July-August 2012
Vol. 16/No. 4

AOML Keynotes

ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

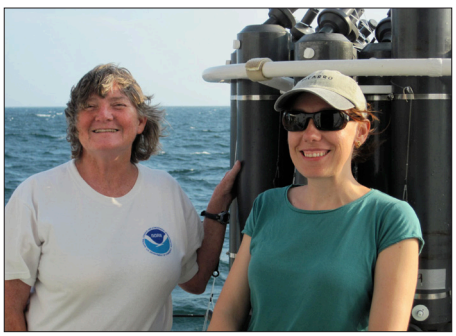
AOML is an environmental laboratory of NOAA's Office of Oceanic and Atmospheric Research on Virginia Key in Miami, Florida

GOMECC-2 Assesses Ocean Acidification Impacts on U.S. Gulf and East Coasts

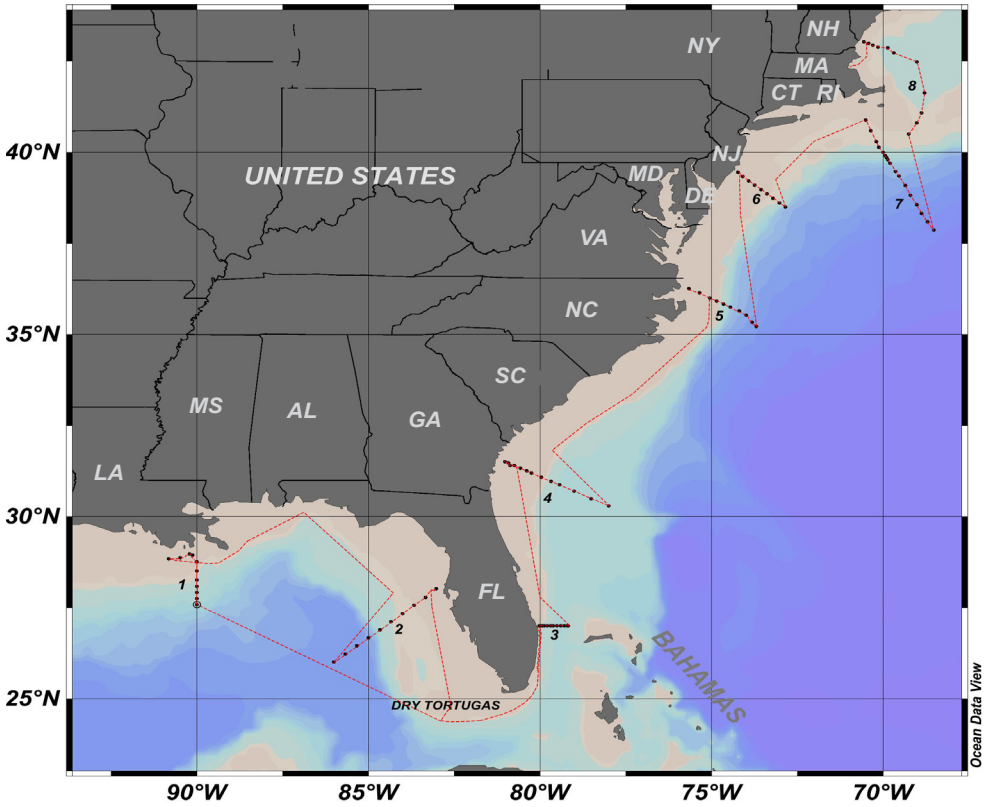
Seawater chemistry has been steadily changing due to the ocean's uptake of excess atmospheric carbon dioxide (CO_2) from the burning of fossil fuels. This increasing CO_2 has caused the carbonate ion concentration and the pH of seawater to decline, resulting in an acidification of the oceans with impacts to marine ecosystems and organisms that use carbonate minerals to build their skeletal structures.

In July, AOML researchers led a successful effort to survey the Gulf and east coasts of the United States for ocean acidification trends. The NOAA ship *Ronald H. Brown* departed Miami on July 21st with a scientific complement that included staff from AOML's Ocean Chemistry and Physical Oceanography divisions, as well as researchers from six academic institutions and other NOAA line offices.

The second Gulf of Mexico and East Coast Carbon (GOMECC-2) cruise was undertaken to map concentrations and trends of key carbon, physical, and biogeochemical parameters in the coastal ocean. Dr. Rik Wanninkhof of AOML's Ocean Chemistry Division led the effort and served as chief scientist for the first ten days of the cruise, while Dr. Michelle Wood, director of the Ocean Chemistry Division, served as the chief scientist for the remaining two weeks.



Drs. Michelle Wood and Leticia Barbero, chief and co-chief scientists for the GOMECC-2 cruise aboard the *Ronald H. Brown* with a CTD (conductivity-temperature-depth) instrument in the background.



Cruise track for the GOMECC-2 effort led by AOML researchers aboard the NOAA Ship *Ronald H. Brown*. A total of 93 CTD stations were completed at eight transects, as well as underway sampling performed along the U.S. Gulf and east coasts during the transit time between transects.

Dr. Leticia Barbero, also with the Ocean Chemistry Division, served as the co-chief scientist and was aided by AOML scientists that included Charles Featherstone, Charles Fischer, James Hooper, Esa Peltola, Kyle Seaton, Andy Stefanick, Kevin Sullivan, and Erik Valdes.

Comprehensive chemical and physical measurements from the ocean bottom to sea surface were performed with a CTD/Rosette/Niskin bottle setup along eight cross-shelf transects (see map above). The focus was to obtain a comprehensive suite of water column measurements of biogeochemical parameters that affect or are affected by ocean acidification. While underway between transects, the *Brown* transited coastal waters between 30 and 100 m depth, making extensive measurements of surface water conditions, collecting air samples continuously from the bow, and making meteorological measurements.

The GOMECC-2 cruise was undertaken in support of NOAA's Ocean Acidification Program to monitor changes in inorganic carbon dynamics due to anthropogenic carbon input and natural changes in coastal regions. It is hoped that the data gathered during the cruise from Miami to Boston will increase understanding of the processes that control ocean acidification and its impacts on coastal ecosystems.

Additional information about the GOMECC-2 cruise can be found at www.aoml.noaa.gov/ocd/gcc/GOMECC2/.

NOAA Boosts Number of Expected Storms for 2012 Atlantic Season

NOAA updated its seasonal hurricane outlook for the Atlantic basin on August 9th, increasing the likelihood for a more active season and the number of named storms expected to develop. In May, NOAA's pre-seasonal outlook predicted between nine and 15 named storms would form during the six-month long Atlantic hurricane season from June 1st to November 30th.

The updated outlook calls for an 85% chance of a near- or above-normal season, with 12-17 named storms, five to eight hurricanes, and two to three major hurricanes with winds above 111 mph (categories 3, 4, and 5 on the Saffir-Simpson hurricane scale).

The higher likelihood for a more active hurricane season is due to favorable wind patterns and warmer-than-average sea surface temperatures across the tropical Atlantic Ocean and Caribbean Sea, climatic factors that both support storm formation. The tropical multi-decadal signal, linked to increased Atlantic hurricane activity since 1995, also supports the likelihood of a busier season. While climate indicators suggest an El Niño event will develop, its suppressive influence on hurricane formation is not expected to be felt during the August-October period of peak activity for the Atlantic basin.

The 2012 hurricane season began with a burst of activity, with Tropical Storms Alberto and Beryl both developing before the official June 1st hurricane season start date. Tropical Storm Debby's formation in the Gulf of Mexico on June 23rd marked the first time since recordkeeping began in 1851 that four storms had developed in a single year before July.

Atlantic Storm Names for 2012

Alberto	Helene	Oscar
Beryl	Isaac	Patty
Chris	Joyce	Rafael
Debby	Kirk	Sandy
Ernesto	Leslie	Tony
Florence	Michael	Valerie
Gordon	Nadine	William

NOAA's 2012 Atlantic Hurricane Seasonal Outlooks

Activity Type	1981-2010 Averages	May 2012 Pre-Seasonal Outlook	August 2012 Updated Seasonal Outlook
Named Storms	12	9-15	12-17
Hurricanes	6	4-8	5-8
Major Hurricanes	3	1-3	2-3

NOAA cautions the outlook provides the public with only a general guide to the expected overall level of activity. It is not a seasonal hurricane landfall forecast, and it does not predict levels of activity for any particular region. Coastal residents and communities potentially impacted by landfalling storms should continue monitoring the tropics and have hurricane preparedness plans in place and ready to activate if the need arises.

NOAA's Atlantic hurricane seasonal outlook is an official product of its Climate Prediction Center, produced in collaboration with researchers from the National Hurricane Center and AOML's Hurricane Research Division (HRD). HRD meteorologist Stanley Goldenberg has been a member of NOAA's seasonal hurricane forecast team since its inception in 1998.

We are increasing the likelihood of an above-normal season because storm-conducive wind patterns and warmer-than-normal sea surface temperatures are now in place in the Atlantic. These conditions are linked to the ongoing high activity era for Atlantic hurricanes that began in 1995. Also, strong early-season activity is generally indicative of a more active season.

Dr. Gerry Bell
Lead Seasonal Hurricane Forecaster

Hurricane Isaac as viewed by the MODIS instrument aboard NASA's Terra satellite before landfall on August 28th. Isaac confounded forecasters on its long trek across the Atlantic Ocean and Caribbean Sea. In spite of favorable sea-surface temperatures that might have fueled Isaac's development, a prolonged encounter with dry Saharan air suspended in the Atlantic prevented the development of a clearly-defined eyewall. The system remained a tropical storm for the majority of its life cycle and only began strengthening after it entered the Gulf of Mexico. Isaac finally became a hurricane on August 28th just hours before landfall in Plaquemines Parish, about 90-95 miles southeast of New Orleans, Louisiana. Isaac lumbered ashore with 80 mph winds, torrential rains, and a storm surge that brought severe flooding to both coastal and inland communities.

Hurricane Andrew—20th Anniversary

Front view of the Naranja Lakes townhome where AOML electronics technician Michael Shoemaker spent the early morning hours of August 24, 1992 with his mother. The two survived by climbing out of the rubble and finding shelter at a neighbor's house as Andrew's eyewall passed overhead.

August 24, 2012 marked the 20-year anniversary of Hurricane Andrew's catastrophic south Florida landfall. The powerful category 5 hurricane came ashore near Homestead, Florida with maximum winds above 160 mph. Andrew leveled portions of south Florida, including Homestead Air Force Base. More than 250,000 individuals were left homeless, while 82,000 businesses were either damaged or destroyed. Twenty years later, Andrew remains one of the costliest disasters in U.S. history.

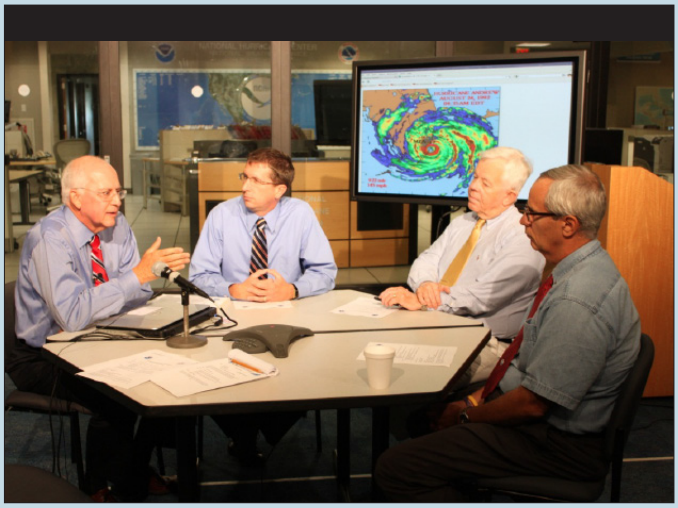
About 4:50 a.m., the wind seemed to be diminishing, and I risked looking up to see what kind of damage there was. The sight that greeted me was truly awe inspiring: the roof was totally gone and the bathroom wall above me was swinging unsupported from the top. But the most amazing sight was to be able to see the inside of the hurricane's eyewall with this churning mass of clouds lit from the sky full of stars.

Michael Shoemaker
AOML electronics technician

Hurricane Andrew was the topic of discussion at a media teleconference hosted by NOAA's National Hurricane Center (NHC) in Miami on July 24th. Four south Florida hurricane experts,

- Max Mayfield, WPLG-TV hurricane specialist and NHC hurricane specialist in 1992,
- Dr. Richard Knabb, Director of the National Hurricane Center,
- Dr. Hugh Willoughby, meteorology professor at Florida International University and Hurricane Research Division Director at AOML in 1992, and
- Dr. Frank Marks, Director of AOML's Hurricane Research Division

met to discuss Andrew in honor of the iconic storm's 20th anniversary on August 24th. Each panelist offered their personal and professional recollections of Andrew, provided insights into the evolving field of tropical meteorology, and spoke of the remaining challenges and goals for improving hurricane forecasts. Andrew became the third category 5 hurricane to strike the United States in the 20th century, following behind the Labor Day hurricane of 1935 and Hurricane Camille of 1969.



Max Mayfield, Richard Knabb, Hugh Willoughby, and Frank Marks discuss Hurricane Andrew at a media teleconference hosted by NOAA's National Hurricane Center on July 24th.

AOML director, Dr. Bob Atlas, represented NOAA leadership and AOML at an event hosted at Florida International University (FIU) in Miami on August 20th to commemorate the 20th anniversary of Hurricane Andrew. Bob spoke of NOAA's research and technology efforts in the years since Andrew that have vastly improved the understanding of hurricane dynamics and the quality of forecasts and warnings. He also spoke of NOAA's current efforts to improve operational forecasts through the Hurricane Forecast Improvement Project.

Other speakers included U.S. Congressmen Mario Diaz-Balart and David Rivera; Richard Knabb, director of the National Hurricane Center; Kate Hale, director of Miami-Dade County Emergency Management operations during Hurricane Andrew; Elizabeth Zimmerman, deputy associate administrator for Response and Recovery with the Federal Emergency Management Agency; and Mark Rosenberg, president of FIU.

The event also served as the official unveiling of FIU's newest facility, the Wall of Wind (WOW). WOW will be used for testing the impact of hurricane winds on built structures. The facility is comprised of 12 high-powered fans that can generate category 5 hurricane force winds (winds above 156 mph).

Researchers Continue Efforts to Improve Hurricane Intensity Forecasts

This summer, AOML's hurricane researchers are once again busy gathering data from the inner core and surrounding environment of tropical cyclones. Flying aboard NOAA's research aircraft, scientists with AOML's Hurricane Research Division (HRD) have been sampling tropical systems that form in the Atlantic and east Pacific basins with a suite of sophisticated instruments to better understand how and why tropical cyclones form, strengthen, and dissipate.

For more than 30 years, HRD has gathered data during the Atlantic and Pacific hurricane seasons as part of its annual Hurricane Field Program. While improvements have been made to track forecasts, understanding the complex processes that enable some storms to rapidly intensify have been more difficult to grasp.

To tackle this challenge, HRD began the Intensity Forecasting Experiment (IFEX) in 2005. Conducted in cooperation with NOAA's Environmental Modeling and National Hurricane Centers, as well as other partners, IFEX is a multi-year effort aimed at gathering data from all stages of the tropical cyclone life cycle. By studying storms from their earliest formation to landfall or decay over the open ocean, researchers hope to develop a better understanding of the internal processes and environment interactions that fuel or weaken tropical cyclone development.

The knowledge and insights gained from IFEX are assisting researchers improve current forecast models, as well as the next-generation, high-resolution hurricane model, the Hurricane Weather Research and Forecasting (HWRF) model.

NOAA Administrator, Dr. Jane Lubchenco, works with Hurricane Research Division meteorologist Lisa Bucci to process data from a GPS dropsonde during an August 27th mission into Isaac aboard NOAA's P-3 hurricane hunter aircraft.

Among the Atlantic storms sampled during the 2012 hurricane season, AOML researchers monitored Hurricane Isaac for more than a week as the tenacious system trekked across the Atlantic Ocean and into the Gulf of Mexico. In spite of favorable environmental conditions that might have enabled Isaac to intensify, the storm was instead hindered for the majority of its life cycle by dry air that prevented it from developing a strong inner core.

Research missions aboard NOAA's P-3 and Gulfstream-IV jet aircraft began for Isaac on August 21st just as the system strengthened into a tropical storm east of the Lesser Antilles. HRD researchers continued observing Isaac and providing real-time data to NOAA's National Hurricane Center until its landfall along the southeast Louisiana coast on August 28th as a category 1 hurricane.

Documenting Isaac's strengthening into a hurricane just hours before landfall fulfilled a major objective for IFEX and provided researchers with new insights into the factors that impact intensification. Insights that will, no doubt, ultimately lead to more accurate intensity forecasts.

Dr. Robert Detrick, Assistant Administrator for NOAA's Office of Oceanic and Atmospheric Research, views real-time tail Doppler radar data with Dr. Paul Reasor of AOML's Hurricane Research Division during a NOAA P-3 mission into Tropical Storm Isaac on August 27th.

Bhavna Rawal aboard the RV *F.G. Walton Smith* prepares water samples for nutrient analysis during an ecosystem monitoring cruise conducted in support of AOML's South Florida Program.

Bhavna Rawal, a science teacher at Northbrook High School in Houston, Texas, participated in the August cruise of AOML's South Florida Program as a 2012 NOAA Teacher at Sea. The program enables teachers to work alongside scientists and crew members during seagoing missions to better understand the marine and atmospheric sciences. The overall goal is for teachers to share the knowledge they've gained with their students.

During the five-day cruise aboard the *F.G. Walton Smith,* Bhavna worked with the scientific team to gather water, sargassum, and plankton samples at 80 stations. She also worked in the wet/dry labs and helped to process and analyze samples for a variety of physical, biological, and chemical components.

AOML researchers and the University of Miami's Rosenstiel School have been conducting the bimonthly cruises of Florida Bay and south Florida's coastal waters since the early 1990s to assess changing patterns of circulation and water quality in the region. Read more about Bhava's experiences as a member of the scientific team on her blog site at http://teacheratsea.wordpress.com/category/bhavna-rawal/.

Workshop Convened to Improve Tropical Cyclone Predictions Over Indian Seas

An international workshop convened to improve tropical cyclone predictions for the North Indian Ocean was held in Bhubaneswar, India on July 9-14th. The six-day event was hosted by the Indian Institute of Technology, Bhubaneswar and featured tropical cyclone experts from India, Australia, and the United States. Dr. Frank Marks, Director of AOML's Hurricane Research Division (HRD), led the U.S. delegation, while Dr. Sundararaman Gopalakrishnan of HRD served as one of the workshop's three principal organizers.

The North Indian Ocean, comprised of the Arabian Sea and Bay of Bengal, generates only 4-6% of the globe's tropical cyclones, yet is responsible for the highest number of cyclone-related deaths worldwide. More than 10,000 fatalities have occurred from each of the last 20 out of 23 tropical cyclone events on the Indian subcontinent. One of the deadliest natural disasters of modern times, the Bhola cyclone of 1970, caused an estimated 500,000 deaths in Bangladesh (formerly East Pakistan) due to storm-surge related flooding of low-lying areas.

The Indian seas account for only 4-6% of the globe's tropical cyclones yet claim the highest number of cyclone-related fatalities worldwide.

The *Advanced Indo-U.S. Training Workshop and Colloquium on Modeling and Data Assimilation for Tropical Cyclone Predictions* featured 11 eminent scientists from the United States, five from India, and one from Australia. Training sessions consisted of 36 hours of lectures and 10 hours of colloquiums, plus discussion sessions and opportunities for participant-lecturer interactions. More than 27 young scientists from academic and meteorological research organizations across India attended, as well as four young scientists from U.S. universities.

Participants of the Indo-U.S. workshop in Bhubaneswar, India. Workshop organizers and lecturers, seated in the first row, are from left to right: Dr. Sandeep Pattnaik, Dr. Sundararaman Gopalakrishnan (of AOML), Professor Fuqing Zhang, Dr. Vijay Tallapragada, Professor Dev Niyogi, Professor Uma Charan Mohanty, Professor Tiruvalum Krishnamurti, Dr. Frank Marks (of AOML), Professor P.C. Panda, Professor Mike Montgomery (of AOML), Professor Dalin Zhang, Dr. Noel Davidson, Dr. M. Ravichandran, Professor Subhasish Tripathy, and Dr. Jian Wen Bao (standing fourth from right) along with participants.

Central to the workshop was NOAA's high-resolution, state-of-the-art Hurricane Weather Research and Forecast (HWRF) modeling system. HWRF became operational in 2007 and has since improved tropical cyclone track, intensity, and structure forecasts. India's Ministry of Earth Sciences and NOAA signed an Implementing Arrangement under the Memorandum of Understanding in 2010 for the India Meteorological Department (IMD) and HRD to improve tropical cyclone forecasts over the Indian seas. As part of this agreement, NOAA transferred the HWRF modeling system to the IMD and its partnering research institution, the Indian Institute of Technology, Delhi.

The workshop thus enabled a sharing of data assimilation and forecasting techniques acquired over the past few years by NOAA and its partnering institutions in the United States. HWRF is now the operational standard for hurricane track and intensity forecasts issued by NOAA's National Hurricane Center in Miami, Florida.

Several organizations jointly sponsored the workshop, including the Indo-U.S. Science and Technology Forum, Council of Scientific and Industrial Research, Ministry of Earth Sciences (of India), NOAA, and the National Science Foundation.

More accurate and timely warnings hold the potential to significantly reduce both the loss of life and property in India. To this end, the workshop paved the way for extensive improvements to be made in cyclonic predictions over the North Indian Ocean. Current track forecast errors are expected to be reduced by at least 20% by 2015, while intensity and rainfall forecasts are expected to be extended from three-day to five-day forecasts by 2015.

Dr. Sundararaman Gopalakrishnan of AOML's Hurricane Research Division, one of three organizers for the workshop, delivered a keynote address in which he emphasized the importance of accurate forecasts for saving lives and property.

Dr. Frank Marks, Director of AOML's Hurricane Research Division, led the U.S. delegation at the workshop in Bhubaneswar, India in July.

South Atlantic Deep Western Boundary Current Measurements Collected during International Cruise

Researchers with AOML's Physical Oceanography Division (PhOD) joined partners from several Argentine universities and agencies on a joint cruise during the first half of July to collect observations of the Deep Western Boundary Current along 34.5°S. The observations were gathered as part of the NOAA-funded Southwest Atlantic Meridional Overturning Circulation (SAM) project.

The cruise aboard the Argentine research vessel ARA *Puerto Deseado* was conducted as part of an international collaborative program to monitor the western boundary components of the global Meridional Overturning Circulation (MOC) in the South Atlantic. The MOC is a slow vertical circulation that exchanges surface and deep waters via poleward surface transports, sinking at high latitudes, and upwelling elsewhere. The variability of the Atlantic MOC has been shown in numerical models to impact global climate signals such as precipitation and air temperature over large portions of the Northern Hemisphere and beyond.

Observations of the southern portion of the Atlantic MOC are critical to gaining a more complete picture of this complex ocean circulation system. The SAM array (see map) has been in the water since March 2009 and, since July 2011, has consisted of four inverted echo sounders equipped with pressure gauges (PIES).

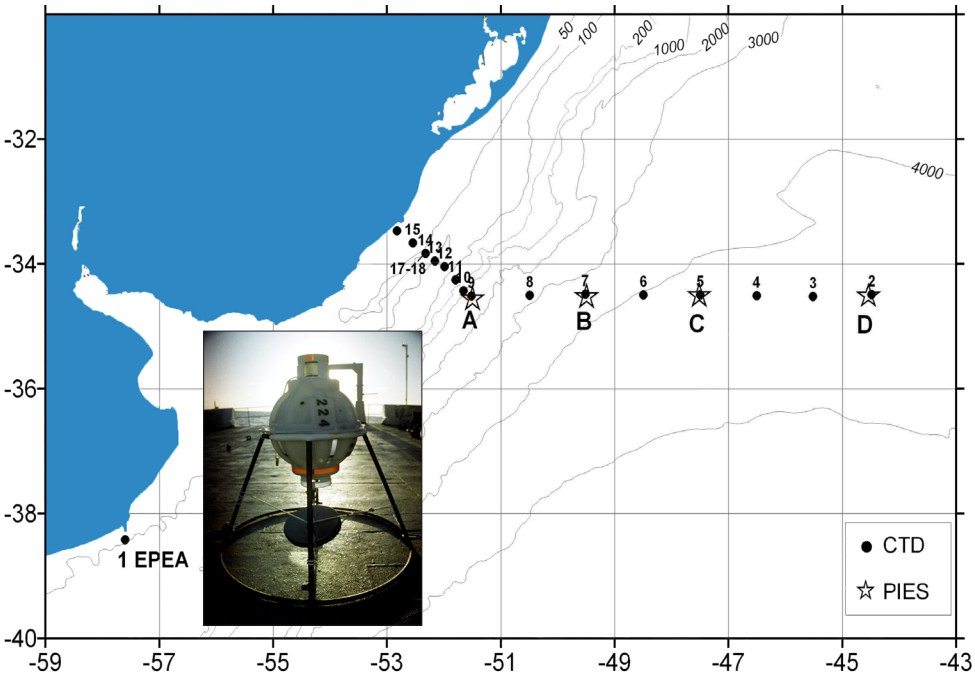
The PIES array is anchored on the ocean floor at depths ranging from 1300 m to 4700 m. The instruments send sound pulses to the sea surface and listen for the return of the reflected sound waves. The round-trip travel time of these acoustic pulses are then combined with hydrographic data (Argo float data, historical conductivity-temperature-depth [CTD] data, and CTD data collected during the SAM cruises) to obtain daily estimates of the temperature and salinity profiles for the full water column.

During this most recent research cruise, scientists acoustically downloaded the data recorded from this line of moored instruments and collected data from a new CTD section. PhOD researchers continue to work with collaborators at the University of Miami, Scripps Institute of Oceanography, and the Massachusetts Institute of Technology, as well as with scientists from Argentina, Brazil, France, and South Africa, to plan a complete trans-basin array of moored instruments in the South Atlantic.

Scientific team for the July 2012 research cruise aboard the Argentine research vessel ARA *Puerto Deseado.*

In this context, the SAM array will be the western boundary component and an important part of this new array, which will allow for the measurement of all components of the MOC at 34.5°S, leading to an improved understanding of the global MOC system.

NOAA's contribution to this effort is funded by the Climate Program Office/ Climate Observation Division, with additional ship time resources provided by the naval hydrographic service agencies of Argentina and Brazil.



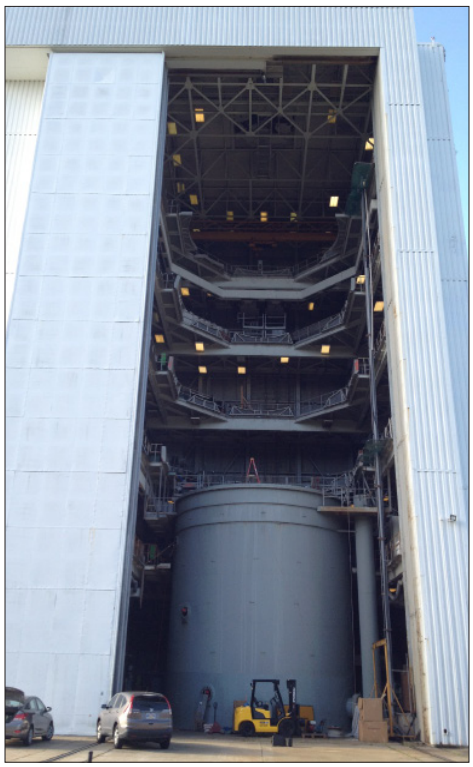
Map of the Argentine coast with the array of pressure-inverted echo sounders (stars) and conductivity-temperature-depth (CTD) stations (black circles) along 34.5°S where data were collected in July 2012. Inset: image of a pressure-inverted echo sounder instrument.

XBT Experiments Conducted to Boost Data Accuracy

In July, Grant Rawson and Pedro Pena of AOML's Physical Oceanography Division conducted an experiment at the Stennis Space Center in Mississippi to determine the fall rate and terminal velocity of expendable bathythermographs (XBTs) during the first meters of their fall. The experiment took place over three days at a NOAA/Southeast Fisheries Science Center test tank within the Space Center facility.

This tank was added to the existing building in the late 1970s for instrument testing and diver training. The tank is 11.5 m tall, 11 m deep, and 10 m wide. The building housing the tank was initially used to prep Saturn rockets before sending them to the launch pad for testing and is 40 m tall inside. This height was ideal for mimicking how an XBT falls when it is deployed from the bridge of a cargo ship, the preferred platform for XBT deployments.

Rawson and Pena were joined by NOAA volunteer divers from Pascagoula, Mississippi, who helped with the in-water operations. Video footage was captured of each drop on a series of four cameras



The NOAA test tank at the Stennis Space Center in Mississippi.

mounted to the side of the tank to create a complete picture of the probe descending through the water column. Behind the drops was a reference line to measure the distance each probe traveled from frame to frame in the video.

In all, more than 130 drops were made at heights ranging from 0 to 26 m to determine the effect that drop height has on the velocity and acceleration of a probe. The next step in the experiment will be to process each drop from each camera frame by frame using tracking software, which simultaneously computes velocity and acceleration.

The XBT network is the main component of the Ship of Opportunity Program, and it is geared towards measuring the upper ocean thermal structure in the open ocean along fixed transects. These temperature observations are used to monitor the variability of key surface and subsurface currents that are critical to understanding the role of the ocean on climate and extreme weather events.

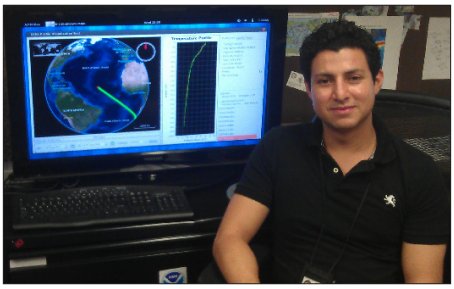
The results from this experiment will allow scientists to reduce the errors of observations taken with XBTs, which represent the largest contribution to the historical global temperature record.

New Web Tool Enables Remote Monitoring of XBT Deployments and Data

Researchers with the Physical Oceanography Division have developed a web-based application to monitor expendable bathythermograph (XBT) deployments and data quality in support of AOML's Ship of Opportunity Program (SOOP). XBTs are probes deployed from ships along transects in all the world's oceans to measure the thermal structure of the upper ocean.

The top priorities for the SOOP project are the deployment, transmission, and dissemination of XBT data in real time through the Global Telecommunication System, and this new application constitutes a critical tool for monitoring these activities.

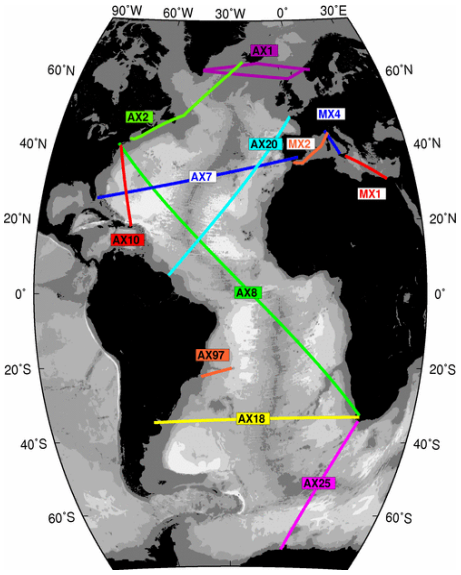
Using the application, onshore personnel can remotely view the location of XBT deployments and their data profiles in real-time. This capability enables them to quickly detect anomalies that could impact data collection or transmission. It also enables them to provide ship riders with feedback on how to resolve these issues, thus avoiding and/or minimizing the loss of XBT data. The tool is available



Jaime Soto of AOML's Ship of Opportunity Program with a computer monitor that displays the new web application developed within the Physical Oceanography Division to remotely monitor and troubleshoot XBT operations.

on AOML's XBT network web page at www.aoml.noaa.gov/phod/goos/xbt_network/index.php.

Data obtained from the SOOP project are used for climate and other scientific studies. Several applications include the study of the ocean's heat storage and the global transport of heat and fresh water. These data are crucial for improving climate prediction models that are initialized using XBT temperature profiles. XBT data submitted to the Global Telecommunications System are also used by data and weather predictions centers to initialize models for weather forecasts.



The network of expendable bathythermographs (XBTs) consists of transects across all ocean basins. XBTs are used to collect temperature observations of the upper 1 km of the ocean and are deployed from research vessels and merchant ships that participate in NOAA's Ship of Opportunity Program. The transects are sampled in two modes: high density and frequently repeated. High density transects measure the upper ocean's thermal structure in key regions to study the temporal variability of surface and subsurface currents and the meridional transport of heat in the Atlantic Ocean. Frequently-repeated XBT transects are predominantly located in tropical regions to monitor seasonal to interannual variability.

Tropical Connections Highlights South Florida's Unique Marine Environment

Pamela Fletcher, a Florida Sea Grant liaison at AOML, and William Kruczynski of the U.S. Environmental Protection Agency are the creators and editors of a new book dedicated to the marine habitats of south Florida. Six years in the making, *Tropical Connections: South Florida's Marine Environment* was published by IAN Press in July.

Tropical Connections is intended to "further the understanding and appreciation of south Florida's diverse and complex ecosystem, correct misconceptions about facts or ecological processes, and promote conservation and management decisions that are based upon sound, defensible scientific findings." The 473-page volume was prepared as a resource for students, educators, policy makers, and everyone interested in learning about south Florida's unique marine ecosystem.

Readers are taken on a journey through the history of the south Florida coastal region. Fletcher and Kruczynski worked with 162 environmental experts from varied disciplines to create easy-to-read fact pages that touch upon every aspect of the marine ecosystem, from the impacts of Henry Flagler's railroad, to hardwood hammocks, to hurricanes. An abundance of maps, charts, diagrams, and photographs help convey the message and enhance the understanding of scientific concepts.

The fact pages are organized under eight chapters that highlight important elements of research and management activities in the region. Chapter introductions present summaries of the most important information and enable the reader to discover interesting facts about

The new *Tropical Connections* book examines south Florida's coastal marine environment from Charlotte County on the west coast to Martin County on the east coast.

scientific findings, research techniques, and management strategies. Each chapter contains an annotated bibliography as a resource for those who would like to learn more about topics covered in the book.

Nine scientists from AOML contributed material for the book, covering topics such as plankton, coastal ocean currents, observing systems, water quality, the roles of sea surface temperature and salinity, and the impacts of hurricanes. Other regional NOAA contributors include the Southeast Fisheries Science Center and the Florida Keys National Marine Sanctuary.

More than 1,500 copies of *Tropical Connections* have been distributed to schools, universities, community leaders,

We wanted to take all of the valuable lessons being learned in our research institutions and management agencies and transfer them in a meaningful way to everyone connected to the south Florida ecosystem.

Pamela Fletcher

and management agencies in south Florida counties. Elisabeth Jacobi, a Broward County marine science teacher, as well as a former Broward County Environmental Educator of the Year and NOAA Teacher at Sea, plans to use the book in her classroom. "A resource like this has never existed before," said Jacobi. "It succinctly touches on all aspects of our marine ecosystem and will help me teach the next generation of coastal citizens to understand, enjoy, and hopefully protect the beauty and richness of this region."

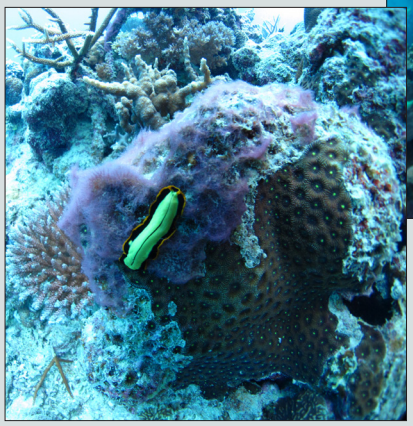
Tropical Connections provides a comprehensive exploration of the wonderous natural world residing just offshore the bustling coastal communities of south Florida and documents the many stresses that threaten its well being, due in large measure to human activity. It challenges the reader to consider the interconnectedness of all living systems and the need for environmental stewardship to ensure the survival of this priceless ecosystem for generations yet to come.

Members of the Early Life History Group at NOAA's Southeast Fisheries Science Center (SEFSC) hosted a gathering at AOML on July 20th to express their gratitude for the use of laboratory space. The group temporarily relocated its operations to AOML in June while the SEFSC facility was undergoing renovations.

Derek Manzello, a coral researcher with the Coral Health and Monitoring Program at AOML, was an invited guest scientist for the Galapagos leg of a Global Reef Expedition cruise sponsored by the Khaled bin Sultan Living Oceans Foundation. For two weeks in June, Derek measured seawater carbon dioxide (CO_2) concentrations, collected coral cores from three coral species, and obtained reef framework samples at Darwin Island, the site of the only remaining coral reef in the Galapagos Islands. The work was undertaken to better understand the impacts of ocean acidification on the health and resilience of coral reefs. Additional information about Derek's participation in the cruise can be found at www.sciencewithoutborders.org/corals-and-carbon-dioxide/.

Derek Manzello places a pH sensor on Darwin Reef, the only coral reef in the Galapagos Islands that survived the El Niño warming event of 1982-1983.

Coral researchers with the Coral Health and Monitoring Program at AOML attended the 12th International Coral Reef Symposium (ICRS) in Queensland, Australia on July 9-13th. The event is hosted every four years by the International Society of Reef Studies and has become the largest forum for the coral reef science community. More than 2000 participants from 80 countries attended the 12th ICRS to share research findings, exchange ideas, build partnerships, and raise awareness of the value, beauty, and fragility of coral reefs. NOAA Administrator, Dr. Jane Lubchenco, made one of nine invited plenary presentations, while AOML's participants—Ian Enochs, Jim Hendee, Derek Manzello, and Ruben van Hooidonk—made numerous presentations within a wide range of symposia themes. Jim Hendee also organized and chaired the *Sensor Networks and their Applications* mini symposium.



While in Australia, AOML's coral researchers had the opportunity to visit a coral reef monitoring station in Agincourt Reef. The site is located on the outer periphery of the Great Barrier Reef, the largest coral reef system in the world. The pristine waters of Agincourt Reef are home to countless coral and marine species as depicted by the images above and to the left. The Great Barrier Reef is composed of more than 2900 individual reefs and covers an area of approximately 133,000 square miles.

Pamela Fletcher and Mike Jankulak of AOML's Ocean Chemistry Divison spent the last week of August in La Parguera, Puerto Rico, performing an extensive equipment swapout on the Coral Reef Early Warning System (CREWS) station located at Media Luna Reef. They were hosted and assisted by personnel from the University of Puerto Rico on the nearby Isla Magueyes. The Puerto Rico CREWS station instruments were last replaced in November of 2010, nearly two years ago, and three of its four underwater instruments had failed before the station went completely offline on April 16, 2012. On this visit, all of the station's underwater cables were replaced, as well as its rechargeable batteries, representing the most significant upgrade to the station since it first began transmitting in January 2006. The station's CTD (conductivity-temperature-depth) sensors were upgraded with different models that are expected to be more reliable. By the end of the week, all meteorological and oceanographic sensors were functioning normally. More information about the La Parguera CREWS site and a detailed account of the work performed on the site may be found at the station's maintenance blog at http://lppr1-log.blogspot.com/.

Perched 18-20 feet above sea level, Mike Jankulak of AOML installs a Vaisala weather transmitter atop the La Parguera CREWS station in Puerto Rico.

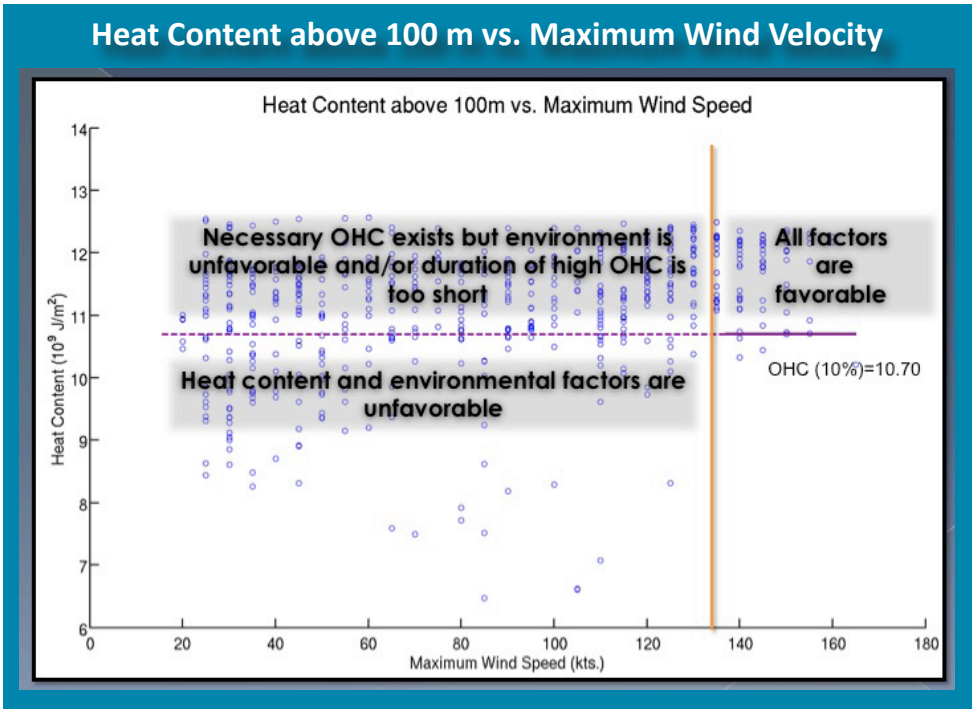
Role of the Atlantic Warm Pool in the Development of Category 5 Hurricanes

Alexandra Ramos, an Undergraduate Scholar of NOAA's Educational Partnership Program, worked as a student intern with the Climate and Hurricane Group of AOML's Physical Oceanography Division during the summer of 2012.

During her stay at AOML, Ms. Ramos investigated the potential role of the Atlantic warm pool (AWP) in hurricane intensification. It has been shown that variability in the AWP—a large body of warm water comprised of the Gulf of Mexico, Caribbean Sea, and western tropical North Atlantic—can influence the number and track of Atlantic hurricanes by changing large-scale atmospheric circulation patterns and other thermodynamic variables. However, it is still unclear if and how the AWP might affect hurricane intensification.

Ms. Ramos analyzed upper ocean temperature data derived from the Simple Ocean Data Assimilation (SODA) data set, version 2.2.6, from 1971 to 2008 in the AWP region associated with tropical cyclone activity. All category 5 hurricanes that originated or developed within the AWP region during this 38-year period were identified.

Their trajectories were plotted against the monthly ocean heat content above 100 meters to examine the behavior of each individual hurricane as it passed through areas of high or low ocean heat content. Results indicated that more than 90% of the category 5 hurricanes intensified in areas of high ocean heat content.



Maximum wind speed of tropical cyclones plotted against the corresponding ocean heat content. It is shown that high ocean heat content is a necessary condition for a tropical cyclone to intensify into a category 5 hurricane.

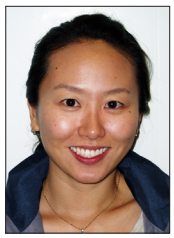
Although other atmospheric variables have to be taken into account, these preliminary results suggest that a high ocean heat content in the AWP area may be a necessary condition for a tropical cyclone to develop into a category 5 hurricane, and that an ocean heat content threshold of 10.7×10^9 J/m^2 is found for category 5 hurricanes (see the figure above). The study suggests that subsurface temperature profiles may be useful as predictors when forecasting the intensity of a tropical cyclone.

In early August, Ms. Ramos presented her research at the 2012 Science and Education Symposium hosted by NOAA's Office of Education. Her presentation, *Role of the Atlantic Warm Pool in the Development of Category 5 Hurricanes,* earned her a score of 94 out of 100. She is currently a physics major attending the University of Puerto Rico at Mayaguez.

AOML hosted its second annual Student Intern Symposium on July 28th. The symposium provided students enrolled in summer internship programs at AOML and at other NOAA facilities in south Florida with the chance to practice making a presentation before a friendly audience, share research results, and discuss their summer experiences. Thanks to Maribeth Gidley of AOML for organizing and hosting the event.

Student interns and their mentors in the first-floor conference room at AOML. Pictured from left to right are Casey Peirano (NOAA Hollings Scholar), Heather Coit (student intern), David Enfield, Alexandra Ramos (NOAA Undergraduate Scholar), Sang-Ki Lee, Alexis Avery (NOAA Hollings Scholar), Aditya Shetty (student intern), Chris Sinigalliano, Rosimar Rios-Berrios (student intern), Maribeth Gidley, Tomislava Vukicevic, Joshua Alland (NOAA Hollings Scholar), Sundararaman Gopalakrishnan, and John Kaplan.

Farewell



Dr. Geun-Ha Park, a CIMAS research scientist with AOML's Ocean Carbon Group, departed AOML in early August to accept a position at the East Sea Research Institute of the Korean Institute of Ocean Science and Technology in Uljin, Korea. During Geun-Ha's three years at AOML, she studied the variability of sea-air carbon dioxide (CO_2) exchange and developed a novel method for estimating seasonal sea-air CO_2 fluxes in near-real time. She was supported with funds from the Climate Observations Division of NOAA's Climate Program Office. The regional and global CO_2 flux estimate Geun-Ha developed can be viewed and extracted from the NOAA ERDAP server at http://cwcgom.aoml.noaa.gov/erddap/griddap/aomlcarbonfluxes.graph.

It's a Boy!

Dana Wusinich-Mendez, a coral reef conservation specialist with NOAA's National Ocean Service stationed at AOML, and her husband Emilio are the proud parents of their first child, a son. Mateo Joseph Mendez was born in Miami on August 17, 2012 and weighed in at 7 lbs. 7 oz. Mateo and his parents are all fine and doing well.

Dr. Tomislava Vukicevic of AOML's Hurricane Research Division meets Dr. Richard Knabb.

The new director of NOAA's National Hurricane Center in Miami, Dr. Richard Knabb, visited AOML on July 26th. While at AOML, Dr. Knabb met with staff from the Hurricane Research Division to learn more about their recent research and field program activities. He was also welcomed by other AOML staff members during an all-hands gathering in the NOAA Miami Regional Library at AOML.

Congratulations

Peter Dodge, John Gamache, and Frank Marks, all meteorologists with AOML's Hurricane Research Division, are the recipients of a 2012 NOAA Administrator's Award. The trio are members of a group that was recognized for its outstanding management of the tail Doppler radar project aboard NOAA's Gulfstream-IV (G-IV) high-altitude jet aircraft. Measurements from the G-IV's tail Doppler radar have enabled scientists to obtain three-dimensional vertical profiles of the wind speed, direction, and precipitation in tropical cyclones. These data are being used to improve forecast models and have become fundamental to enhancing NOAA's weather forecasting and research capabilities.

Pamela Fletcher, a Florida Sea Grant liaison at AOML, was recently certified to conduct benthic and fish assessments by Reef Check, an international non-profit organization dedicated to preserving and sustaining reefs ecosystems around the world. Pamela hopes to use the Reef Check methodology, which has become an international standard for evaluating reef health, to contribute to the Integrated Coral Observing Network/Coral Reef Early Warning System (ICON/CREWS) database currently being developed at AOML. Additional information about Reef Check can be found at www.reefcheck.org.

Kelly Goodwin and Christopher Sinigalliano of AOML's Environmental Microbiology Program are the recipients of a 2012 NOAA Technology Transfer Award. Kelly and Chris were recognized for their leadership in developing microbial source tracking tools for identifying contamination sources in coastal waters. These tools are now being used by city and county managers to devise mitigation strategies for restoring water quality, decrease risks to human health, and preserve coastal economies.

Michael Jankulak of AOML's Ocean Chemistry Division earned a Master of Science degree in electrical and computer engineering (MSECE) from the University of Miami's College of Engineering in July. Mike's thesis, *Prediction of Rapid Intensity Changes in Tropical Cyclones using Associative Classification*, explored applications of data mining technologies to the problem of predicting the rapid intensification and rapid weakening of tropical cyclones, working with the Statistical Hurricane Intensity Prediction Scheme (SHIPS) dataset. Mike's project involved mining this dataset for association rules, building them into a classifier, and comparing the performance of this classifier against other artificial intelligence techniques such as decision trees, neural networks, adaptive boosting, and support vector machines.

Liping Zhang, a CIMAS associate scientist with AOML's Physical Oceanography Division, earned a Ph.D. in physical oceanography from the Ocean University of China in June. Liping's thesis focused on the impact of the hydrological cycle on climate under the global warming scenario based on data analysis and climate modeling experiments. Because of her thorough research, she was named an "Excellent Doctoral Student" by China's Ministry of Education. Liping was also recognized as being an outstanding graduate student of the Ocean University of China in Shandong Province. She is currently researching the relationship of the Atlantic warm pool to the Atlantic meridional overturning circulation.

Federal employees are required to complete a mandatory training about the No FEAR Act by November 2, 2012. The online course can be accessed at https://doc.learn.com.

Travel

Rik Wanninkhof attended the 2012 Aquatic Sciences meeting of the Association for the Sciences of Limnology and Oceanography in Otsu, Japan on July 8-13, 2012.

Michelle Wood attended the Diel Cycles Workshop at the Bigelow Laboratory in Boothbay Harbor, Maine on July 9-11, 2012.

Shenfu Dong made a presentation at the American Meteorological Society's 18th Air-Sea Interaction Conference in Boston, Massachusetts on July 9-12, 2012.

Sundararaman Gopalakrishnan, Frank Marks, and Michael Montgomery attended the Advanced Indo-U.S. Workshop and Colloquium on Modeling and Data Assimilation for Tropical Cyclone Predictions in Bhubaneswar, India on July 9-14, 2012.

Ian Enochs, James Hendee, Derek Manzello, and Ruben van Hooidonk attended the 12th International Coral Reef Symposium in Cairns, Australia on July 9-13, 2012.

Bob Atlas attended a NOAA Senior Research Council meeting in Seattle, Washington on July 16-19, 2012. He also met with colleagues at NASA's Jet Propulsion Laboratory in Pasadena, California and gave two scientific talks at the Optical Engineering and Applications Symposium in San Diego, California on August 12-16, 2012.

Rick Lumpkin attended the 2012 CLIVAR Summer Summit meeting in Newport Beach, California on July 17-20, 2012.

Alan Leonardi attended a meeting of NOAA's Southeast and Caribbean Regional Team (SECART) in Charleston, South Carolina on July 23-27, 2012.

Paul Willis attended and made a presentation at the 16th Conference on Clouds and Precipitation in Leipzig, Germany on August 3, 2012.

Molly Baringer, Shenfu Dong, Silvia Garzoli, Gustavo Goni, Christopher Meinen, and Chunzai Wang attended the U.S. Atlantic Meridional Overturning Circulation Annual Principal Investigators meeting in Boulder, Colorado on August 15-17, 2012.

Recent Publications *(AOML authors are denoted by capital letters)*

Amarin, R.A., W.L. Jones, S.F. El-Nimri, J.W. Johnson, C.S. Ruf, T.L. Miller, and E. UHLHORN, 2012: Hurricane wind speed measurements in rainy conditions using the airborne Hurricane Imaging Radiometer (HIRAD). *IEEE Geoscience and Remote Sensing,* 50(1):180-192.

ENOCHS, I.C., and D.P. MANZELLO, 2012: Responses of cryptofaunal species richness and trophic potential to coral reef habitat degradation. *Diversity,* 4(1):94-104.

FOLTZ, G.R., M.J. McPhaden, and R. LUMPKIN, 2012: A strong Atlantic meridional mode event in 2009: The role of mixed layer dynamics. *Journal of Climate,* 25(1):363-380.

HUANG, X.-L., and J.-Z. ZHANG, 2012: Hydrolysis of glucose-6-phosphate in aged, acid-forced hydrolyzed nanomolar inorganic iron solutions: An inorganic biocatalyst? *RSC Advances,* 2(1):199-208.

KLOTZ, B.W., and P. Kucera, 2012: Observations of coastally transitioning west African mesoscale convective systems during NAMMA. *International Journal of Geophysics,* 2012:438706, 25 pp.

Li, W.-W., C. WANG, D. Wang, L. Yang, and Y. Deng, 2012: Modulation of low-latitude west wind on abnormal track and intensity of Tropical Cyclone Nargis (2008) in the Bay of Bengal. *Advances in Atmospheric Sciences,* 29(2):407-421.

MONTGOMERY, M.T., C. Davis, T. Dunkerton, Z. Wang, C. Velden, R. Torn, S.J. Majumdar, F. Zhang, R.K. Smith, L. Bosart, M.M. Bell, J.S. Haase, A. Heymsfield, J. Jensen, T. Campos, and M.A. Boothe, 2012: The Pre-Depression Investigation of Cloud Systems in the Tropics (PREDICT) experiment: Scientific basis, new analysis tools, and some first results. *Bulletin of the American Meteorological Society,* 93(2):153-172.

PEREZ, R.C., S.L. GARZOLI, C.S. MEINEN, and R.P. Matano, 2011: Geostrophic velocity measurement techniques for the Meridional Overturning Circulation and meridional heat transport in the South Atlantic. *Journal of Atmospheric and Oceanic Technology,* 28(11): 1504-1521.

REASOR, P.D., and M. Eastin, 2012: Rapidly intensifying Hurricane Guillermo (1997), Part II: Resiliency in shear. *Monthly Weather Review,* 140(2):425-444.

ROGERS, R., S. LORSOLO, P. REASOR, J. GAMACHE, and F.D. MARKS, 2012: Multiscale analysis of tropical cyclone kinematic structure from airborne Doppler radar composites. *Monthly Weather Review,* 140(1):77-99.

Song, Z., F. Qiao, X. Lei, and C. WANG, 2012: Influence of parallel computational uncertainty on simulations of the Coupled General Climate Model. *Geoscientific Model Development,* 5:313-319.

Turk, D., C.S. MEINEN, D. Antoine, M.J. McPhaden, and M.R. Lewis, 2011: Implications of changing El Niño patterns for biological dynamics in the equatorial Pacific Ocean. *Geophysical Research Letters,* 38: L23603, 6 pp.

UHLHORN, E.W., and D.S. Nolan, 2012: Observational undersampling in tropical cyclones and implications for estimated intensity. *Monthly Weather Review,* 140(3): 825-840.

VAN HOOIDONK, R., and M. Huber, 2012: Effects of modeled tropical sea surface temperature variability on coral reef bleaching predictions. *Coral Reefs,* 31(1):121-131.

Van Sebille, E., M.O. BARINGER, W.E. Johns, C.S. MEINEN, L.M. Beal, M. Femke de Jong, and H.M. van Aken, 2011: Propagation pathways of classical Labrador Sea water from its source region to 26°N. *Journal of Geophysical Research,* 116:C12027, 18 pp.

Atlantic Oceanographic and Meteorological Laboratory

4301 Rickenbacker Causeway
Miami, FL 33149
www.aoml.noaa.gov

Dr. Robert Atlas.....Director
Dr. Alan Leonardi.....Deputy Director
LCDR Stephen Meador....Associate Director
Dr. Silvia Garzoli.....Chief Scientist
Dr. Frank Marks.....Hurricane Research Division Director
Dr. Michelle Wood.....Ocean Chemistry Division Director
Dr. Gustavo Goni.....Physical Oceanography Division Director

Keynotes is published bimonthly to highlight AOML's recent research activities and staff accomplishments.

***Keynotes* publishing editor:** Gail Derr

AOML conducts research to understand the physical, chemical, and biological characteristics and processes of the ocean and the atmosphere, both separately and as a coupled system. The principal focus of these investigations is to provide knowledge that leads to more accurate forecasting of severe storms, better utilization and management of marine resources, better understanding of the factors affecting both climate and environmental quality, and improved ocean and weather services for the nation.