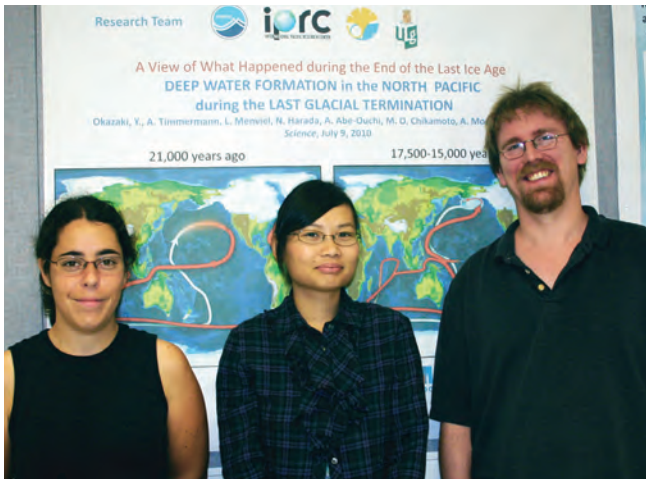
VISITING SCHOLARS

Searching for the Carbon during the Last Glacial Maximum

The CO_2 concentration in the atmosphere has fluctuated over Earth's life more or less in unison with global surface temperature. Today it is around 380 ppm, in the early 1800s, before industrialization took off, it was around 280 ppm, and during the Last Glacial Maximum (LGM), 20,000 years ago, it stood at 190 ppm. Given the importance of the carbon cycle in climate, scientists want to know where the additional 90 ppm CO_2 in the atmosphere during pre-industrial times was stored during the LGM and what caused its release to the atmosphere during the last glacial termination. According to a recent review, changes in ocean circulation, biological production, and sediment burial have been made responsible.

Megumi Chikamoto, research scientist at the JAMSTEC Research Institute for Global Change, visited the IPRC for 6 months to work with **Axel Timmermann** and his team on tracking down the missing LGM carbon. Their tool is the MIROC: Model for Interdisciplinary Research On Climate, developed at the Atmosphere and Ocean Research Institute of The University of Tokyo, the National Institute for Environmental Studies, and the Japan Agency for Marine-Earth Science and Technology, in combination with an offline marine carbon cycle model. Run under glacial boundary conditions and freshwater forcing, MIROC simulates a deep ocean circulation that is quite similar to the reconstructed glacial ocean state.



Megumi Chikamoto (middle) with Audine Laurian and Axel Timmermann

When the scientists calculated the ocean carbon response to the glacial climate state in MIROC, they noted that an intensification of Antarctic Bottom water production clearly increased the carbon storage of the abyssal oceans, as predicted by numerous studies before. To the great surprise of Chikamoto and Timmermann, this effect was almost completely compensated in their model by the decreased uptake of carbon in the North Atlantic. According to their modeling results ocean circulation changes alone are unlikely to have been the main driver for glacial-interglacial variations in atmospheric CO_2 contration.

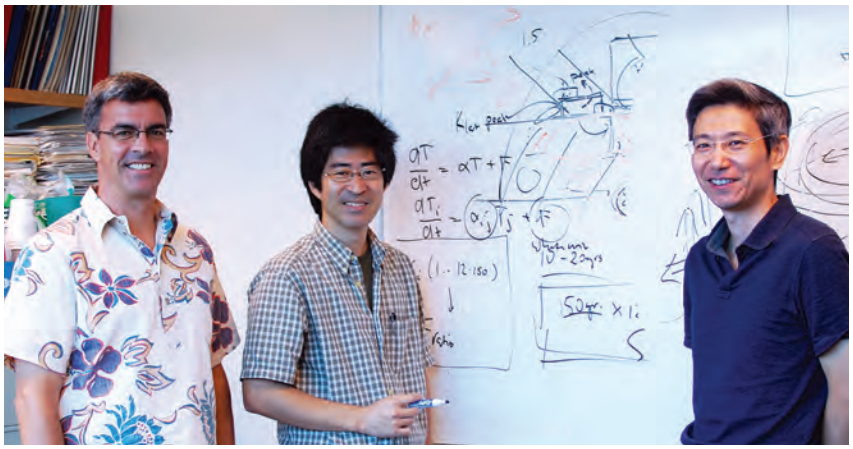
In their future collaborative work, Chikamoto and Timmermann will explore the role stratification-dependent mixing and North Pacific circulation changes on the fate of glacial carbon in the ocean.

Black Sea Coastal Processes

Viacheslav Kremenetskiy, senior researcher at the P. P. Shirshov Institute of Oceanology in Moscow, visited the IPRC for several weeks in January 2011 to continue his study of the Black Sea mean dynamic topography with IPRC's Senior Research **Nikolai Maximenko**. The project is funded by the US Civil Research & Development Foundation and the Russian Foundation for Basic Research. Despite the large number of available historical observations of this inland sea with its densely populated coastline, a firm understanding of the dynamics of its marginal and inner sea has been elusive. The Black Sea intrigues oceanographers on account of the complex interplay among the coastal process, which take place on small space- and time-scales over an intricate shoreline topography, not yet resolved by today's satellites or global models.

Nikolai Maximenko with Viacheslav Kremenetskiy.

Explorations with the Coupled GCM for the Earth Simulator



Bunmei Taguchi (middle) with Niklas Schneider and Shang-Ping Xie.

Along with their global atmospheric model and global ocean model, the JAMSTEC Earth Simulator's Geophysical Fluid Simulation Research Group has developed a coupled version, the Coupled GCM for the Earth Simulator (CFES). The Earth Simulator group has been able to run CFES at a much higher resolution than most models currently available for climate assessments. **Bunmei Taguchi**, Earth Simulator scientist, spent 3 months during the 2010 – 2011 winter at the IPRC to work on different CFES projects. This was a return home for Taguchi who received his 2006 Ph.D. at UH Mānoa under the mentorship of IPRC faculty member **Shang-Ping Xie**.

The first of Taguchi's projects deals with the Pacific Decadal Oscillation (PDO), a well-known Pacific climate pattern with phases typically of 20-to-30-year duration. In one phase, the water north of 20°N is warm in the eastern and cool in the western North Pacific, during the other phase, it is just the opposite. The phases have a detectable impact on climate and marine life. Taguchi wants to track down the causes of the temperature shifts. "Finding the mechanisms, though, is not so easy; the model is nearly as complicated as nature," says Taguchi. "But in the model, the phenomenon can be followed over a longer period of time than in historical observations. And once we've zeroed in on a mechanism, we can carry out an experiment to test our hypothesis." IPRC's **Niklas Schneider** and Xie are project consultants.

Another CFES project deals with the following sequence of climate events: El Niño warms the Indian Ocean; the warming lasts through the summer long after El Niño has decayed and makes for a dryer Indian monsoon; this Indian Ocean warming, which Xie dubbed the *capacitor effect* (see *IPRC Climate,* Vol. 9, no. 2), excites in the summer after El Niño the Pacific – Japan pattern with intense convective activity over East Asia and the tropical Northwestern Pacific. After the so-called mid-70s climate shift in the Pacific, the relationship between the three climate phenomena has become tighter. By analyzing 170 years of CFES output, Taguchi wants to confirm that this relationship waxes and wanes over decades.

Taguchi's third project focuses on the mysterious east-west "stripes" in ocean currents and surface temperature. These stripes that IPRC's **Nikolai Maximenko** was among the first to detect in satellite images, are surface signals of deep ocean currents. CFES is able to simulate their surface signatures, and Taguchi and IPRC's Assistant Researcher **Ryo Furue** intend to study how the atmosphere and surface winds respond to these signals.

Tropical Cyclones in a Warming Climate

Hiroyuki Murakami from JAMSTEC and Japan's Meteorological Research Institute (MRI), visited the IPRC from November to February to work with **Bin Wang** on tropical cyclone research. Their paper with MRI's **Akio Kitoh**, "Future change of western North Pacific typhoons: Projections by a 20-km-mesh global atmospheric model," concludes that there will be fewer tropical cyclones in the western North Pacific due to weaker large-scale rising motion, and that the region where

tropical cyclones form will shift eastwards during the peak season because the low-level vorticity is predicted to be greater and vertical shear to be weaker further east than today. The model's changes in tropical cyclone tracks and formation depend on the spatial pattern of future sea surface temperature in a warming Earth. Murakami presented his findings at the SOEST Symposium: *The Science of Climate Change in Hawai'i* on January 20 (see pg. 12). The paper appeared in the February 2011 issue of *Journal of Climate*.

Discussing the Generation of Gravity Waves

A participant at the IPRC-hosted AGU Chapman conference *Atmospheric Gravity Waves and their Effects on General Circulation and Climate*, (see pg. 16), **Takeshi Horinouchi**, Associate Professor at the Faculty of Environmental Earth Science, Hokkaido University, took the opportunity to visit the IPRC in March 2011. He discussed with IPRC scientists his research on the atmospheric general circulation and on the generation of gravity waves. While at the IPRC, he also gave a seminar "Moist Hadley circulation: Constraints and the role of wave-convection coupling in an aquaplanet AGCM."

From left, Shang-Ping Xie, Takeshi Horinouchi, Kazuyoshi Kikuchi, and Yu Kosaka.

Aloha and Welcome to the IPRC

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