



# 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*

## Wealth of Data Gathered in Tropical Atlantic Support Climate Variability Studies

Researchers from the Physical Oceanography Division of AOML participated in a tropical Atlantic cruise beginning in November to collect oceanographic and atmospheric data, and service five surface moorings. The cruise, in support of the Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) Northeast Extension project (PNE), has been conducted about once per year starting in 2006 with the aim of improving understanding and predictability of climate variability in the tropical Atlantic.

The 2013 PNE cruise departed Bridgetown, Barbados on November 11th aboard the NOAA ship *Ronald H. Brown* and concluded in Recife, Brazil on December 8th. Four groups participated and focused on the following activities: hydrography, moorings, infrared radiation and skin temperature, and atmosphere.

Oversight of the cruise and collection of hydrographic data were accomplished by an AOML team of four: Gregory Foltz (Chief Scientist), Renellys Perez, Grant Rawson, and Shaun Dolk. A technician from NOAA's Pacific Marine Environment Laboratory (PMEL) oversaw the mooring recovery and deployment operations, and a scientist from the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS) acquired ocean skin temperature and



Participants of the November-December 2013 PIRATA Northeast Extension cruise. Not shown are Shaun Dolk (AOML), Everette Joseph (AEROSE), Elsa Castillo (AEROSE), and Malgorzata Szczodrak (RSMAS).

infrared radiation measurements. The Aerosols and Ocean Science Expeditions (AEROSE) group from NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) and Howard University collected atmospheric measurements throughout the cruise.

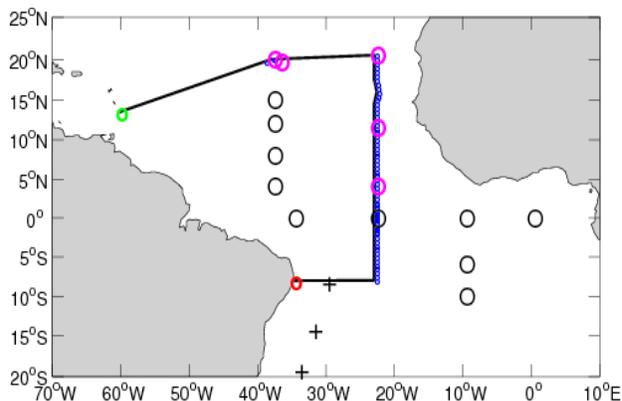
PIRATA is an international partnership between the United States, Brazil, and France to maintain an array of 17 surface moorings that span the tropical Atlantic Ocean. The moorings measure near-

surface atmospheric temperature, winds, humidity, and radiation, as well as subsurface ocean temperature, salinity, and velocity.

The original 12-buoy array was initially deployed during 1997-1999 and later reduced to 10 buoys due to extensive vandalism from fishing boats at two locations. A southwest extension of three moorings was deployed during 2005 to study ocean-atmosphere variability near Brazil, and the northeast extension of four moorings, a collaboration between AOML and PMEL, began in 2006. The moorings require servicing at about 12-month intervals to replace sensors and batteries and recover data.

The main motivation for PIRATA is to improve understanding and predictability of ocean-atmosphere variability in the tropical Atlantic on intraseasonal to decadal time scales. Small fluctuations in the tropical Atlantic can exert a strong influence on rainfall in Brazil and western Africa, as well as hurricane activity in the Atlantic basin. *(continued on page 2)*

Track of the NOAA Ship *Ronald H. Brown* during the November-December 2013 PIRATA Northeast Extension cruise (black line). Green circle denotes the starting location in Barbados; red circle shows the location of the end port in Recife, Brazil. Pink circles indicate the locations of the PNE moorings that were serviced during the cruise. Black circles show the locations of the PIRATA "backbone" array, and black crosses are the locations of the Southwest Extension moorings. Blue circles show the locations of 69 CTD casts.

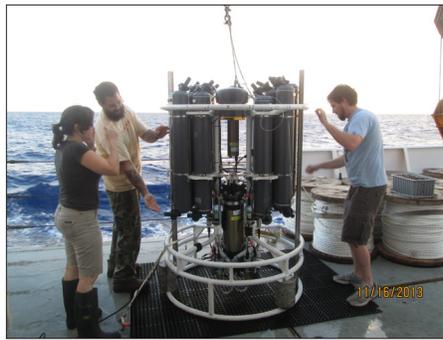


(continued from page 1)

In the past decade, there have been several extreme climate events in the tropical Atlantic region linked to coupled ocean-atmosphere variability in the tropical Atlantic, most notably severe Amazon droughts in 2005 and 2010, record Atlantic hurricane activity in 2005, and extreme flooding in northeast Brazil in 2009. Improved understanding and predictability of such events will benefit societies across South America, western Africa, the Caribbean, and eastern United States.

PIRATA's northeast extension consists of four moorings in the central and eastern tropical North Atlantic, where there are large seasonal and interannual variations of ocean surface temperature and rainfall that are poorly understood. One mooring is located at 20°N, 38°W and three extend from 4°N to 20°N along the 23°W meridian. An additional experimental TFlex mooring, which represents the next generation of PIRATA mooring design, was recovered and deployed near 20°N, 38°W.

During the November-December cruise, AOML's team measured temperature, salinity, pressure, velocity, and dissolved oxygen concentration in the upper 1500 m of the ocean from 69 conductivity-temperature-depth (CTD) casts, primarily along 23°W. Additional temperature, salinity, and pressure data continue to be acquired from two Argo floats that were deployed during the transit to the first PNE mooring, and surface currents are being monitored



AOML's Renellys Perez (left), Grant Rawson (middle), and Shaun Dolk (right) take water samples after a CTD cast.



Michael Strick from PMEL (right) and two members of the *Brown's* deck crew deploy a TFlex mooring near 20°N, 38°W during the PIRATA Northeast Extension cruise.

from 20 drifting buoys that were deployed between the equator and 9°N along 23°W. Several buoys were deployed into strong northwestward flow associated with the crest of a tropical instability wave (TIW) and will gather surface temperature and velocity information that will help to quantify the role of TIWs in the equatorial Atlantic heat and momentum budgets.

In addition to the standard measurements from CTD casts, special emphasis was placed on resolving the vertical structure of currents in the upper 100 m of the ocean. To accomplish this goal, the AOML team increased the vertical resolution of the upward-looking acoustic Doppler current profiler (ADCP) attached to the CTD frame and the downward-looking ADCP mounted on the ship's hull.

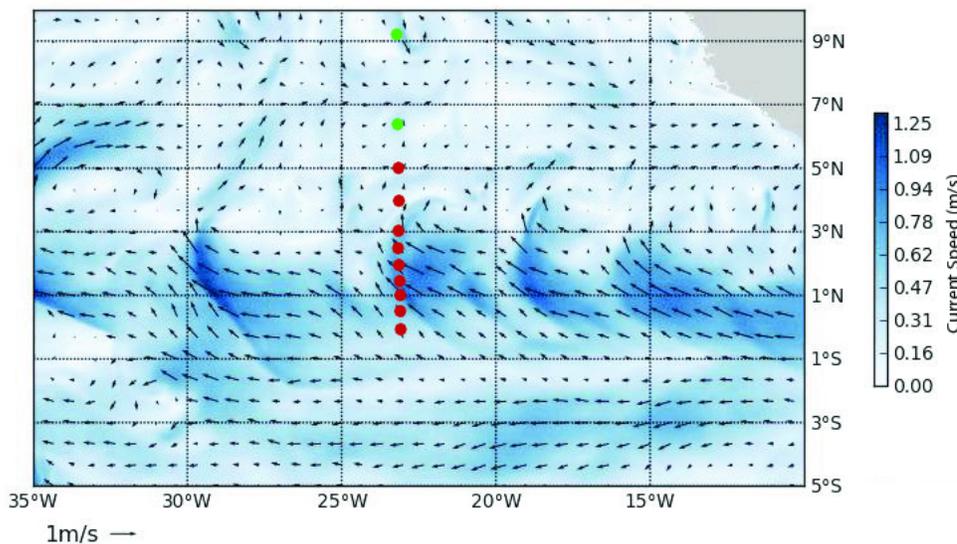
With the help of PMEL technicians, AOML also mounted two single-depth current meters on the 4°N, 23°W PNE mooring at depths of 5 m and 20 m to augment measurements from the existing

current meter at 10 m. Quantification of the upper-ocean vertical structure of currents is important for understanding the role of the ocean in sea surface temperature and salinity variability but, in the past, has been elusive because of limited direct velocity measurements.

In recent years, there has been an increasing appreciation for the role of anthropogenic and natural aerosols in tropical Atlantic climate variability. Building on a string of successful measurement campaigns during past PNE cruises, the AEROSE team collected meteorological observations of aerosols, ozone, and atmospheric conditions during the November-December cruise. These data are being used to investigate the effects of the Saharan air layer on the marine boundary layer, clouds, precipitation, and the surface radiation balance.

The AOML team conducted five sets of expendable bathythermograph (XBT) comparison drops using 96 probes. These tests were performed near selected CTD stations using instruments provided by Sippican, Inc., with the goal of improving XBT technology. The PNE cruise also supported researchers from RSMAS, who mounted a Marine-Atmosphere Emitted Radiance Interferometer (M-AERI) instrument on the bow of the ship to measure surface infrared radiation and ocean skin temperature. The data will be used to improve understanding of the surface radiation balance and to interpret satellite-based measurements of sea surface temperature.

The wealth of oceanic and atmospheric data collected during the PNE cruise, and measurements that continue to be collected from five PIRATA moorings and surface drifters, are important components of the global ocean observing system that will be used in climate studies and for operational weather, ocean, and climate forecasting.



Locations of single surface drifter deployments (green circles) and pairs of drifter deployments (red circles) during the PNE cruise. Blue shading indicates the strength of surface currents on November 30th, when the buoys were deployed at 4°N. Subsequent buoys were deployed approximately every 4-6 hours as the *Ronald H. Brown* travelled southward. Black arrows show the strength and direction of the currents. Surface velocity map is from the Mercator Ocean operational analysis.

# Hurricane Researchers Achieve Important Milestones Despite Quiet Season

The 2013 Atlantic hurricane season, which officially ended on November 30th, will be noted in the record books as having been a relatively quiet year with the fewest hurricanes since 1982. In fact, it will be ranked as the sixth least-active Atlantic hurricane season since 1950.

Despite this, the 2013 season was quite an active year for scientists with AOML's Hurricane Research Division (HRD). Flying aboard NOAA's hurricane hunter aircraft, they conducted missions into Tropical Storms Gabrielle and Karen, as well as Hurricane Ingrid, to gather data for research and assimilation into numerical models.

These data were collected as part of HRD's annual Hurricane Field Program, a large component of which is the Intensity Forecasting Experiment (IFEX). A goal of IFEX is to better understand the physical processes and other factors that enable tropical cyclones to change intensity, as well as improve tropical cyclone intensity forecasts.

As part of their efforts to gather data for research, HRD scientists released 136 airborne expendable bathythermographs and 367 dropwindsondes from NOAA's P3 and Gulfstream-IV (G-IV) aircraft. These instruments enabled them to obtain information about important features in the atmosphere and ocean.

The G-IV jet gathered data during nine flights and the two P3 aircraft conducted 17 missions for a total of 150 flight hours



Eric Uhlhorn, Robert Rogers, and Jun Zhang of AOML's Hurricane Research Division just before a NOAA P3 flight into Tropical Storm Gabrielle.

spent sampling these three tropical systems. Many of the flights were coordinated with NASA's Hurricane Severe Storm Sentinel missions, which featured two high-altitude, unmanned Global Hawk aircraft.

One of the highlights of the season was that, for the first time, the P3's tail Doppler radar data were transmitted directly to NOAA Central Operations and successfully assimilated into the operational Hurricane Weather and Research Forecast (HWRF) model. This was a significant accomplishment for NOAA that enabled the P3's Doppler radar data to be included in the latest high-resolution models as part of the effort to continually improve intensity and track forecasts. The tail Doppler radar data provided vital information about the direction and strength of the winds found in Gabrielle, Ingrid, and Karen.

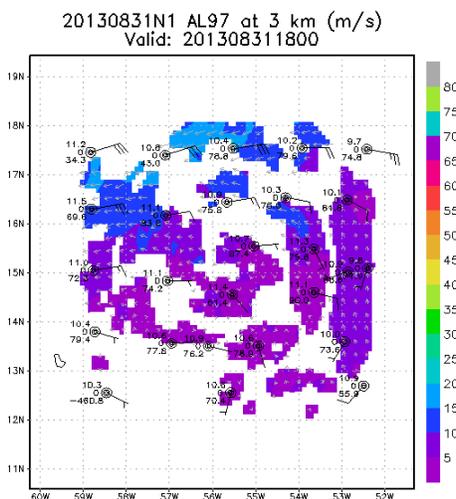
On the modeling and data assimilation fronts, a new basin-wide version of the HWRF developed at HRD was run in real-time during the season, allowing for multiple storms to be forecast concurrently for the first time. Additionally, HRD provided near-real-time runs of a research version of HWRF initialized with the Hurricane Ensemble Data Assimilation System (HEDAS), a testbed for improving the assimilation of data into the operational HWRF model.

For the first time, high-resolution cloud-motion vectors, as well as other satellite retrievals, were ingested with HEDAS. The model forecasts showed that the assimilation of these data with a sophisticated data assimilation system could provide better forecasts of track and intensity than the current operational system. HRD's HWind group successfully made 33 surface-wind analyses for six storms that formed in the Atlantic basin this year.

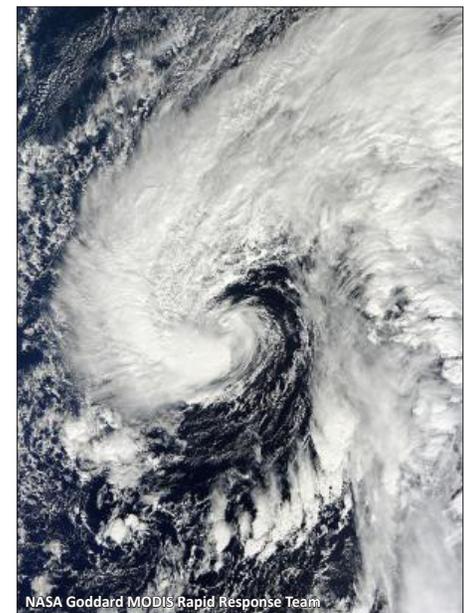
HRD scientists are thankful for the successes and major milestones they achieved during the 2013 Atlantic season, all without having a single hurricane make landfall in the U.S. and with only minimal loss of life and property to the public due to tropical systems.

2013 ATLANTIC STORMS			
Number	Type	Name	Dates
1	TS	Andrea	Jun 5-7
2	TS	Barry	Jun 17-20
3	TS	Chantal	Jul 7-10
4	TS	Dorian	Jul 23-Aug 3
5	TS	Erin	Aug 15-18
6	TS	Fernand	Aug 25-26
7	TS	Gabrielle	Sep 4-13
8*	H	Humberto	Sep 8-19
9*	H	Ingrid	Sep 12-16
10	TS	Jerry	Sep 29-Oct 3
11	TS	Karen	Oct 3-6
12	TS	Lorenzo	Oct 21-24
13	TS	Melissa	Nov 18-21

\*Hurricanes Humberto and Ingrid intensified to only category 1 strength, marking the first year since 1968 that the Atlantic basin has failed to produce a tropical system of category 2 or greater strength.



Tail Doppler radar and dropwindsonde composite at 3-km altitude from the Gulfstream-IV flight into the system that eventually became Tropical Storm Gabrielle.



NASA-MODIS satellite image of Subtropical Storm Melissa developing in the central Atlantic Ocean on November 18th. The late-forming system transitioned to tropical storm status on November 20th while moving rapidly to the northeast. Melissa brought gusty winds to the Azores Islands but dissipated harmlessly at sea on November 21st, becoming the last named storm of the 2013 Atlantic hurricane season.



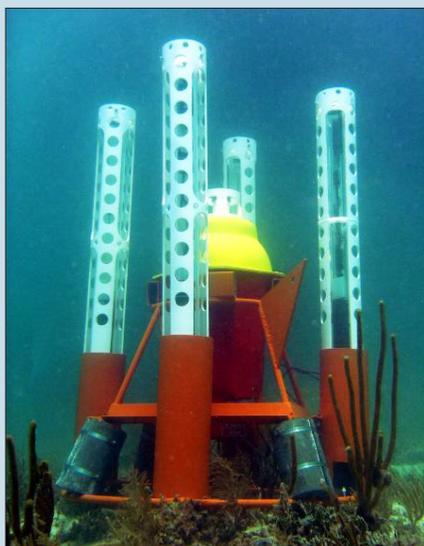
AOML coral researcher Jim Hendee (right foreground) addresses an audience at the Institute of Marine Affairs in Trinidad and Tobago about the importance of monitoring environmental conditions at coral reef sites.

AOML coral researcher Jim Hendee, along with partners Jon Fajans (Consulting for All Reef Monitoring Services, Inc.) and John Halas (Environmental Moorings International, Inc.) visited Trinidad and Tobago in November to speak to the local marine science community about environmental monitoring at coral reef sites. The trio was hosted by the Institute of Marine Affairs, who provided a venue for their presentations about the Coral Reef Early Warning System (CREWS) network extension project. Through NOAA's collaboration with the Caribbean Community Climate Change Centre, CREWS buoys were installed at two sites in Trinidad and Tobago: Buccoo Reef Marine Park off the southwest tip of Tobago and the other at Angel's Reef, off of Goat Island, in the northeast. The presentations were well attended and included members from the Institute of Marine Affairs, Trinidad and Tobago Coast Guard, University of the West Indies, the Tobago House of Assembly, and the U.S. Embassy.

Dr. Silvia Garzoli, a cooperative institute scientist with AOML's Physical Oceanography Division and AOML's former Chief Scientist, was an invited speaker for a panel discussion on sea level rise in south Florida. The Greater Miami Chamber of Commerce hosted the event on December 12th, and an estimated 100 local businesses participated. Silvia served as a review editor for the 2013 Intergovernmental Panel on Climate Change (IPCC) report. She spoke about the report's conclusions, as well as uncertainties associated with the IPCC model projections. In particular, Silvia called attention to the fact that these uncertainties are usually not considered by insurance companies in their assessment of local impacts. NBC6 Chief Meteorologist John Morales moderated the panel, which also included the mayor of Pinecrest, a representative from an environmental consulting firm, and a member of the reinsurance industry. Each of these speakers referenced Silvia's clear description of model uncertainties, the variables surrounding the IPCC projections, and possible impacts to south Florida. Silvia also received great support for her stance on focusing not on the worst-case scenario, but on the changes that can be made in south Florida today to improve resiliency and reduce vulnerability.



Dr. Silvia Garzoli of AOML (far right) joins other community leaders in a panel discussion on the possible impacts of sea level rise in south Florida.



On December 20th, researchers with AOML's Physical Oceanography Division (PhOD) deployed their ABISS (Adaptable Bottom Instrument Information Shuttle System) data pod system off the Florida Shelf in approximately 750 meters of water. The deployment was conducted as a deep water field test of ABISS, a technology developed by PhOD engineers. The use of a data pod system such as ABISS holds the potential to more quickly retrieve data for climate analysis and prediction, as well as greatly reduce ocean observing system costs, which currently require ship time to recover data every 6-12 months. ABBISS will rest on the ocean floor gathering data during the 6-month long field test. At predetermined intervals, the system will release its expendable data pods, which will float to the ocean surface and transmit their recorded data via satellite. If proven successful, ABISS will be deployed as part of the existing ocean observing networks in the Atlantic and around the globe to more efficiently and cost effectively retrieve data from deep ocean moored instruments.

Prototype version of the Adaptable Bottom Instrument Information Shuttle System developed at AOML.

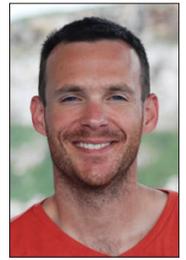
# Happy Holidays 2013



AOML hosted its annual holiday party celebration on December 19th. Staff, friends, and family enjoyed an afternoon of fun and good cheer, complete with food, goodies, music, singing, dancing, and an assortment of raffle prizes. The happy event was organized by AOML's Buoy and Gulls group.

## Congratulations

Dr. Derek Manzello, a coral researcher with AOML's Ocean Chemistry and Ecosystems Division, is the recipient of a 2011 Outstanding Scientific Paper Award from NOAA's Office of Oceanic and Atmospheric Research (OAR). OAR's Outstanding Scientific Paper Awards recognize the most original, important, and best written peer-reviewed papers by federal and cooperative institute scientists that have contributed to or contain the results of research sponsored by OAR. Derek won in the Oceans and Coasts category for his 2010 paper in the journal *Coral Reefs*\* that explored the impacts of thermal stress and ocean acidification upon the growth rates of corals from the eastern tropical Pacific. At that time, Derek was a cooperative institute employee but, as of December 2013, has become AOML's newest federal employee.



\*Manzello, D.P., 2010: Coral growth with thermal stress and ocean acidification: Lessons from the eastern tropical Pacific. *Coral Reefs*, 29(3):749-758.

## Welcome Aboard

Dr. Xaymara Serrano joined the staff of AOML's Ocean Chemistry and Ecosystems Division in November as a National Research Council post-doctoral scientist. Xaymara will work with AOML's Coral Health and Monitoring Program researchers to study the synergistic effects of high temperature and eutrophication on the early life stages of corals. She is a recent graduate of the Living Marine Resources Cooperative Science Center at the University of Miami's Rosenstiel School of Marine and Atmospheric Science with a Ph.D. in marine biology and fisheries.



## AOML Staff Welcome the Next Generation

Bradley Klotz, a University of Miami-Cooperative Institute for Marine and Atmospheric Studies scientist with AOML's Hurricane Research Division, and his wife Kristie are the proud parents of twins, born in Miami on November 5th. Samuel Klotz (Sam) weighed in at 6.5 pounds, while his sister Victoria (Tori) weighed in at 6 pounds even. Mom, Dad, and kids, their first, are all doing well and in good health.



Newborns Sam and Tori Klotz, born in Miami on November 5th.

In November, AOML director Dr. Bob Atlas welcomed his fifth grandchild. Bob is delighted with the birth of Eli, his newest grandson, who is healthy, happy, thriving, and strong.

## Combined Federal Campaign

December 2, 2013-January 15, 2014

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activities and staff accomplishments.

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

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*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.*