

## IPRC Plays Key Role in Climate Science Center

On October 7, Secretary of the Interior **Ken Salazar** announced the establishment of the Pacific Islands Climate Science Center, a consortium of the University of Hawai'i at Mānoa and Hilo, and the University of Guam. "The nationwide network of Climate Science Centers will provide the scientific talent and commitment necessary for understanding how climate change and other landscape stressors will change the face of the United States, and how the Department of the Interior, as our nation's chief steward of natural and cultural resources, can prepare and respond," said Salazar.

The Pacific Islands Climate Center will be led at UH Mānoa by IPRC

Director **Kevin Hamilton**; at UH Hilo by **Donald Price**, Director of the Tropical Conservation Biology and Environmental Science (TCBES) graduate program; and at the University of Guam by **Frank Camacho**, Executive Director of the Center for Island Sustainability. Key contributions to the development of the successful proposal were provided by **Charles "Chip" Fletcher**, Associate Dean of UH Mānoa's School of Ocean and Earth Science and Tech-



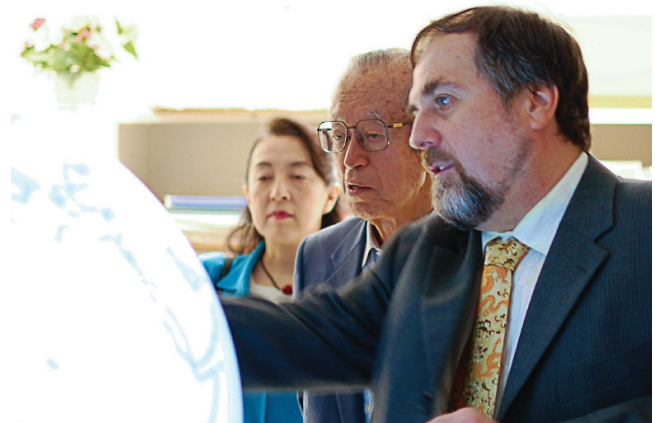
nology (SOEST), UH Mānoa Professor of Geography **Thomas Giambelluca**, and **Samuel Walker**, Institutional Researcher for Renewable/Alternative Energy Management at the University of Guam.

"The University of Hawai'i is conducting groundbreaking research in the area of climate change, and we're excited to be recognized for our expertise in this area with the establishment of this climate science center," said UH President **M.R.C. Greenwood**. "Together with the University of Guam and other government and institutional partners, we will continue our efforts to understand the nature of climate systems and improve the predictability of climate change and variations, particularly as it affects the Asia Pacific region."

## Koji Omi Visits IPRC

**Koji Omi**, founder and chairman of the *Science and Technology in Society (STS) Forum*, visited the IPRC on September 2. Until his recent retirement from politics, Omi was a prominent figure in the Japanese government, elected to the House of Representatives for a total of 26 years. He served in the cabinet in several portfolios including Minister of State for Science and Technology Policy and Minister of Finance. Omi founded the *STS Forum* with the aim of building a worldwide network among scientists, policymakers, and business people. The *Forum* considers the implications of the "lights and shadows" of science for humankind, and seeks ways to ensure further progress of science and technology while keeping inherent risks under proper control. Climate science and its role in public policy is an important component of the *Forum's* deliberations. During his visit, Omi invited IPRC participation in the *Forum's* annual meeting in Kyoto.

Koji Omi was accompanied by **Asako Omi**, Executive Secretary to the *STS* Chairman, and by **Yuko Miyabe**, Vice Consul at the Consulate General of Japan in Honolulu.



Asako Omi, Koji Omi, and Kevin Hamilton studying display on IPRC's Magic Planet.

## IPRC and the 2011 APEC Leaders' Meeting

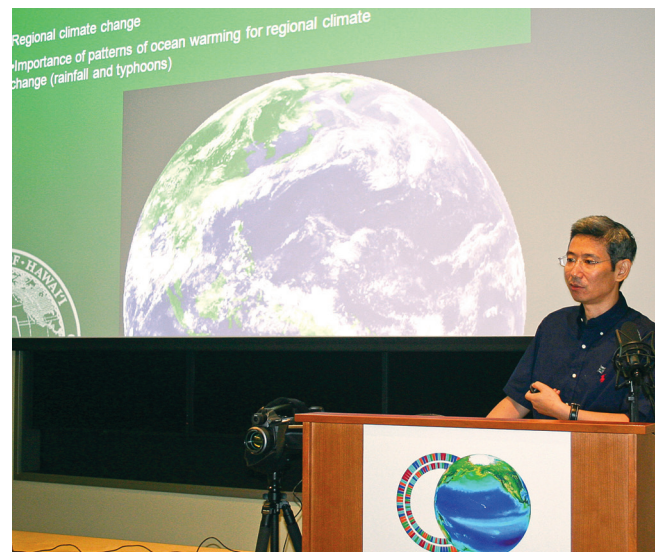
Hawai'i was on the world stage when Honolulu hosted the annual Leaders' Meeting of the Asia Pacific Economic Cooperation (APEC) November 12–13. This was the finale and the centerpiece of a series of major APEC-related events in Hawai'i, attracting President Obama and many national leaders and top-level officials from the Pacific region and over two thousand reporters.

The University of Hawai'i was asked by the Hawai'i Host Committee to play a key role in making the APEC events productive and memorable for the participants. One of the goals of the Host Committee was highlighting Hawai'i's scientific accomplishments related to "Sea and Sky." IPRC, with its expertise in environmental science and its international focus on the Pacific region, played a major role in this. IPRC hosted the annual symposium of the APEC Climate Center (see page 24), one of the biggest APEC thematic meetings preceding the Leaders' Meeting.

The IPRC was also chosen to be highlighted in "familiarization tours" organized for Chinese media by the Host Committee. In July, eight Beijing-based journalists from such news organizations as the *China Daily*, the *Economic Daily*, the *People's Daily* and the *Economic Observer* visited Honolulu. As part of their visit, a tour of the University of Hawai'i's research vessel *Kilo Moana* was arranged along with a briefing for the reporters in the ship's conference room. IPRC Director **Kevin Hamilton**, who introduced the IPRC and described some recent noteworthy studies, was one of the two scientists presenting.

Two further tours were arranged: One on September 14 for ten Shanghai journalists from the *Shanghai Morning Post*, *Jiefang Daily*, *Wenhui Daily*, and the *Shanghai Daily*; and on September 21 for Guangzhou journalists from the *Southern Daily/Nanfang Daily*, *Guangzhou Daily*, *Yangcheng Evening News*, and *Guangzhou TV*. Each group visited C-MORE Hale on the UH Mānoa Campus, where the journalists heard presentations about UH research relating to China. Among the scientists presenting was IPRC's **Shang-Ping Xie**, who spoke in Chinese about IPRC's research on climate change in East Asia and on developing a better understanding of how global warming will affect rainfall and severe weather.

The Host Committee also created videos about Hawai'i that were shown on hotel TV channels during the meeting (see [www.apec2011hawaii.com/stay-connected/videos](http://www.apec2011hawaii.com/stay-connected/videos)). The video



IPRC's Professor Shang-Ping Xie at familiarization session for Guangzhou journalists.

"From Deep Space to Deep Ocean" describes IPRC's role as a Japan – US collaboration and features animations showing several recent IPRC research results. Finally IPRC was featured in a special booklet, *Inspiration to Innovation*, prepared for the APEC meeting that highlighted accomplishments of UH Mānoa scientists.

## IPRC Director Visits JAMSTEC and MEXT Officials

IPRC Director **Kevin Hamilton** visited the Headquarters of the Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT) on October 11 to review IPRC's achievements and its close ties with Japanese climate science. He met individually with **Kanji Fujiki**, Director-General of the MEXT Research and Development Bureau; **Toshihide Fukui**, Director for Environmental Science and Technology; and **Yuichi Inoue**, Director of the Ocean and Earth Division. On October 12 the JAMSTEC Tokyo Office hosted a meeting between Hamilton and Executive Directors **Yoshihisa Shirayama** and **Hitoshi Hotta**, together with **Katsufumi Akazawa**, Manager of International Affairs Division; **Yukio Masumoto**, RIGC Program Director; **Tsuneyoshi Yamanishi**, Director of the Advanced Research and Technology Promotion Department (ARTPD); **Toru Kimoto**, International Affairs coordinator for the ARTPD; and **Tetsuro Isono** and **Chihiro Baba** of the International Affairs Division. The participants discussed the current status of operations at IPRC and possible long-term plans for IPRC and JAMSTEC.

## Recent IPRC Postdoc Receives Major Award

**Takeaki Sampe**, former IPRC postdoctoral fellow and now assistant professor at the University of Aizu, received the 2011 Yamamoto-Syono Award for Outstanding Papers at the annual fall meeting of the Meteorological Society of Japan (MSJ) in Nagoya. Each year the MSJ gives this award to a scientist under the age of 35 for outstanding papers in meteorology. Sampe received the award for his paper on the Meiyu-baiu formation (Sampe and Xie 2010, *Journal of Climate*), titled “Large-scale dynamics of the Meiyu-baiu rainband: Environmental forcing by the westerly jet.” The work, which was done while Sampe was at the IPRC, addresses the mechanisms forming the Meiyu-baiu rainband, which lingers over East Asia in early summer. The paper pointed out that conventional analyses could not separate cause and effect of the rainband. By focusing on the mid-tropospheric circulation the authors disentangled the causality, showing the role of advection of warm air and transient eddies along the jet stream in the rainband’s formation.



Takeaki Sampe with photo of award.

## Intergovernmental Oceanographic Commission Official Visits

**Wenxi Zhu**, head of the UNESCO Intergovernmental Oceanographic Commission Regional Secretariat for WEST-PAC, visited the IPRC in September as part of his three-week trip across the US under the auspices of the US Department

of State “International Visitor Leadership Program.” Zhu was involved in coordinating marine policy, ocean research and capacity building in the Western Pacific. Zhu was interested in learning about IPRC’s research related to the climate of the Western Pacific and about the excellent community resource provided by IPRC’s Asia-Pacific Data-Research Center. IPRC Senior Researcher **Nikolai Maximenko** also gave a briefing on his efforts to study surface ocean currents and the transport of floating marine debris. Zhu was accompanied on his visit by State Department official **Linda Harris**.



From left: IPRC Director Kevin Hamilton, Linda Harris and Wenxi Zhu.

## Russian Ship Encounters Tsunami Debris

Ever since the March 11 Japan tsunami washed millions of tons of debris into the Pacific Ocean, IPRC’s Senior Researcher **Nikolai Maximenko** and Scientific Programmer **Jan Hafner** have been trying to track the trajectory of this debris, which is a threat to marine life, small ships and coastlines. For nearly half a year they had only their state-of-the-art — but still untested — computer models of ocean currents to speculate where the debris might be traveling.

Then on September 11 a surprising event came to their aid when the Russian ship *Pallada* docked in Honolulu Harbor. *Pallada* is a “tall ship,” i.e., a traditionally rigged three-masted sailing vessel used for training Russian cadet seamen. The 354-foot-long *Pallada* had arrived in Honolulu on its homeward journey to Vladivostok at the end of a 3½-month training voyage. **Chris Woolaway** (Hawaiian Ocean Safety Team) arranged an interview on board the ship between Maximenko and Captain **Vasily Sviridenko** and Information and Education Mate **Natalia V. Borodina**.

Maximenko, a native of Russia, described in fluent Russian where the tsunami debris might be found, pointing to the September 11 computer-model plot of the debris field.



The STS *Pallada*. Images courtesy STS *Pallada*.

“The captain is seriously concerned about the debris,” translated Borodina. “The reason the huge commercial vessels travelling the North Pacific have not reported anything is because they cut through such stuff like a knife through butter. Although *Pallada* is one of the largest tall ships plying the seas, it is still by comparison a small ship and the debris is very dangerous for *Pallada’s* thin hull.”

When asked whether he would help in the search for the debris, the captain replied, “Sure! I will have our eager young cadets be on the lookout for debris 24 hours a day.”

After nearly two weeks, exciting email messages started coming from *Pallada*. Soon after passing Midway Islands (see plot below): “Yesterday, i.e. on September 22, in position 31°042,21’N and 174°045,21’E, we picked up on board the Japanese fishing boat. Radioactivity level – normal, we’ve measured it with the Geiger counter,” writes Borodina. “At the approaches to the mentioned position (maybe 10 – 15 minutes before) we also sighted a TV set, fridge and a couple of other home appliances.” Later, on September 27: “We keep sighting every day things like wooden boards, plastic bottles,



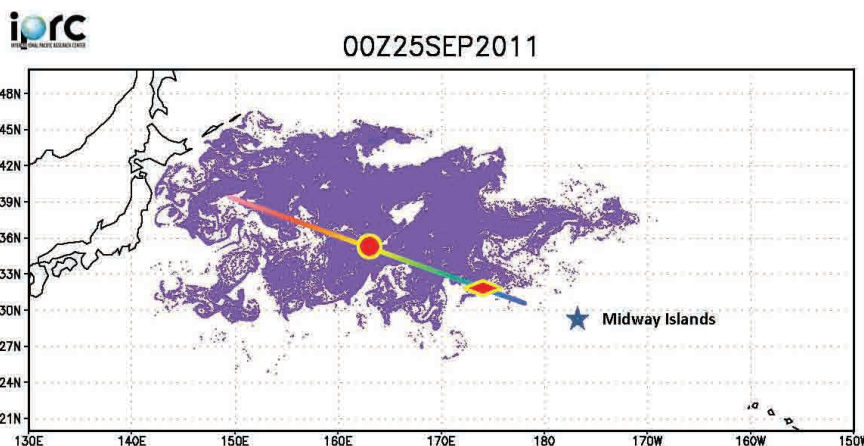
The fishing boat from Fukushima is being lifted aboard the *Pallada*.

buoys from fishing nets (small and big ones), an object resembling wash basin, drums, boots, other wastes. All these objects are floating by the ship.”

On October 8, *Pallada* entered the port of Vladivostok, and Borodina was able to send pictures. The most remarkable one was of a small fishing vessel about 20 feet long, which they were able to hoist up onto *Pallada*. The markings on the wheel house of the boat show its home port to be in the Fukushima Prefecture, the area hardest hit by the tsunami.

With the exact locations of some of the by now widely scattered debris, the scientists can make more accurate projections about when the debris might arrive at the Papahānaumokuākea Marine National Monument. The first landfall on Midway Islands is anticipated this winter. What misses Midway will continue towards the main Hawaiian Islands and the North American West Coast.

The IPRC has created a series of web pages dedicated to marine and tsunami debris information. The address is [soest.hawaii.edu/iprc/news/marine\\_and\\_tsunami\\_debris/debris\\_news.php](http://soest.hawaii.edu/iprc/news/marine_and_tsunami_debris/debris_news.php)



Plot shows the stretch of *Pallada’s* route where debris was sighted between September 21 and 28, 2011. The red rhombus marks the location where the Japanese boat was found, and the red circle denotes maximum debris density experienced. Purple color shows the distribution of the tsunami debris in the Surface Current Diagnostic (SCUD) model on September 25.

## IPRC Scientists in the Community

### Hawai'i Climate Change Stakeholders Meet

IPRC Director **Kevin Hamilton** was a speaker at two daylong workshops titled “Climate Change Impacts on Fresh Water Resources in Hawai'i” held at the East-West Center in Honolulu on July 8 and July 15. The very interactive workshops were designed to inform officials who make decisions that impact, or are impacted by, the availability of fresh water in Hawai'i. The following Hawai'i State offices were represent-



Participants at the Hawai'i Climate Change Stakeholders Meeting.

ed: Commission on Water Resource Management; Civil Defence; Department of Agriculture; Department of Business, Economic Development and Tourism; and Department of Health.

Also present were representatives of the US Army Corps of Engineers and the Honolulu Board of Water Supply, and representatives of several nonprofit community organizations.

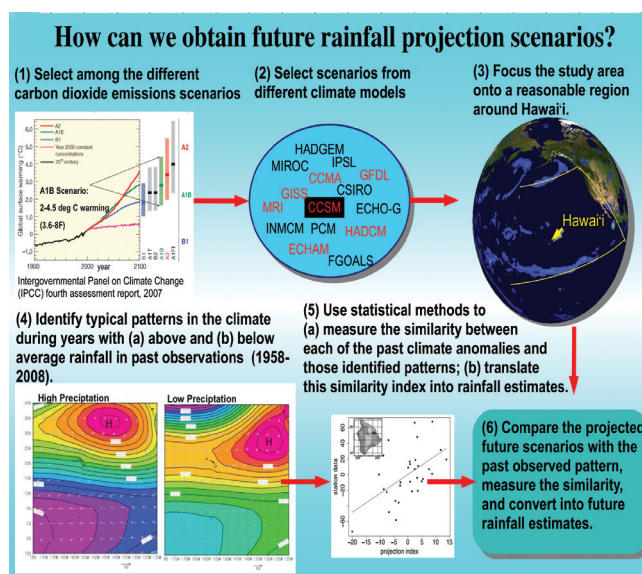
### IPRC Takes Part in the Hawai'i Conservation Alliance Annual Conference

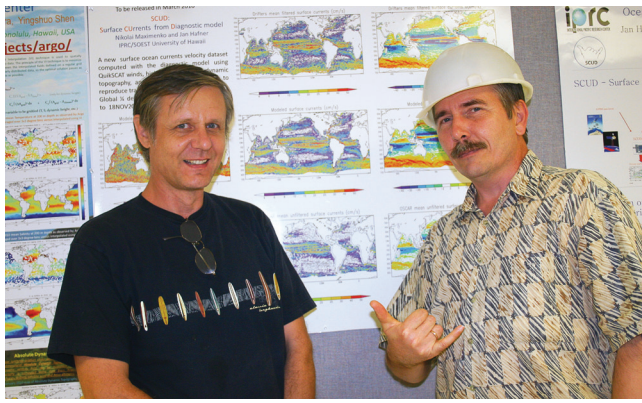
This yearly conference of the Conservation Alliance gathers hundreds of people to discuss strategies for managing and protecting Hawai'i ecosystems and to share information and practical experiences among the various organizations dealing with land management, legislature, and government. This year's meeting on August 2–4 focused on “Island Ecosystems: The Year of the Forest.” Standing questions for the Alliance are: How will global warming impact rainfall in Hawai'i? Will heavy rain events become more frequent, droughts become more severe? Will windward and leeward regions face the same threats?

**Oliver Elison Timm**, Assistant Researcher at the IPRC, hopes to find answers by looking at the historical rainfall data and by downscaling computer-simulations of future climate change scenarios. Regarding historical records, Elison Timm and his colleagues in Geography at UH Mānoa and at the Cooperative Institute for Research in Environmental Sciences, University of Colorado, have expanded their rainfall stations from 150 to more than 1000 stations, covering the seven major Hawaiian Islands. This large data set allowed them for the first time to zoom in on the spatial details of the projected rainfall changes. Using the 40-member ensemble simulation from NCAR's CCSM3 (medium-range emissions scenario

A1B), the statistical downscaling revealed for the 2040–2060 period a general increase in precipitation by 10–30% along the already wet mountain ranges of Kauai, Oahu, Maui and the Big Island. Leeward and central regions of Oahu, Kauai, and the northeast part of the Big Island appear to suffer from a 10–30% loss in the wet-season rainfall under this scenario. Overall, the findings suggest that with further global warming, the Hawaiian Islands are in for less winter rainfall.

The plot shows changes in rainfall that could be expected under future global warming according to projections in a downscaled global climate model.





Jan Hafner with Nikolai Maximenko wearing hard hat found at Barking Sands Beach.

### *Inspecting Marine Debris at the Pacific Missile Range Facility*

IPRC's marine debris specialists **Nikolai Maximenko** and **Jan Hafner** were invited in July to inspect unusual pieces of marine debris that had just been found at the Pacific Missile Range Facility on Barking Sands Beach, on the west side of the island of Kaua'i. The beach is patrolled daily for security purposes. Since **Dennis Rowley**, Environmental Manager and Range Complex Sustainment Coordinator, took up his post 6 years ago, he had never seen such a large amount of marine debris on the beach! Maximenko thinks that this debris is from the March 11 tsunami — probably not from Japan but from some other Hawaiian island that was inundated by the tsunami.

### *IPRC Scientist Gives Keynote at Lualima Conference*

**Nikolai Maximenko** was invited to speak at the 2011 Lualima Conference, a statewide meeting about litter control, greening initiatives and other ways to keep Hawai'i beautiful. Held on August 27, 2011, at the Maui Arts & Cultural Center, the meeting was sponsored by the "Keep the Hawaiian Islands Beautiful" organization. During the opening ceremonies, the mayor of each of Hawai'i's four counties presented awards for environmental achievements in business, community and government in his county. In the aftermath of the March tsunami in Japan, marine debris was a major topic at the conference. Maximenko presented his modeling results showing that the Hawaiian Islands could see some tsunami debris on their west-facing beaches in Spring 2012 and east-facing beaches in 3 to 5 years.

### *IPRC Participates in SOEST Open House*

The School of Ocean and Earth Science and Technology (SOEST) at UH Mānoa opened its doors October 21-22 to the public. Over 6000 public and private school students, children, parents, and other interested people came to the two-day event to learn about earth science. IPRC scientists put on several events featuring slide shows and the Magic Planet spherical projection system for the occasion: **Jim Potemra** described how the tall and powerful surfing waves are generated by winds far away from Hawai'i; **Jan Hafner** told about the tsunami debris and where it was headed, showing the animation of the debris field expansion and pictures of the Fukushima boat picked up by *Pallada* (see p. 14); **Malte Heinemann** and **Michelle Tigchelaar** demonstrated with a video they had created, how car exhaust makes water more acidic and how a more acidic ocean dissolves corals. **Pedro DiNezio**, **Matt Widlansky**, **Ryo Furue**, and **Michael Mehari** showed various climate and earth-science animations on the Magic Planet, taking requests from the audience. **Miho Ishizu**, **Pang-chi Hsu**, **Jinbao Li**, and **Prasamsa Singh** insured that everything ran smoothly. **François Ascani** did a great job as IPRC's "salesman" attracting the crowds to our events.



Demonstrating how CO<sub>2</sub> from car exhaust enters water, making the water more acidic; this happens also in the ocean, dissolving corals.

## IPRC Scientists In the Media

### *Tree Rings Tell 1,100-year History of El Niño*

IPRC's **Jinbao Li** and **Shang-Ping Xie**, and their international colleagues published a study in the May issue of *Nature Climate Change* titled "Inter-decadal modulation of El Niño amplitude during the past millennium." Their analyses show that the annually resolved tree-ring records from North America correlate closely with

150 years of ocean surface temperature records and various coral isotope records in the tropical Pacific, giving an account of the intensity of El Niño events over the past 1,100 years and offering key observational benchmarks for evaluating and perfecting climate models. Their study was picked up by a wide range of media, including the *Honolulu Star-Advertiser*, *Discovery-News*, *Tucson Citizen*, *PlanetSave*, and *MSNBC.com*.



Bristlecone Pine



Drilling platform.

### *East Africa's Climate under the Spell of El Niño since the Last Ice Age*

IPRC's **Axel Timmermann** co-authored the August *Science* article "Reduced inter-annual rainfall variability in East Africa during the last ice age," which shows that the waxing

and waning of rainfall in eastern tropical Africa in unison with the El Niño–Southern Oscillation existed already 20,000 years ago. The region's last 3,000 years have seen a less stable climate. The study was featured in such online media as *ScienceDaily*, *ScienceNewsline*, and *Red Orbit*.

### *\$3 Billion "Big Wind" Project and Climate Change*

In an August 24 *Honolulu Weekly* article about controversial plans to build a wind farm on the islands of Lanai and Molokai to generate electricity for Oahu, **Kevin Hamilton** was quoted: "In response to anticipated global warming, we have a fairly robust expectation of weaker tradewinds in the

Pacific, nearer the equator. What will happen around Hawai'i, up here at 20 degrees North, is less certain, however, and we can't be sure that the long-term trend will be for weaker trades here, or how big the trend could be. As research at my center, led by Dr. **Hiroki Tokinaga**, has shown that since wind speed generally increases with height, the trend to larger ships has introduced a



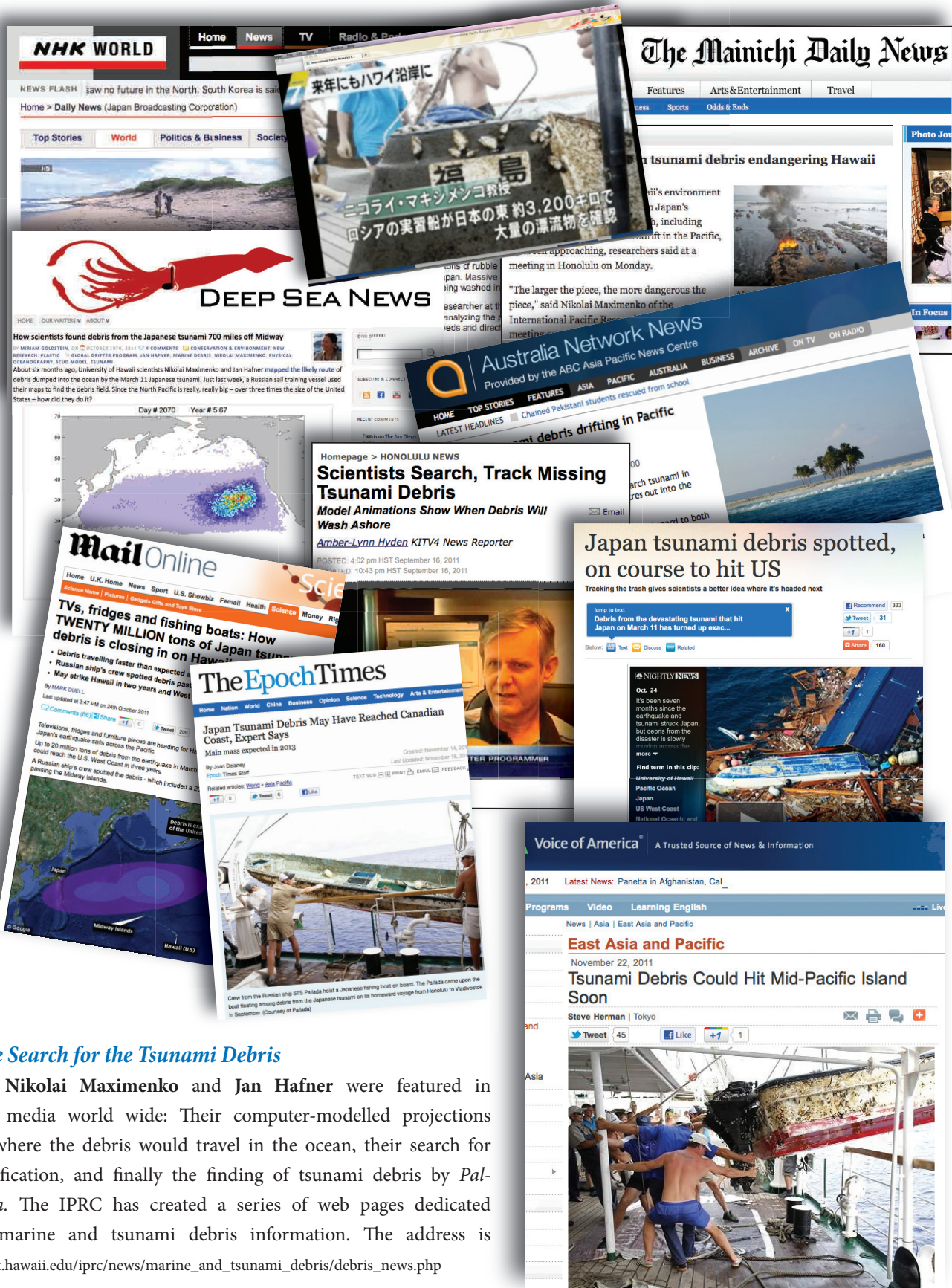
spurious increase in the 'observed surface' winds over the ocean."

### *El Niño and the Tropical Eastern Pacific Annual Cycle Run to the Same Beat*

Like waves on an ocean, different climate cycles will occasionally synchronize—but two Pacific cycles not only briefly synchronize but then "lock" into phase. This locking syn-

chronization occurs between El Niño events and the seasonal cycle of sea surface temperatures in the eastern equatorial Pacific according to research by UH Mānoa PhD candidate **Karl Stein** and IPRC's **Axel Timmermann** and **Niklas Schneider**. Their study titled "Phase Synchronization of the El Niño-

Southern Oscillation with the Annual Cycle" appeared in the September issue of *Physical Review Letters*. The findings are expected to improve prediction of El Niño events. Their study was featured by many online science news media: *ScienceDaily*, *Physorg*, *ScienceNewsline*, and *Raising Islands*.



### The Search for the Tsunami Debris

Nikolai Maximenko and Jan Hafner were featured in the media world wide: Their computer-modelled projections of where the debris would travel in the ocean, their search for verification, and finally the finding of tsunami debris by *Pallada*. The IPRC has created a series of web pages dedicated to marine and tsunami debris information. The address is [soest.hawaii.edu/iprc/news/marine\\_and\\_tsunami\\_debris/debris\\_news.php](http://soest.hawaii.edu/iprc/news/marine_and_tsunami_debris/debris_news.php)



# The 2011 IPRC Public Lecture in Climate Science

The 2011 *IPRC Public Lecture in Climate Science* was held on the evening of October 19 on the Mānoa campus of the University of Hawai'i. Over 150 students, faculty, and members of the general public listened to the talk entitled "Climate Change and Development: Avoiding the Unmanageable and Managing the Unavoidable" by **Rosina Bierbaum** of the University of Michigan's School of Natural Resources and Environment. A former Acting Director of the White House Office of Science and Technology Policy, Bierbaum is a distinguished expert in the interface of environmental science with national and international policy and was appointed by President Obama in 2009 as one of the 20 members of the President's Council of Advisors on Science and Technology.

Bierbaum began by noting the idea that human-induced increases in atmospheric concentrations of CO<sub>2</sub> could lead to higher global temperatures dates back to the 19<sup>th</sup> century. Recent decades have seen rapidly rising atmospheric concentrations of CO<sub>2</sub> and other greenhouse gases and accumulating evidence of a warmer climate. Bierbaum referred to ten well-established observed trends in recent decades consistent with a warming world. Air temperatures through the troposphere, surface air temperature over land and over oceans, sea surface temperature, atmospheric humidity, ocean heat content and global sea level are all increasing, while sea-ice cover, snow cover and glacier mass are decreasing.

Other observed indicators of a warming world include plants that are shifting upward on moun-



Rosina Bierbaum. Image courtesy Jian Ma.

tain slopes and toward the poles and that flower earlier in the year. Projections suggest that a mean global warming of at least 2°C above the preindustrial baseline is nearly inevitable, but if we continue "business as usual," future generations could see global temperatures rise by 6°C or even more.

Worrying trends that may be related to global climate change are already impacting societies worldwide. Global precipitation has increased along with the number

of severe storms and major flooding events. At the same time drying trends in the interior of some continents have been observed and crop losses due to drought now average about \$5 billion/year. With fewer cold days such pests as red ants and kudzu are not kept at bay and are presenting increasing problems for agriculture.

Bierbaum stated that, left unmanaged, climate change will reverse development progress and compromise the well-being of current and future generations. Impacts will be felt



Listening to Rosina Bierbaum's lecture. Image courtesy Jian Ma.

everywhere, but much of the damage will be felt by citizens of developing countries. The world's poorest people will suffer the most, especially through losses in agricultural land and food production.

Co-author of the World Bank's *2010 World Development Report*, Bierbaum discussed the report's approach to creating a climate-smart world for managing climate change. Human activities must change. The report's mantra is *act now, act together, act very differently* before it's too late.

*We must act now*, or staying near the 2°C global mean warming will be out of reach. Retrofitting our infrastructure, changing our institutions and our behaviors to become climate smart will take decades. The Rio Accord was nearly 20 years ago, but the global community still has not acted effectively on controlling greenhouse gas emissions.

*We must act together* as a global community. High-income countries must take the lead in creating a climate-smart world, building more efficient electricity generation systems and providing for more efficient energy use in buildings, vehicles and other machines. For example, switching the US SUV fleet to cars meeting current European Union fuel economy standards would offset the emissions needed to provide basic electric power service to the world's 1.6 billion people who now lack electricity. Since developed countries have caused much of the greenhouse emissions to date, they may reasonably be expected to help offset costs for curbing emissions in developing countries. But developing countries, too, must help to mitigate greenhouse gas emissions by controlling deforestation, more planting of forests, and implementing sustainable grassland management, soil restoration, and improvements in farming practices.

*We must act differently*. Bierbaum pointed out that worldwide public funding for alternate and more efficient

energy research & development stands currently at \$13 billion/year, the amount Americans spend on pet food or the French on cheese. World subsidies for petroleum products, in contrast, are over \$150 billion/year. Stabilizing the global temperature rise near 2°C, will require a dramatic decrease in energy demand and a radical transformation of our energy infrastructure by expanding renewable energy sources and developing carbon sequestration technology. It will also be necessary to increase global biosphere carbon sinks by



Rosina Bierbaum with Kevin Hamilton. Image courtesy Jian Ma.

planning and managing our soils and forests sustainably. As substantial climate change seems inevitable we also need to plan for a broad program to adapt our infrastructure and economic practices to the expected warmer world.

This was the third IPRC Public Lecture presented by distinguished colleagues. The IPRC looks forward to continuing this series of annual lectures for the community.

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## IPRC Public Lectures

### 2009 *A Tale of Environmental Change*

By Dr. Susan Solomon, Senior Scientist,  
National Oceanic and Atmospheric Administration

### 2010 *Changing World, Changing Ocean*

By Dr. Susan Avery, President and Director of  
Woods Hole Oceanographic Institution

### 2011 *Climate Change and Development: Avoiding the Unmanageable and Managing the Unavoidable*

By Dr. Rosina Bierbaum, Professor,  
University of Michigan