IPRC NEWS

New UH–JAMSTEC Cooperative Agreement Extends Scientific Partnership

With the negotiation and signing of a new Cooperative Agreement between the University of Hawai'i (UH) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the IPRC research partnership with JAMSTEC, which began in October 1997, will continue through March 31, 2014. Signed by JAMSTEC President **Yasuhiro Kato** and UH President **David McClain**, the new agreement is the first to define the institutional framework for the research conducted under the JAMSTEC–IPRC Initiative.



UH President David McClain, signing the new Cooperative Agreement, with SOEST Dean Brian Taylor (left) and IPRC Interim Director Kevin Hamilton.

JAMSTEC Officials Visit the IPRC

Shiro Imawaki, the new JAMSTEC Executive Director, and **Shiro Matsugaura**, of the JAMSTEC International Affairs Division, visited the IPRC on December 11 and 12, 2009. The visit afforded our JAMSTEC colleagues a chance to hear in detail about research underway at the IPRC, including the exciting work of many of our younger scientists.



Scientific Advisory Committee Reviews New IPRC Science Plan

The IPRC Scientific Advisory Committee met from December 8 to 10, 2008, at the IPRC to learn about recent and ongoing IPRC research and to review and discuss the draft of the new IPRC Science Plan.



IPRC Scientific Advisory Committee: seated from left, Peter Cornillon (University of Rhode Island), Masahisa Kubota (Tokai University), Toshiyuki Hibiya (University of Tokyo), Masahide Kimoto (University of Tokyo); standing from left, Roberto Mechoso (University of California at Los Angeles), Kevin Hamilton (IPRC Interim Director), Jerry Meehl (US co-chair, National Center for Atmospheric Research), Humio Mitsudera (Japan co-chair, Hokkaido University), and Brian Taylor (Dean, UH School of Ocean and Earth Science and Technology).

Celebrating Research Achievements at JAMSTEC

IPRC scientists participated in two symposia held at the Yokohama Institute for Earth Sciences (YES): the Joint Annual Symposium of the Frontier Research Center for Global Change (FRCGC) and of the Institute of Observational Research for Global Change (IORGC) on March 16, 2009; and the symposium *Past, Present and Future of Climate Variations Research* on March 17. Interim Director **Kevin Hamilton**

Executive Director Shiro Imawaki (left) and Shiro Matsugaura (in white shirt) with IPRC's young Japanese scientists.

represented the IPRC at the Joint Symposium, with a presentation of IPRC Research Highlights. The March 17 symposium celebrated the achievements of the FRCGC Climate Variations Research Program (CVRP) and its Director, University of Tokyo Professor **Toshio Yamagata**. In recognition of the important partnership between CVRP and IPRC, two IPRC scientists gave invited talks. **Shang-Ping Xie** presented "Climatic Influences of Indian Ocean Dynamics: The Thermocline Dome and Beyond" and **Tangdong Qu** presented "Tracking the Origin of Thermostad Waters in the Eastern Pacific."

Winter – Spring Visitors to the IPRC

During the 2008-2009 winter and spring IPRC hosted a bumper crop of distinguished international colleagues who made extended visits to collaborate with IPRC scientists. Hiroyuki Murakami from Japan's Advanced Earth Science and Technology Organization visited IPRC's Bin Wang to analyze tropical cyclones in the high-resolution global simulations produced by the Japanese Meteorological Research Institute. Professor In-Sik Kang of Seoul National University also visited Bin Wang to continue their collaboration on seasonal climate prediction. George Boer from the Canadian Centre for Climate Modelling and Analysis in Victoria worked with Kevin Hamilton on stratospheric influences on tropospheric climate. Wataru Ohfuchi from the JAMSTEC Earth Simulator Center visited Hamilton to continue their long-standing collaboration on analysis of high-resolution global atmospheric model simulations.



From left, Bin Wang, In-Sik Kang, George Boer, Wataru Ohfuchi, Hiroyuki Murakami, Kevin Hamilton.

Akio Ishida and Yoshikazu Sasai, research scientists at the Frontier Research Center for Global Change, visited the IPRC in February to discuss collaborations between FRCGC and IPRC on studies of the marine ecosystem. Sasai stayed on until late March to work with IPRC's **Kelvin Richards** on the interannual variability of primary production in the Eastern Tropical Pacific. They compared observations of primary production seen in ocean color satellite measurements with results from an ecosystem model embedded in the Ocean General Circulation Model for the Earth Simulator. The model was found to capture much of the observed variation.



From left, Richards discussing primary production variation in the tropical Pacific Ocean with JAMSTEC colleagues Sasai and Ishida.

Andrey Zatsepin, Head of Experimental Physics of the Ocean Laboratory at the P.P. Shirshov Institute of Oceanology in Moscow, visited Nikolai Maximenko in December 2008 to discuss their joint project on the coastal ocean dynamics of the Black Sea. The Black Sea is affected mostly by coastal ocean processes, which are much more complex in an inner sea than in the open ocean. The study will combine satellite and ship observations with laboratory experiments that are conducted in rotating tanks and can simulate the effects of the Coriolis force on the Black Sea.



Andrey Zatsepin (right) discussing rotating water tanks with Nikolai Maximenko.

Syukuro "Suki" Manabe visited the IPRC in February. Now a Senior Scientist with the Princeton University Program in Atmospheric and Oceanic Sciences, Manabe has had a distinguished career in both Japan and the US and is widely regarded as the "father of global climate modeling." For many years, he led the climate group at the NOAA Geophysical Fluid Dynamics Laboratory. Then from 1997 to 2001, he was director of the Global Warming Research Program at the JAMSTEC Frontier Research System for Global Change.

IPRC senior and junior scientists took the opportunity to discuss modeling issues with this pioneer in numerical climate modeling. One subject discussed during the visit was finalizing a contribution dealing with Manabe's career for the American Meteorological Society (AMS) Oral Histories Project. This contribution is based on the interview of Manabe conducted in 2005 by *IPRC Climate* editor **Gisela Speidel**. The original version of the interview was published in *IPRC Climate* Vol. 5, no 2. The expanded version will be deposited in the AMS archive. The IPRC is pleased to have been involved in this important project developing primary sources to document the history of atmospheric science!



Suki Manabe (right) in discussion with Kevin Hamilton.

Sir Brian Hoskins, C.B.E., F.R.S, visited the IPRC from March 11 to 13. Hoskins, one of the outsanding dynamical meteorologists of his generation, is Director of the Grantham Institute for Climate Change at Imperial College in London. In his special joint IPRC– Department of Meteorology lecture



Sir Brian Hoskins

on March 11, titled "Understanding of Storm Tracks from Idealised World GCM Simulations," he first reviewed observational studies of midlatitude storm tracks, noting particularly the localization and alignment of the North Atlantic storm track. He then presented results of a standard "aqua-planet" global atmospheric general circulation model with specified zonally symmetric sea surface temperatures (SSTs), an experiment that produces a midlatitude track that extends all around the globe and is anchored by the SST gradients. He ended his talk with results from a series of simulations in which more realistic features were successively added: first a flat continent with shape and location similar to North America, then the effects of a topographic barrier representing simplified Rocky Mountains, and lastly, the SST patterns representing the effects of the ocean currents (notably the Gulf Stream). The incremental results showed the impact of North American topography in producing the Atlantic storm track.

The mini-symposium *Climate Processes over the Asia-Pacific Region* was held in conjunction with Hoskins' visit (see Meetings, page 19).

Brian Hoskins during the *Mini-Symposium an Climate Processes over the Asia-Pacific Region.*



Susan Solomon Gives Inaugural Lecture in IPRC Public Lecture Series

The IPRC began an exciting new endeavor on the evening of March 2, 2009, with the inaugural IPRC Public Lecture in Climate Science presented by Susan Solomon, senior scientist with the National Oceanic and Atmospheric Administration Earth System Research Laboratory in Boulder, Colorado. A leader in the field of atmospheric science, Solomon made some of the first chemical measurements of the ozone hole in Antarctica, establishing manmade chlorofluorocarbon com-pounds (CFCs) as its cause. These scientific results provided impetus for the negotiation and implementation of the 1987 Montreal Protocol, the international agreement that regulates global CFC emissions. From 2002 to 2008, Dr. Solomon was co-chair of the Physical Science Working Group of the Intergovernmental Panel on Climate Change (IPCC), and her efforts were key in preparing the recent IPCC Fourth Assessment Report on Climate Change. She has won numerous prestigious awards in the US and abroad, among them the US National Medal of Science and the 2004 Blue Planet Prize of the Asahi Foundation in Japan. In 2008 Time magazine recognized Solomon as one of the "100 most influential people in the world."

Solomon's lecture, "A Tale of Environmental Change: Something for Everyone about Climate Change, and Climate Gridlock," attracted an audience of nearly 200 students, faculty, and members of the general public. She began by describing the approach adopted by the IPCC in preparing its assessments of the current state of climate science, and noted the wide participation by the global science community in the process. The IPCC emphasizes the aspects of the science that are most clearly established and takes pains to identify those areas that are potentially very important, but still uncertain. Solomon noted that the final "summary for policymakers" in the IPCC assessments must be approved word-for-word by the representatives of the 113 national governments involved in the IPCC process.

Solomon went on to describe some of the well-established scientific results that should underpin societal response to the global warming issue. Although individual decadal



Susan Solomon gives the inaugural lecture of *IPRC Public Lecture Series*.

periods may not show rising global-mean surface temperatures, the overall record from the late 19th century to the present shows an unequivocal warming trend. The warming trend is clearest when the data are aver-

aged over the globe—at individual locations the warming trend can be less obvious.

The degree and rapidity of the global-mean warming over the last century appear to be unprecedented, in recent times at least, and coincide with unprecedented rapid increases in the atmospheric concentrations of long-lived greenhouse gases, most notably carbon dioxide. These changes in atmospheric composition are largely due to human activities. Sophisticated models of the climate system account for the observed warming only when human-induced greenhouse gas concentrations are included together with natural processes.

The models can be used to project the response of the Earth system to possible scenarios of future human greenhouse gas emissions. The most plausible scenarios have global-mean temperature rising by about 3°C by the end of the 21st century. The local implications of such a climate change will likely be considerable. For example, rainfall patterns can be expected to shift significantly, and most dry regions in the



midlatitudes can be expected to become drier. By the end of the century, models predict in some areas as much as a 20% reduction in average rainfall. To put this in context, Solomon pointed out that during the famous "Dust Bowl" era, the Great Plains of the US had roughly 10% less rainfall than normal for about 15 years. Control of these climate changes would involve major changes in the world's economy. The development of the broad international consensus required to significantly regulate emissions is complicated by the inequities in wealth and industrial development. Solomon pointed out that currently the wealthiest 1 billion people are responsible for 5 times the per capita emission of the remaining 5.5 billion people. Even within the developed world there are inequities, with the average emission of each American roughly twice that of a person in Europe or Japan.

Solomon noted that, just as the water level in a bathtub depends upon

the amount of water coming in and draining, the level of carbon dioxide in the atmosphere is controlled by emissions and sinks (notably uptake by the ocean and the terrestrial biosphere). Currently the emission rate exceeds the capacity of the sinks to absorb all the added carbon dioxide; in the analogy, the bathtub is filling even with an open drain. To stabilize carbon dioxide concentrations it will be necessary to reduce very significantly current emission rates.

Comparing the situation with the successful Montreal Protocol on CFC reduction, Solomon said, "The times, the numbers and players at the table, equity issues, sustainable development issues, and poverty alleviation make this issue much more complex. It will be a heroic task in the next generation: stabilize and then reduce emissions while developing countries develop. Susan Solomon with IPRC Interim Director Kevin Hamilton discussing research with graduate student Jian Ma and postdoctoral fellow Axel Lauer.

Never before has there been a greater need for a joint and well-informed societal choice."

Building on this successful start, the IPRC will establish the IPRC Public Lecture in Climate Science as an annual event. We plan to bring a distinguished environmental scientist each year to the IPRC to interact with our scientists and students and to present an evening lecture to the general public. This is a high-profile addition to outreach efforts at the IPRC and the University of Hawai'i to inform the public about the science that underlies critical environmental issues.

IPRC–JAMSTEC Research on Modeling Tropical Cyclones Garners Wide Attention

The publication of tropical cyclone results from the NICAM model (p. 13) made quite a media stir. The study, led by IPRC postdoctoral fellow Hironori Fudeyasu and co-authored with IPRC's Yuqing Wang, University of Tokyo Prof. Masaki Satoh and IAMSTEC's Tomoe Nasuno, Hiroaki Miura, and Wataru Yanase, was published under the title "Global Cloud-System-Resolving Model NICAM Successfully Simulated the Lifecycles of Two Real Tropical Cyclones," in November 2008 in Geophysical Research Letters. Chosen as an "AGU Journal Highlight," the paper led to stories appearing in over 20 online news sites (iprc.soest.hawaii. edu/news/newslinkssaved/08 12 Fudeyasu. html), including some in India, Malaysia and Korea. This work was also featured in the News section of the Bulletin of the American Meteorological Society. An interview with Satoh about this work was published by Mainichi Newspapers in Japan (iprc.soest.hawaii. edu/japanese/news/news.html).



Hironori Fudeyasu discussing tropical cyclone simulations with IPRC visitor Syukuro Manabe.



Monsoon Studies with NICAM

From March 19 to 31, 2009, Kazuyoshi Kikuchi and Yoshiyuki Kajikawa, who are doing monsoon research at the IPRC, visited JAMSTEC scientists working on the global cloud-systemresolving model NICAM. They discussed with Masaki Satoh (Subleader, Global Environment Modeling Research Program), Hirofumi Tomita (Research Scientist, Global Environmental Modeling Research Program), Kazuyoshi Oouchi (Research Scientist, Global Environment Modeling Research Program), Tomoe Nasuno (Research Scientist, Global Environment Modeling Research Program), Yoshiki Fukutomi (Research Scientist, Hydrological Cycle Research Program), and other JAMSTEC colleagues possible future collaborations on analyzing the existing NICAM output and designing future NICAM experimentsexperiments that would provide new detailed knowledge about monsoon processes and could help in forecasting monsoon rainfall.

Discussing monsoon research using NICAM, from left, Tomoe Nasuno, Yoshiyuki Kajikawa, Kazuyoshi Oouchi, Yoshiki Fukutomi, Kazuyoshi Kikuchi, Masaki Satoh, Hirofumi Tomita.

IPRC–Hokkaido University Collaboration Continues

The exchange between IPRC and Hokkaido University, begun by Hokkaido Prof. Youichi Tanimoto, has continued with the January–March visit of Hokkaido graduate student Kohei Yoshida. While at the IPRC, Yoshida worked with Kevin Hamilton on observational studies of the structure of the Quasi-biennial Oscillation near the tropical troposphere. Yoshida gave an "IPRC Luncheon Discussion" on results of his work.



Kevin Hamilton with Hokkaido graduate student Kohei Yoshida.

IPRC Acquires Magic Planet

With the support of UH School of Ocean and Earth Science and Technology (SOEST) and a generous gift from former IPRC Executive Associate Director Lorenz Magaard, the IPRC has acquired a "Magic Planet." This system allows still images or animations to be projected on a glowing 24-inch diameter sphere. The software for the computer-driven projections permits the planetary rotation to be automatically added to the images and the orientation of the rotation axis to be varied. The Magic Planet is being used for visualizing IPRC's

model simulation and diagnostic data sets as well as for educational and outreach activities at IPRC and other units of SOEST.

A valuable feature is that presentation material developed for the IPRC Magic Planet can be adapted easily for display on the 8-foot diameter NOAA Science-on-a-Sphere (SOS) at Honolulu's Bishop Museum and at other institutions around the world. The acquisition of the IPRC Magic Planet projector was spearheaded by **Jim Potemra**, a faculty member at the IPRC and the Hawai'i Institute of Geophysics and Planetology (HIGP). Magic Planet. *Inset:* Former Executive Associate Director Professor Lorenz Magaard, whose generous donation helped the IPRC acquire a Magic Planet.



At the Bishop Museum's *Mad About Science* festival, Jim Potemra displays for comparison two different global warming scenarios: one on the Magic Planet provided by the IPRC and one on a borrowed system from NOAA (see page 29; photo courtesy of Bishop Museum).



IPRC Scientists Active in Climate Research Community

IPRC Interim Director **Kevin Hamilton** visited Boulder from November 17 to 20, 2008, to participate in the external advisory panel review meetings for the National Center for Atmospheric Research Earth & Sun Systems Laboratory (ESSL) and its constituent Divisions and Institutes. In addition to participating in the main ESSL review, Hamilton chaired the review panel for The Institute for Integrative & Multidisciplinary Earth Studies (TIIMES).

Bin Wang is serving on the special committee for "Assessment of Climate Predictability and Prediction on Intraseasonal to Seasonal Timescales" of the National Academies' Atmospheric Science and Climate Board. The committee is charged with writing a national report on climate predictability and prediction. Wang is also co-chair of the Organizing Committee for the International Monsoon Symposium, which will be held in Jakarta, Indonesia, July 16–17, 2009; and he is a co-organizer of the 6th workshop for the Asian Monsoon Years (AMY 2007–2012).

IPRC's Nikolai Maximenko, Niklas Schneider, and Oleg Melnichenko organized and convened with



Kevin Hamilton talking with NCAR Senior Scientist John Gille during the ESSL review.

Emanuele Di Lorenzo (Georgia Institute of Technology) the special session *Anisotropic Mesoscale Structure of Basin-Wide Ocean Circulation* at the 2008 Fall AGU Meeting in San Francisco held December 15–19, 2008.

IPRC's Alumnus Receives Okada Prize

Former IPRC scientist **Fumiaki Kobashi** received the Okada Prize at this year's Spring Meeting of the Oceanographic Society of Japan, which was held from April 5 to 9, 2009, in Tokyo. The prize is awarded to a young member of the Society who has made outstanding contributions to the progress of oceanography.

Kobashi was honored with this prize for his "Analytical study on the North Pacific subtropical front," which consists of two parts: the formation mechanism of the subtropical front, which he discovered with **Humio Mitsudera** and **Shang-Ping Xie** while he was at the IPRC, and a description of air-sea interaction over the subtropical front, which he recently analyzed with Xie and other colleagues (see *IPRC Climate*, vol. 8, no. 2). Kobashi is now professor at Tokyo University of Marine Science and Technology.



Fumiaki Kobashi receives the Okada Prize.

IPRC Active in the Community

The IPRC took part in the Bishop Museum's "Mad About Science" annual festival, which this year had climate change as its theme.







Axel Timmermann as the Mythbuster.



At Bishop Museum's Festival, Oliver Timm explains 800,000-year-long temperature and CO₂ record.



IPRC Outreach Specialist Gisela Speidel helps Sophia Hudelist create an Ice Age over the twin peaks Mauna Loa and Mauna Kea that were covered by ice 18,000 years ago. (Photo courtesy of Puja Hudelist)

Axel Timmermann (above) played the Climate Change Expert who answered questions and busted climate myths.

Oliver Timm's 800,000-year record of temperature and CO_2 data from the EPICA ice core in Antarctica, which covered over 25 feet of the exhibit walls (top left), was greeted with amazement and many questions.

Jim Potemra (see page 27) asked visitors to compare future air and sea surface temperature projections displayed on two Magic Planets that showed animations for different increases in atmospheric CO_2 concentrations.

Children enjoyed creating an ice age or a meltdown for the Island of Hawai'i (18,000 years ago Mauna Kea had a glacier) with **Gisela Speidel** (bottom left) by letting more snow fall than melt (or more snow melt than fall), to experience what happens when climate processes are not in balance.

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NEW IPRC STAFF



Ju Chen joined the IPRC as a postdoctoral fellow in November 2008. He received his PhD in 2006 from the South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Sciences, in Guangzhou. For his dissertation, Chen analyzed the contribution of the upper-layer circulation to the interannual vari-

ability of the intermediate and deep water of the South China Sea. He continued studying the circulation and water mass of the South China Sea as an assistant researcher at the SCSIO until coming to the IPRC. At the IPRC, Chen is working with **Tangdong Qu** on a project to understand the source, migration, and destination of 13°C water in the Southern Pacific, with a focus on the year-to-year and decade-to-decade variations in the annual subduction rate and how this rate affects tropical Pacific 13°C water.



Puthiya V. S. Kallikkal

Puthiya Veettil Sooraj Kallikkal joined the IPRC as a postdoctoral fellow in January 2009. He received his PhD in 2005 from Cochin University of Science and Technology, India. For his dissertation, Sooraj used observational and modeling diagnostics to study the onset of the South Asian summer monsoon. Af-

ter completing his PhD, he worked first as a research associate at the Centre for Atmospheric and Oceanic Science, Indian Institute of Science, analyzing the sea surface temperature cold bias in CCSM simulations of the tropical Indian Ocean, and then as a postdoctoral fellow at the Climate Environment System Research Centre of Seoul National University, Korea. At the IPRC, Sooraj is working with **H. Annamalai** on a project to develop a dynamical seasonal climate prediction system for the Pacific Islands; he is also interested in issues related to the seasonal prediction of the South Asian Monsoon. Sooraj says, "I continue to be fascinated by the rather chaotic nature of weather and the challenges in trying to develop seasonal forecast procedure."



MinHo Kwon

MinHo Kwon joined the IPRC as a postdoctoral fellow in November 2008. He received his PhD in atmospheric sciences from Seoul National University in 2006. For his dissertation, he analyzed the decadal variability of the East Asian summer monsoon. He found that the monsoon circulation changed

significantly in the mid-1990s, and he investigated how these changes might be related to global climate variations. After receiving his PhD, he worked for the Research Institute of Basic Sciences at Seoul National University and at the Korea Meteorological Administration on their forecast of seasonal mean climate of East Asia using statistical models. At the IPRC, Kwon is working with **Tim Li** on changes in the characteristics of tropical cyclones under a warmer climate. He says, "I am curious about what controls the number of tropical cyclones in a warmer climate state."



Shayne McGregor

Shayne McGregor joined the IPRC as a postdoctoral fellow in March 2009. He completed his Masters and PhD degrees in the Department of Environment and Geography at Maquarie University, Sydney, Australia. His dissertation focused on investigating the mechanisms that contribute to the interdecadal vari-

ability of the El Niño-Southern Oscillation. At the IPRC, McGregor is working with **Axel Timmermann** on identifying changes in tropical Pacific climate during the last millenium. This project also seeks to indentify whether the changes in tropical Pacific climate are driven by processes internal or external to the climate system. McGregor: "I am fascinated and absorbed by tropical Pacific variability and the strength of its global climatic impacts."



Laurie Menviel

Laurie Menviel, who joined the IPRC as a postdoctoral fellow in January 2009, hails from France. She received her Master's degree in Geochemistry from the University of Aix-Marseille in 2002 and her PhD from the Department of Oceanography, University of Hawai'i at Mānoa, in 2008. Her dissertation dealt with

the interaction between the carbon cycle and climate on millennial to glacial timescales. At the IPRC, Menviel is working with **Axel Timmermann** to further understand the interaction between climate and the carbon cycle. At present, their main project focuses on describing the response of climate and the marine carbon cycle to past (and eventually future) freshwater releases from Antarctica. Their tool is an Earth system model of intermediate complexity, the LOVECLIM, which consists of the following components: atmospheric circulation, carbon cycle, ocean circulation and sea ice, vegetation cover, and ice-sheet surface and flow.



Jing Xu

Jing Xu joined the IPRC as a postdoctoral fellow in November 2008. She worked for over a decade at the National Meteorological Center of the China Meteorological Administration and comes with abundant experience in research and operational short-range weather forecasting, and in marine and applied

meteorology. She received her PhD from Nanjing University of Information Science and Technology (NUIST) in 2008. Her dissertation dealt with forecasting such hazards as debris flows and landslides, particularly landslides triggered by typhoon rain. At the IPRC, Xu is working with **Yuqing Wang** on a project to understand the physical mechanisms that control tropical cyclone intensity and structure changes. She says, "I am curious about what determines the distribution and the extent of heavy rainfall and high winds in a tropical cyclone."

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IPRC Bids Sayonara

Three scientists from the IPRC have relocated to the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and are now working in the Climate Variation Predictability and Applicability Research Program of the Research Institute for Global Change: **Mototaka Nakamura** is working as senior scientist on research of extra-tropical air-sea interactions, troposphere-stratosphere interactions, and extreme events. **Hidenori Aiki** is working as scientist on the nonhydrostatic simulation of tidal internal waves in the Indonesian Sea. Former Postdoctoral Fellow **Ingo Richter** has become a JAM-STEC scientist and is studying decadal climate variability and seasonal climate forecasts in southern Africa.

The new Research Institute for Global Change has been created from a merger of the Frontier Research Center for Global Change (FRCGC) and the Institute of Observational Research for Global Change. The Climate Variation Predictability and Applicability Research Program has emerged from the former Climate Variations Research Program of the FRCGC.