water such as large beams and poles. Many pieces, especially plastic ones will break apart with time into smaller and smaller pieces recirculating in the ocean and becoming ingested by birds and marine animals.

What is El Niño Taimasa?

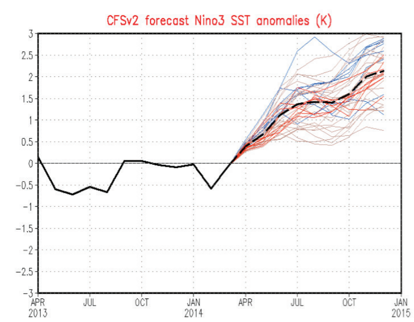


During very strong El Niño events, sea level drops abruptly in the tropical western Pacific and tides remain below normal for up to a year in the South Pacific, especially around Samoa. The Samoans call the wet stench of coral die-offs arising from the low sea levels *taimasa* (pronounced [kai’ ma’sa]). The international study to uncover the reasons for this phenomenon and its climate effects was spearheaded by IPRC’s **Matthew Widlansky** and published in the February 2014 issue of the *Journal of Climate*. It was featured in the Italian online *Meteogiuliacci* and in *Science Daily*.

Climate research at the International Pacific Research Center

IPRC’s Director **Kevin Hamilton** and Meteorology Professor **Yuqing Wang** were featured on **Jay Fidell’s** *ThinkTech Hawaii* internet tv show on February 17. They described the climate research conducted at the IPRC and the close partnership with the Japan Agency for Marine-Earth Science and Technology. Of particular interest on the show was IPRC’s Hawai‘i Regional Climate Model that Wang is developing for climate forecasts for Hawai‘i, with its complex topography and associated microclimates. See: tinyurl.com/IPRCthink.

The tropical Pacific is primed for El Niño



“I would say there is an 80 percent chance that a big El Niño will develop by the end of the year. Just how powerful the phenomenon will be is the subject of intense debate within scientific circles,” IPRC’s **Axel Timmermann** was quoted as saying on April 11 on the front page of the *Honolulu Star-Advertiser* with regard to the recent predictions from NOAA about the possibility of an El Niño building up this summer through winter. In Timmermann’s s opinion the El Niño will rival the one in 1997/98, the largest on record.

IPRC Takes Part in SOEST Open House

Every two years since 1991, the School of Ocean and Earth Science and Technology (SOEST) at the University of Hawaiʻi has held Open House for the local elementary, middle and high schools as well as for the broader community. The 2013 Open House, on October 25 and 26, corresponded with SOEST's 25th Anniversary. This year's event set a record with an attendance estimated at 7,600. As in previous years, IPRC participated in the activities, entertaining and informing many school groups with a series of lecture-demonstrations.

IPRC's **Jim Potemra** showed how storms far away from Hawaiʻi create the powerful surfing waves for which Hawaiʻi is known.

Postdoctoral fellows **Malte Heinemann** (left in picture above) and Tobias Friedrich donned white lab coats to demonstrate how atmospheric CO_2 can dissolve coral.

Jan Hafner told about marine debris and the driftage from the 2011 Japan tsunami that has travelled across the Pacific toward the US and Canada and circulated back, reaching Hawaiʻi windward shores. The audience was awed seeing an actual oyster buoy and a refrigerator door that had come all the way to Hawaiʻi from the tsunami.

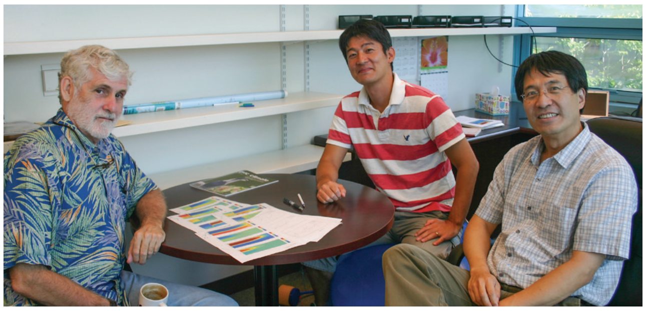
Using a water-filled rotating tank, **Niklas Schneider** gave lively demonstrations of atmospheric weather and oceanic processes, including the converging surface currents that produce the Great Pacific Garbage Patch.

IPRC's **Ryo Furue**, **Megumi Chikamoto**, **Yoshimitsu Chikamoto**, **Matthew Widlandsky**, **François Ascani**, **Kin-Lik Wang** and **Chunxi Zhang** made up the logistic team ensuring that everything ran smoothly. Outreach Specialist **Gisela Speidel** led the IPRC effort.

Flow between Marginal Seas and Open Ocean

Former IPRC Postdoctoral Fellow **Shin Kida**, now research scientist at JAMSTEC, visited the IPRC in August 2013 to discuss the dynamics of marginal sea–open ocean exchange flows with **Bo Qiu** (Oceanography Department, University of Hawai'i Mānoa) and IPRC's **Jay McCreary** and **Ryo Furue**. Although the theory known as "Island Rule" has greatly furthered knowledge of water mass exchange, it assumes that the straits are wide and deep. Since the marginal seas of the western Pacific are separated from the open ocean mostly by narrow or shallow straits, the Island Rule has limited applicability for these seas.

Kida and his colleagues are developing a theory that is more appropriate for estimating the transport of the water mass exchange of the marginal seas in the Western Pacific. Working with Qiu, Kida found that the exchange flow between the Okhotsk Sea and North Pacific is driven mainly by the East Kamchatka Current, a study published in 2013. The magnitude of the water exchange can be estimated by using Kelvin's Circulation Theorem for the region around the Kuril Island Chain. Currently Kida is focusing on the Japan Sea and water exchange with the open ocean.



Shin Kida (center) with Jay McCreary and Bo Qiu.

Paleoclimate Group Advances Ice-Sheet Modeling

Following the Ice-sheet Workshop organized by IPRC's Paleoclimate Group from September 10th to 14th, 2013, in Puna on Hawai'i Island, **David Pollard** (Pennsylvania State University) and **Fuyuki Saito** (JAMSTEC) visited the IPRC to work further with **Axel Timmermann** and **Malte Heinemann** on disentangling details of ice-sheet modeling. The workshop had dealt mostly with recording peak ice-sheet-model-densities and forging plans for more research. Aside from the scientist pictured here, **Ayako Abe-Ouchi** from the University of Tokyo and **Michelle Tigchelaar** from the University of Hawai'i participated in the Puna workshop; **Oliver Elison Timm** joined the workshop by skype from the State University of New York at Albany.

From left, Malte Heinemann, Axel Timmermann, David Pollard and Fuyuki Saito posing for the IPRC Climate.

Cyber Infrastructure and Environmental Modeling

Dilawar Grewal, special advisor and information computing technology consultant at the University of the South Pacific visited IPRC on January 23 to discuss possible collaborations with UH in cyber infrastructure and environmental modeling. He met with **Gwen Jacobs**, UH's Director of Cyber Infrastructure, IPRC's Computer System Manager **Ron Merrill** and IPRC Director **Kevin Hamilton**.

From left, Kevin Hamilton, Gwen Jacobs, Ron Merrill, and Dilawar Grewal.

Lake Suigetsu Tells about past Climate Change in East Asia

Kana Nagashima, a paleoclimate scientist with the Environmental Biogeochemical Cycle Research Program, Research Institute for Global Change at JAMSTEC, visited the IPRC from January 15 to March 14. She is a specialist in reconstructing past Asian monsoon and westerly jet variations based on marine and lake sediment cores.

Interested in past rapid climate change, Nagashima is exploring the changes in the wind system over East Asia and in the annual precipitation as recorded in a sediment core (SG06) recovered from Lake Suigetsu in Japan. The core, which even reflects seasonal variations and goes back at least 70 thousand years, shows several changes in precipitation during the 10–20 thousand years before the present. These changes diverge from trends seen in proxy-precipitation records from China.

Trying to solve this mystery, Nagashima is working with **Axel Timmermann's** paleoclimate group to see whether the paleoclimate models have clues about the nature and mechanisms that could have caused these precipitation changes and their regional differences.

Axel Timmermann with Kana Nagashima.

JAMSTEC CFES Model Used for Indian Ocean Climate Study

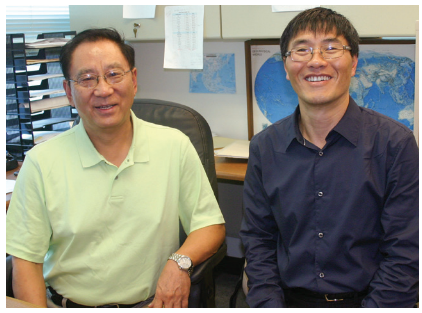
Motoki Nagura, scientist with the JAMSTEC Tropical Climate Variability Research Program, specializes in Indo-Pacific Ocean climate variations. He visited the IPRC in November – December 2013 to study with IPRC's Senior Scientist **H. Annamalai** the Indian Ocean monsoon climate systems in coupled models. In most of the cutting-edge CMIP3 and 5 models rainfall is weaker than observed over southern Asia and the eastern equatorial Indian Ocean, but stronger over the western equatorial Indian Ocean.

The coupled general circulation model (GCM) for the Earth Simulator (CFES), however, simulates the Indian Ocean monsoon climate systems well, they have found and are partnering with other scientists at JAMSTEC to investigate whether a realistic simulation of the equatorial Indian Ocean sea surface temperature (SST) and rainfall in CFES improves the subsequent simulation of the monsoon. They have conducted a series of coupled model sensitivity experiments, whose model solutions Nagura examined during his visit.

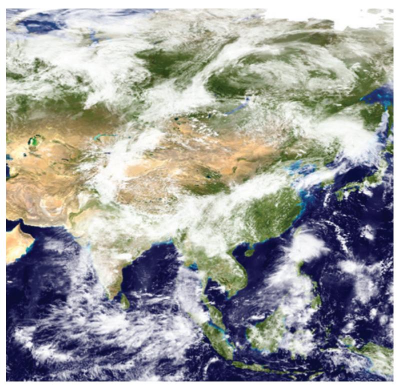
Motoki Nagura (left) with H. Annamalai.

Partnership in Operational Climate Model Development

Shaoqing Zhang, a research scientist at GFDL Princeton, visited IPRC October 14-21 2013. During his week-long stay, he gave an IPRC seminar and 4 lectures to IPRC postdoctoral fellows: two lectures on data assimilation fundamentals and the other two on advanced topics in climate estimation and prediction. He was invited by IPRC's faculty **Bin Wang** who has led a modeling team to develop an operational climate prediction model for the APEC Climate Center in Busan. Zhang's visit established a close partnership with Wang's team working on coupled climate model initialization and data assimilation with ensemble Karman filter technique. His visit was supported by GFDL director's special funds.



Bin Wang (left) with Shaoqing Zhang.



Scholars on Sabbatical at the IPRC

The IPRC is fortunate to have several distinguished scholars visiting for their sabbatical during the spring semester.

Emanuele Di Lorenzo, professor of ocean and climate dynamics, School of Earth and Atmospheric Sciences, Georgia Institute of Technology, specializes in regional and coastal oceanography, climate and ecosystem dynamics, and coupled ocean and atmosphere variability. Di Lorenzo has also established a new international study group on social-ecological-environmental systems in the coastal ocean, an initiative he is conducting under the North Pacific Marine Science Organization (PICES) to foster trans-disciplinary work between climate, marine ecosystem and social scientists.

During his sabbatical at the IPRC, Di Lorenzo is continuing his work with **Niklas Schneider** on studying the factors that underlie the decal variability of the North Pacific circulation and the impact of this variability on climate. They are using at present the high-resolution Regional Ocean Modeling System (ROMS) to determine how ocean eddies could mediate the decadal variations in the climate system. As part of the new JAMSTEC–IPRC Collaborative Studies initiative, they will also study these decadal climate variations in a new integration of the Ocean Model for the Earth Simulator (OFES).

From left, Axel Timmermann, Kim Cobb, Emanuele Di Lorenzo, and Niklas Schneider.

Kim Cobb, who joins her husband at the IPRC, is associate professor in the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. She specializes in tropical Pacific climate variability and change, stable isotope geochemistry, water isotopes and global hydrology, as well as paleoclimate modeling. During her sabbatical, Cobb is working with **Axel Timmermann** and his paleoclimate group on comparing her long coral records of past tropical Pacific climate with the group's modeling simulations of the same period. Kobb and Timmerann also share an interest in using paleoclimate data to improve the understanding of past El Niño – Southern Oscillation activity.

Per Knudsen, Professor and Head of the Geodesy Unit at the National Space Institute of the Technical University of Denmark in Lyngby, Denmark, specializes in the use of satellite altimetry for modeling ocean general circulation. He has contributed to using satellite altimetry to derive mean sea surface, marine gravity field, ocean tides and sea level rise. As part of the global monitoring of the geodetic reference systems, his unit operates the permanent GPS station and tide gauges in Greenland, which are used to detect changes in, for example, sea level and ice caps, and crustal deformations. The launch of the geodetic gravity field satellite missions – the latest being the European Gravity field and steady-state Ocean Circulation Explorer (GOCE) – has reestablished the use of geodetic techniques in estimating the ocean general circulation.

During his sabbatical at the IPRC, Knudsen is working with **Nikolai Maximenko** on modeling the mean dynamic ocean topography and ocean currents using drifter data and on integrating drifter velocities with geodetic estimates based on satellite altimetry and GOCE geoid models.

Per Knudsen (left) with Nikolai Maximenko.

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