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AOML Keynotes

ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

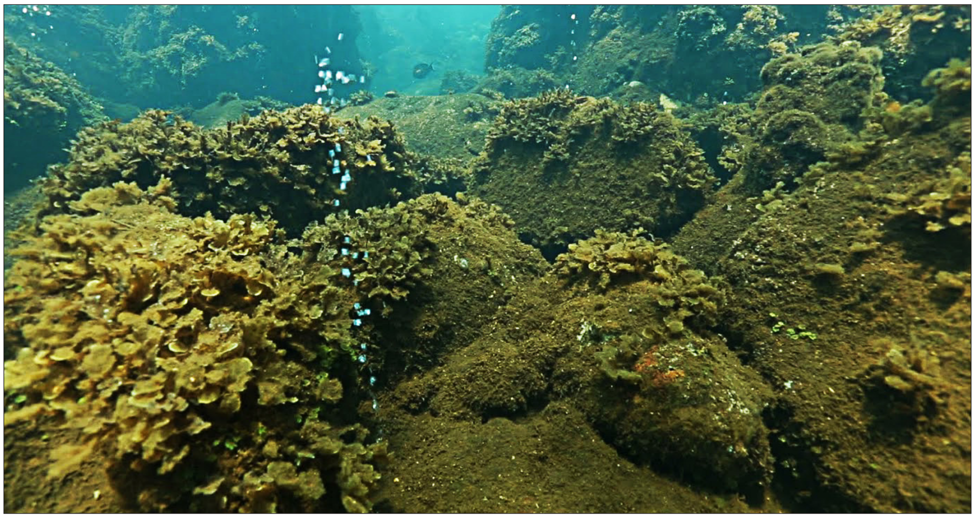
AOML is an environmental laboratory of NOAA's Office of Oceanic and Atmospheric Research located on Virginia Key in Miami, Florida

Volcano Spewing Carbon Dioxide Drives Coral to Give Way to Algae

Scientists with AOML, the University of Miami's Cooperative Institute for Marine and Atmospheric Studies (CIMAS), and their colleagues have documented a dramatic shift from vibrant coral communities to carpets of algae in remote Pacific Ocean waters where an undersea volcano spews carbon dioxide.

The new research, published online August 10th in *Nature Climate Change,** provides a stark look into the future of ocean acidification—the absorption by the global oceans of increasing amounts of human-caused carbon dioxide emissions. Researchers predict that elevated carbon dioxide absorbed by the global oceans will drive similar ecosystem shifts, making it difficult for coral to build skeletons and easier for other plants and animals to erode them.

"While we've done lab simulations of how increased carbon dioxide influences coral growth, this is the first field evidence that increasing ocean acidification results in such a dramatic ecosystem change from coral to algae," said Ian Enochs, lead author of the study and CIMAS researcher with the Acidification, Climate, and Coral Reef Ecosystems Team at AOML.

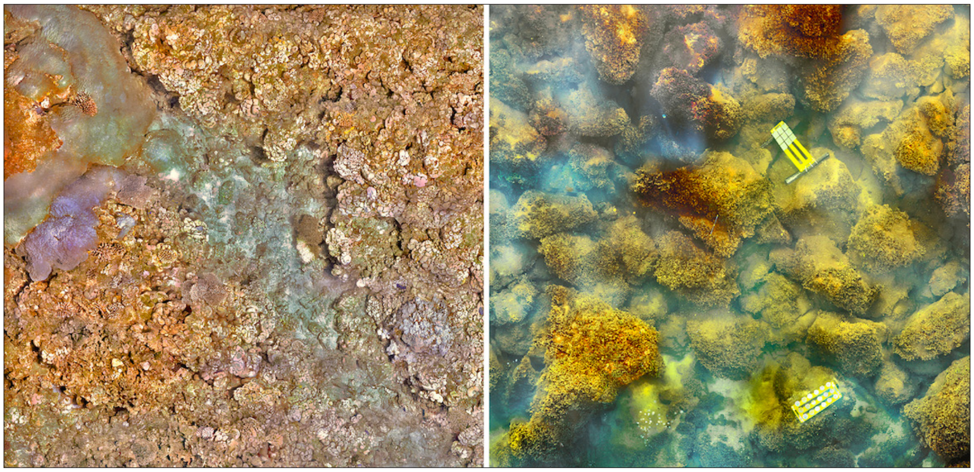


Submarine vents continuously spew bubbles of carbon dioxide into the reef environment of the uninhabited volcanic island of Maug in the Commonwealth of the Northern Mariana Islands.

"Healthy coral reefs provide food and shelter for abundant fisheries, support tourism, and protect shorelines from storms. A shift from coral to algae-covered rocks is typically accompanied by a loss of species diversity and the benefits that reefs provide."

The research was conducted on Maug, an uninhabited volcanic island in the Commonwealth of the Northern Mariana Islands about 450 miles from Guam. This location allowed scientists to single out a small geographic area that experiences carbon dioxide levels that vary from present day to those predicted for a hundred years into the future. Maug also provided researchers with an area with few other man-made stressors for coral, such as overfishing and pollution from land.

By setting up underwater instruments to continuously measure the effects of carbon dioxide, scientists were able to use this natural laboratory to show that coral cover decreased under higher levels of carbon dioxide, giving way to less desirable algae-covered rocks near the volcano's vents.



High-resolution photomosaic images taken at Maug Island, Commonwealth of the Northern Mariana Islands, show a shift from a coral-dominated ecosystem (left) to an algae-dominated ecosystem (right) as a result of increased carbon dioxide in the environment.

***Enochs, I.C., D.P. Manzello, E.M. Donham, G. Kolodziej, R. Okano, L. Johnston, C. Young, J. Iguel, C.B. Edwards, M.D. Fox, L. Valentino, S. Johnson, D. Benavente, S.J. Clark, R. Carlton, T. Burton, Y. Eynaud, and N.N. Price, 2015: Shift from coral to macroalgae dominance on a volcanically acidified reef. *Nature Climate Change,* doi:10.1038/nclimate2758.**

NOAA Increases Likelihood for Below-Average Atlantic Hurricane Season

NOAA's updated Atlantic Hurricane Season Outlook, issued August 6th, calls for a 90 percent probability for a below-average hurricane season. A below-normal season is now even more likely than predicted in May, when the chance of a below-normal season was estimated at 70 percent. This 90 percent probability is the highest confidence level given by NOAA for a below-normal season since seasonal hurricane outlooks began in 1998.

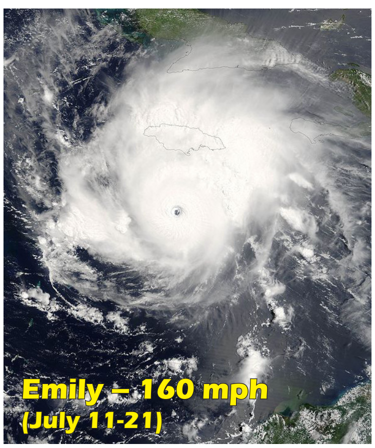
"Tropical storms and hurricanes can and do strike the United States, even in below-normal seasons and during El Niño events," said Dr. Gerry Bell, lead seasonal hurricane forecaster with NOAA's Climate Prediction Center. "Regardless of our call for below-normal storm activity, people along the Atlantic and Gulf coasts should remain prepared and vigilant, especially now that the peak months of the hurricane season have started."

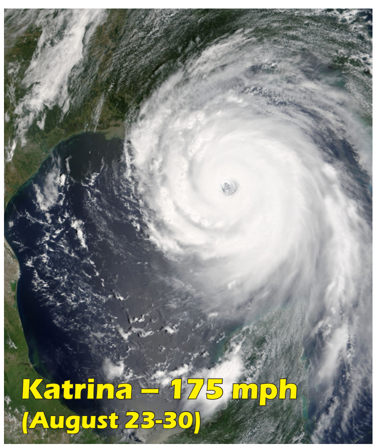
The updated outlook also lowers the overall expected storm activity this season. The outlook now includes a 70 percent chance of 6-10 named storms (from 6-11 in the initial May Outlook), of which 1-4 will become hurricanes (from 3-6 in May), and 0-1 will become major hurricanes (from 0-2 in May).

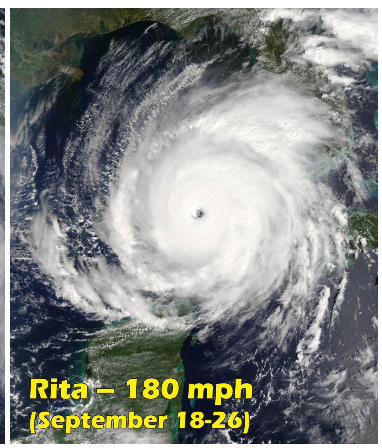
Forecasters attribute the high likelihood of a below-normal season to three primary factors:

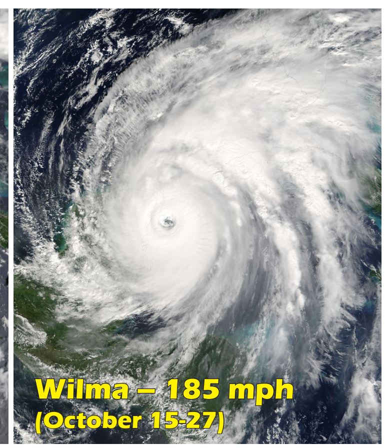
- El Niño has strengthened as predicted, and NOAA's latest El Niño forecast calls for a significant El Niño to continue through the remainder of the hurricane season.
- Atmospheric conditions typically associated with a significant El Niño, such as strong vertical wind shear and enhanced sinking motion across the tropical Atlantic and Caribbean Sea, are now present. These conditions make it difficult for storms to develop, and they are predicted to continue through the remaining four months of the hurricane season.
- Tropical Atlantic sea-surface temperatures are predicted to remain below average with anomalies cooler than the rest of the global tropics.

The 2015 Atlantic pre-season hurricane outlook is an official product of NOAA's Climate Prediction Center, produced in collaboration with the National Hurricane Center and AOML's Hurricane Research Division.


Emily – 160 mph (July 11-21)


Katrina – 175 mph (August 23-30)

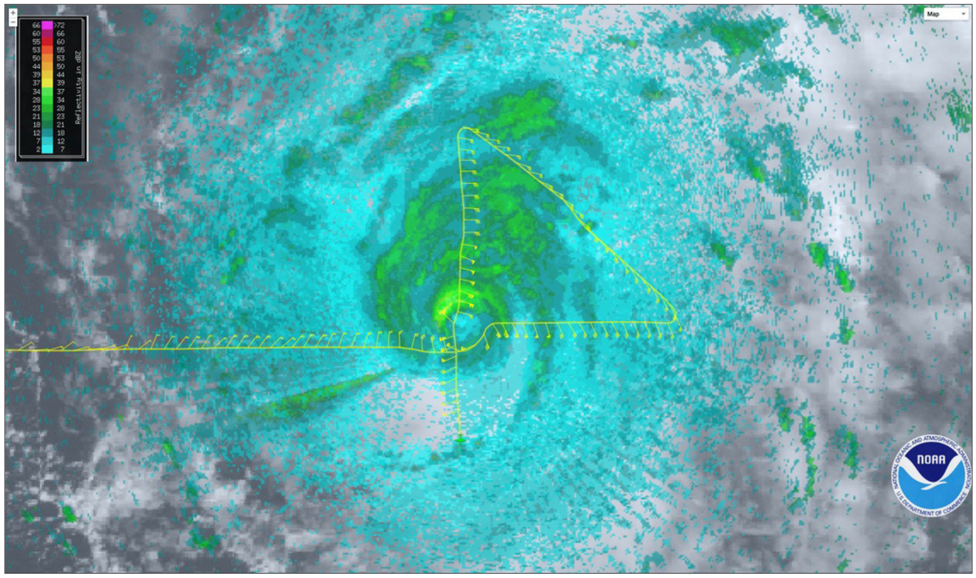

Rita – 180 mph (September 18-26)


Wilma – 185 mph (October 15-27)

Record-Breaking 2005 Atlantic Hurricane Season Celebrates 10-Year Anniversary

In 2005, environmental conditions that favor busy hurricane seasons prompted NOAA to state with almost 100% certainty that the Atlantic season would be above average. By season's end, records that had stood for decades had been shattered: 2005 generated more named storms (28), hurricanes (15), and major hurricanes striking the US (4) than all previous seasons since records began in 1851. Adding to this was the unprecedented formation of four powerful category-5 hurricanes (winds >155 mph)—Emily, Katrina, Rita, and Wilma (shown above with peak winds). All four storms would set records. Emily's July 16th intensification to category-5 status marked the earliest date for an Atlantic system. Katrina became the most costly hurricane in US history, slamming into the Gulf coast on August 29th with 125 mph winds and a 20+ foot storm surge that caused catastrophic damage and loss of life. A decade later, Rita is still recognized as the most intense hurricane observed in the Gulf of Mexico, while Wilma is still the most intense hurricane observed in the Atlantic. In total, two tropical storms (Arlene and Tammy) and six hurricanes (Cindy, Dennis, Katrina, Ophelia, Rita, and Wilma), struck the US in 2005. The hyperactive season is remembered as the most deadly, destructive, and costliest in modern times.

Wealth of Data Gathered in Hurricane Danny and Tropical Storm Erika



A geo-referenced image taken August 21, 2015 of Hurricane Danny by the lower-fuselage radar on NOAA's P-3 hurricane hunter aircraft (green line depicts the P-3's flight track). Danny intensified into a category-3 storm on August 21st with top winds of 115 mph, becoming the 2015 Atlantic season's first major hurricane.

AOML's hurricane researchers conducted a number of field activities in August that provided data and critical insights into Atlantic tropical cyclones Danny and Erika. The two storms enabled them to test new instruments in support of the 2015 Hurricane Field Program and conduct research that will benefit future forecasts. Among the highlights were more than 15 successful manned and unmanned aircraft missions into Danny and Erika to collect and provide real-time data to the National Hurricane Center (NHC), as well as evaluate forecast models.

NOAA flew five P-3 aircraft missions and two G-IV jet missions into Hurricane Danny, the first major hurricane of the season. For Erica, NOAA flew five P-3 missions and three G-IV missions as the storm impacted the Caribbean. The P-3 missions into Danny marked the first real-time transmission of geo-referenced imagery from the P-3's lower-fuselage radar to NHC forecasters. This imagery provided valuable information about the structure of Danny as the storm churned in the Atlantic far from land (see image at top right).

The P-3 flights also measured the wind structure of Danny and Erika and the wind shear environment surrounding them. Using the tail Doppler radar instrument aboard the P-3, researchers documented high levels of wind shear across the Caribbean, one of the products of a strong El Niño in the Pacific Ocean and a major contributor to the dissipation of both storms.

During missions into Danny and Erika, scientists gathered observations for the first time with a Doppler wind lidar instrument mounted to the side of the P-3 fuselage that measures wind velocity in regions without rain. The lidar data will be processed and evaluated for possible inclusion in the HWRF research model to improve wind speed estimates in model guidance.

NASA's Global Hawk unmanned aircraft completed the first two flights of its 2015 NOAA field campaign when it flew above Tropical Storm Erika on August 26th and 29th. The Global Hawk used onboard instruments to profile the inner workings of Erika and released dropsondes to collect temperature, moisture, wind speed, and wind direction data. These real-time data were transmitted for the first time and incorporated into operational forecast models.

Other instruments aboard the Global Hawk, such as the microwave sounder from NASA's Jet Propulsion Laboratory, gathered vertical profiles of temperature and humidity and was able to provide a unique view of Erika's interaction with the Saharan Air Layer, a mass of dry air that inhibited Erika's growth.

NASA's Global Hawk unmanned aircraft (left) flew two 24-hour missions into Tropical Storm Erika, while NOAA's P-3 hurricane hunter aircraft (right) flew multiple missions into Hurricane Danny and Tropical Storm Erika.

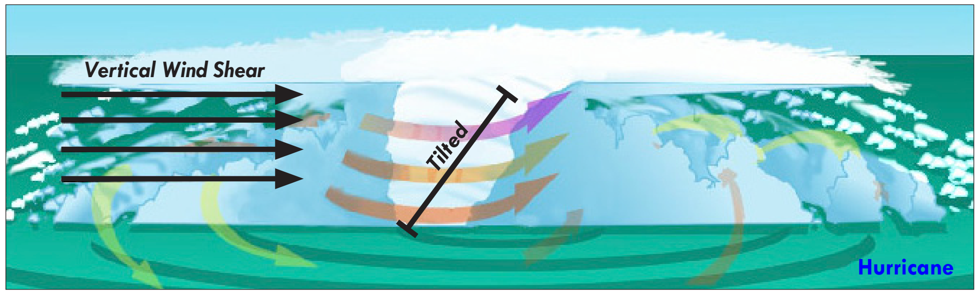
The Global Hawk, managed by NASA's Armstrong Flight Research Center in California, provided a unique vantage point of Erika at 60,000 feet altitude, flying about 15,000 feet higher than NOAA's G-IV jet. Both of its flights were 24 hours in length, nearly three times as long as that of manned aircraft. The Global Hawk is part of NOAA's Sensing Hazards with Operational Unmanned Technology (SHOUT) project, which seeks to improve hurricane forecasts of track and intensity using data collected by the unmanned aircraft from high in the stratosphere down to the ocean's surface.

Below the ocean's surface, another type of unmanned vehicle was in place, collecting data on Erika's interaction with the upper level of the ocean as the storm passed through the Caribbean. AOML's two underwater gliders traversed the waters off of Puerto Rico, gathering temperature measurements that are critical to understanding the ocean's role in how storms form, evolve, and intensify. These data should also provide researchers with a better understanding of the ocean's response to the passage of storms which, in turn, will improve ocean models used in hurricane forecasts.

Data collected by NOAA's hurricane hunter aircraft and the Global Hawk were uploaded in real-time to the Global Telecommunications System for inclusion in environmental models, better enabling researchers to predict the future activity and intensity of Danny and Erika.

Behind the 2015 Atlantic Hurricane Season: Wind Shear and Tropical Cyclones

With the 2015 Atlantic hurricane season underway, researchers are pointing to the strong presence of El Niño as the major driver suppressing the development of tropical cyclones in the Atlantic basin. But what specific conditions are associated with El Niño that lead to a less than ideal environment for tropical cyclone development? Through research and observation, hurricane researchers know strong environmental wind shear is a major factor affecting potential hurricane development and growth. This hurricane season, AOML researchers are delving further into the relationship between wind shear and tropical cyclones.



In the presence of vertical wind shear, a storm's core structure will be tilted in relationship to the wind shear. This tilting disrupts the flow of heat and moisture, which inhibits the storm from developing and strengthening.

What is wind shear?

Wind shear is the variation of the wind's speed or direction over a short distance within the atmosphere. For tropical cyclones, wind shear is important primarily in the vertical direction, as these storms occupy a large vertical slice of the atmosphere from sea level to the top of the troposphere, which extends up to about 40,000 feet altitude in the tropics in summer.

How does wind shear affect tropical cyclone development?

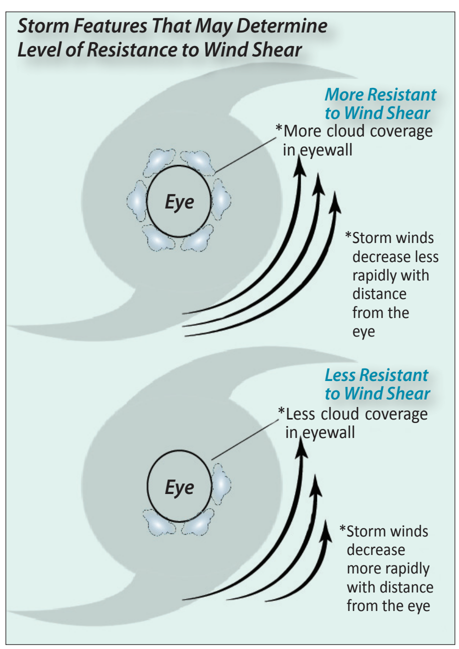
Tropical weather systems are vulnerable to changes in the broader atmosphere surrounding them, often influenced by large features such as areas of high and low pressure and fronts. If there's too much wind, these weather systems have trouble organizing and developing into tropical cyclones. As a tropical system forms, heavy thunderstorms build near the center. Given the right environment, these systems can eventually begin turning counterclockwise (or cyclonically) in the northern hemisphere. With little to no wind shear, the turning within the tropical system is uniform and the storm becomes vertically aligned, helping to keep it intact and, likely, strengthening.

The most favorable condition for tropical cyclone development is the absence of wind shear. When wind shear is present, however, a storm's core structure becomes vertically tilted in relationship to the wind shear, disrupting the flow of heat and moisture. Tropical cyclones are heat engines powered by the massive heat release associated with water vapor condensing into liquid water. Vertically-tilted systems are less efficient at drawing in warm, moist air from the ocean and will be less likely to develop and strengthen.

How does El Niño affect the presence or absence of wind shear?

El Niño is a climate phenomenon driven by above average ocean temperatures in the central and eastern tropical Pacific. While that warmth helps boost Pacific storm activity, the extra heat transferred to the atmosphere leads to a domino effect, altering climate around the globe.

Specifically, the instability over the warm equatorial Pacific during El Niño creates changes in the jet stream over the Northern Hemisphere, resulting in decreased wind shear in the Pacific and increased wind shear across much of the Caribbean and Atlantic. El Niño also increases the atmospheric stability, or resistance of the atmosphere to vertical motion, in the Atlantic basin, which suppresses hurricane activity.



Model results suggest certain features such as cloudiness within the eyewall, as well as the structure of the wind outside the eyewall, may determine a storm's level of resistance to wind shear.

Can a storm persist despite the existence of wind shear?

AOML researchers are focusing on particular characteristics of developed tropical cyclones that enable them to persist despite increased levels of wind shear. The theoretical work focuses mainly on how a tropical cyclone's wind structure is disrupted by wind shear.

Using a simple mathematical model, researchers can estimate the degree to which the center of the storm becomes vertically tilted based on the cloudiness within the eyewall, as well as the structure of the wind outside the eyewall. By modeling the development of storm tilt, a better understanding of a tropical cyclone's behavior is gained in the presence and absence of wind shear.

Results suggest that tropical cyclones are more likely to resist disruption by vertical wind shear when clouds cover a large portion of the eyewall and when winds decrease less rapidly from the eye (see graphic in middle column). These model simulations show promise in understanding the fundamental physical processes driving intensity and structural changes of tropical cyclones due to environmental factors.

A Doppler wind lidar instrument added to NOAA's hurricane hunter aircraft this season will assist AOML researchers collect observational data to better understand the wind environment around storms. The lidar instrument is used to collect, process, and transmit atmospheric data from within a hurricane, enabling NOAA to sample the winds inside the eyewall of storms. By leveraging observational expertise and new data combined with modeling, AOML researchers hope to learn more about the wind environment and interaction between wind shear and tropical cyclones, allowing them to better predict a hurricane's future activity and intensity.

AOML Scientist Participates in Science and Capacity Building Workshop

Dr. Christopher Meinen, a scientist with AOML's Physical Oceanography Division, participated in a science and capacity building workshop at the National Oceanography Centre (NOC) on July 27-29 in Southampton, UK.

The workshop, entitled the "Collaboration of overturning-circulation observing arrays in the Atlantic (COCOA)," brought together scientists and technical personnel from Argentina, Brazil, South Africa, the United Kingdom, and the United States to identify ways that the partners in the long-term Meridional Overturning Circulation (MOC) array at 26.5°N can aid in the operations, experimental development, and analysis of data from the newer MOC array at 34.5°S.

Dr. Meinen and other scientists at AOML have been key players in the 10+ years of observations collected by the North Atlantic MOC array at 26.5°N (the "RAPID-MOC/MOCHA/WBTS array") together with their partners at NOC and at the University of Miami. AOML scientists have also been among the leaders in developing the new array in the South Atlantic at 34.5°S through the NOAA-funded SAM project.

Participants of the July 27-29, 2015 "COCOA" workshop at the National Oceanography Centre, Southampton, United Kingdom. Photo courtesy of Ben Moat, NOC – used with permission.

The new South Atlantic array, called the "South Atlantic MOC Basin-wide Array (SAMBA)", involves partners from Argentina, Brazil, France, South Africa, and the US. One of the main foci of the workshop was to present some of the "lessons learned" by AOML scientists and their NOC partners to aid the newer groups involved in the SAMBA array.

Talks were presented on everything from tall mooring design and instrument calibration techniques to MOC calculation methods, data sharing policies, and long-term funding and ship time collaboration between countries.

These discussions will lead to better quality data being collected and will help NOAA and its partners better understand the structure and variability of the MOC, which is one of the near-term goals of the US interagency Ocean Research Priorities Plan.

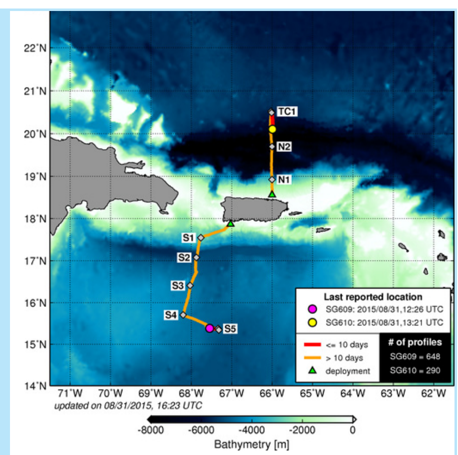
Underwater Gliders Begin Third Mission in Support of Hurricane Research

This summer, AOML's two underwater gliders began their third mission in support of better understanding the ocean's role in tropical cyclone development and intensification. The mission officially began on July 15th with the successful launch of one of the gliders into the Caribbean Sea south of Puerto Rico. The second glider was subsequently launched in the tropical North Atlantic Ocean north of San Juan, Puerto Rico on August 11th.

During their five months at sea, the gliders are expected to gather more than 3000 temperature, salinity, and oxygen profiles, as well as current velocity profiles, to depths as great as 1000 meters. These data will be used to assess conditions in the upper ocean during hurricane season and will be assimilated into real-time hurricane forecast models.

The glider deployments were conducted from aboard the R/V *La Sultana*, a research vessel of the University of Puerto Rico-Mayaguez (UPRM). Staff with AOML's Physical Oceanography Division—Ulises Rivero and Grant Rawson, a Cooperative Institute research associate—led the deployments in collaboration with Julio Morell and Luis Pomales of UPRM. Francis Bringas of AOML's Physical Oceanography Division led the shore-based piloting of the gliders.

The real-time data gathered by the gliders is used by researchers investigating the thermal structure of the upper ocean in regions that have been linked to the rapid intensification of tropical cyclones. The progress of the gliders, as well as the data they gather, can be tracked at http://www.aoml.noaa.gov/phod/goos/gliders/observations.php.



Above: **Map shows the location of AOML's underwater gliders in the Caribbean Sea and North Atlantic Ocean on August 31st.**

Left: **AOML staff work alongside University of Puerto Rico-Mayaguez personnel to launch glider GS609 into the Caribbean Sea south of Puerto Rico on July 15th.**

Gulf of Mexico Marine Ecosystem Changes Over the Decades

Scientists studying the Gulf of Mexico now have a better understanding of how naturally-occurring climate cycles, as well as human activities, can trigger widespread ecosystem changes that ripple throughout the Gulf food web and the human communities dependent on it, thanks to a new study published in the July issue of the journal *Global Change Biology*.*

A team of NOAA scientists spent three years reviewing over 100 indicators derived from environmental, fishery, and economic data, including sea surface temperatures, currents, atmospheric patterns, fishing efforts, harvests, and revenues. Through extensive analysis, they found a major ecosystem reorganization that appeared to be timed with a naturally-occurring climate shift that occurred around 1995.

The climate phenomenon is known as the Atlantic Multidecadal Oscillation (AMO), a climate signal in the North Atlantic Ocean that switches between cool and warm phases, each lasting for 20-40 years at a time. The AMO was in a cool phase between 1965 until 1995 and, since 1995, has been in a warm phase. The AMO influences global ocean and weather conditions in the northern hemisphere, such as hurricane activity in the Atlantic Ocean and the severity and frequency of droughts.

However, the AMO is not as extensively studied as other climate phenomena such as El Niño, and this study is the first to investigate what scientists hope will be many future studies examining how the AMO influences ecosystem-scale change in the Gulf of Mexico. Scientists hope this work will spur interest in further studying this phenomenon and its implications for the marine environment in this region.

"These major ecosystem shifts have probably gone unrecognized to date because they are not apparent when considering single species or individual components of the ecosystem," said lead investigator Dr. Mandy Karnauskas of NOAA's Southeast Fisheries Science Center. "Only when we put a lot of things together, including currents, hypoxia, fish abundances, fishing effort, and more, does a strong climate signal emerge."

Additionally, scientists observed shifts in many species around the late 1970s coincident with the advent of the U.S. Magnuson-Stevens Fishery Conservation and Management Act, a policy designed to set rules for international fishing in U.S. waters, making the expansion of certain fisheries more favorable for economic development and ensuring the long-term sustainability of the nation's fish stocks.

Fish species in NOAA's Flower Garden Banks National Marine Sanctuary located in the northwestern Gulf of Mexico off the coast of Texas.

The scientists expect their study to be useful to resource managers throughout the Gulf region. While managers cannot control Earth's natural climate cycles, they may need to consider how to alter management strategies in light of them to effectively meet their mandates.

Karnauskas' research team included scientists from NOAA's Southeast Fisheries Science Center, AOML, the University of Miami, and the University of Texas.

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*Karnauskas, M., M.J. Schirripa, J.K. Craig, G.S. Cook, C.R. Kelble, J.J. Agar, B.A. Black, D.B. Enfield, D. Lindo-Atichati, B.A. Muhling, K.M. Purcell, P.M. Richards, and C. Wang, 2015: Evidence of climate-driven ecosystem reorganization in the Gulf of Mexico. *Global Change Biology,* 21(7):2554-2568 (doi:10.1111/gcb.12894).

A team of scientists from AOML and NOAA's Southeast Fisheries Science Center in Miami have conducted a series of surveys in Florida Bay this year as part of an ongoing project to investigate how juvenile sport fish in the bay respond to changes in water quality and habitat resulting from Everglades restoration efforts. Florida Bay serves as a nursery ground for numerous commercial and recreational reef fish species. The spotted seatrout (*Cynoscion nebulosus*) is one of the best indicators for estuarine health as it spends its entire life within the bay, making it sensitive to fluctuations in water quality, including salinity. It is also the second most commonly caught sport fish in Florida Bay, accounting for almost 30% of all catches.

During the surveys, scientists collected water quality and seagrass measurements, as well as conducted otter trawls to sample juvenile sport fish populations. This year's surveys were remarkable for having the highest salinities on record in July, with a maximum salinity of 65.4 and temperatures above 38°C in the stratified bottom layer. These extreme salinities and temperatures resulted in a fish kill and seagrass die-off.

Left: **A juvenile spotted seatrout, one of the targeted sport fish in the study, is measured and recorded.**

Above: **AOML researcher Chris Kelble records seagrass conditions in Florida Bay during a recent survey.**

An AOML Coral Health and Monitoring Program (CHAMP) turbidity instrument has been repeatedly deployed at a site near the Port of Miami. The instrument provides in-water measurements of turbidity to calibrate and validate satellite estimates of turbidity for reefs (PI: Lew Gramer), in partnership with the University of South Florida's Optical Oceanography Lab. The instrument package was built and programmed by CHAMP team members Natchanon "Mana" Amornthammarong and Mike Shoemaker; it can measure turbidity in continuous autonomous operation for more than 2 weeks in shallow waters. The instrument has been deployed in Florida waters with the assistance of NOAA Corps officers Michael Doig, Ben Vandine, Marc Weekley, and James Europe. It will next ship to the island of Saipan in the Commonwealth of the Northern Mariana Islands for similar deployment by partners there.

LT Marc Weekley with the turbidity instrument developed at AOML prior to its deployment.

One of the earliest Coral Reef Early Warning System (CREWS) stations established by researchers with the Coral Health and Monitoring Program (CHAMP) at AOML was decomissioned in August due to age and structural instability. The St. Croix CREWS station in the U.S. Virgin Islands was installed in the Salt River Bay National Historical Park and Ecological Preserve in April 2002 and was subsequently updated with a new architecture in September 2006. For nearly 12 years the station transmitted data and produced ecological forecasts, even remaining operational during several storms. In May 2014, a newly-installed CTD (conductivity-temperature-depth) instrument exploded, rupturing part of the station's fiberglas pylon and compromising its integrity. Deemed irreparable, the station was dismantled and removed from service on August 12-13, 2015 by John Halas of Environmental Moorings International, Inc., and Mike Shoemaker of AOML, both of whom were involved in its original installation.

***Left:* The St. Croix CREWS station in its prime. *Right:* The end of an era as the station is dismantled and removed from service due to age and structural damage.**

Researchers with the Coral Health and Monitoring Program (CHAMP) at AOML are installing buoy-type Coral Reef Early Warning System (CREWS) stations (i.e., instead of pylons) in the Caribbean through a collaborative agreement with the Caribbean Community Climate Change Center. To date, stations have been deployed in Little Cayman, Belize (2), Tobago (2), Barbados, and the Dominican Republic (2). A new phase of expansion is expected to include stations in the Bahamas (Clarence Town, Long Island), St. Lucia, Curacao, San Andres, and Cuba, as well as Antigua and Barbuda, the Commonwealth of Dominica, Grenada, Montserrat, St. Kitts and Nevis, and the Grenadines. The goal is to place CREWS stations at all four corners of the Caribbean, as well as in the middle, to provide long-term, highly intensive, near real-time environmental data at reef sites. Forecasts generated by the stations alert researchers, conservationists, and local managers to adverse ecological conditions that could potentially impact coral reefs (e.g., bleaching episodes).

An example of the new type of CREWS station being installed at reef sites throughout the Caribbean by researchers with AOML's Coral Health and Monitoring Program.

On August 21st, staff with AOML's Physical Oceanography Division (PhOD) invited AOML director Dr. Bob Atlas to visit the new PhOD ocean instrumentation exhibit located on the second floor back hallway. The exhibit is useful for explaining to visitors some of the key contributions AOML has made to the design, implementation, and maintenance of the ocean observing system. PhOD staff also took the opportunity to recognize Dr. Atlas' ten-year anniversary as the director of AOML. They presented him with a copy of the book *The Oceans, Their Physics, Chemistry, and General Biology* by Sverdrup, Johnson, and Fleming. The book was signed by all division employees, who enjoyed a brief social time with Bob while enjoying pastelitos and other treats.

Ulises Rivero of PhOD's instrumentation group (far right) discusses some of the ocean-observing equipment on exhibit with AOML director Dr. Bob Atlas (center).

New Faces Participate in Bimonthly Survey along 27°N

Three student interns with AOML's Physical Oceanography Division (PhOD) joined the science team aboard the R/V *F.G. Walton Smith* for a hydrographic survey of the Florida Straits on July 14-15, 2015. For each of the interns—Vinicius Webber, Allyson Rugg, and Ciro Liutti—this was their first experience participating in an oceanographic research cruise.

The ship departed Virginia Key from the University of Miami Rosenstiel School pier for the 2-day trip (one of six similar surveys of the Florida Current scheduled in 2015); sampling operations were conducted at nine stations in the Florida Straits along 27°N before returning home on the second day. While at sea, the students were involved with the deployment and recovery of the CTD (conductivity, temperature, depth) instrument package and also participated in drawing water samples from CTD Niskin bottles for subsequent laboratory analysis.

The Student Interns

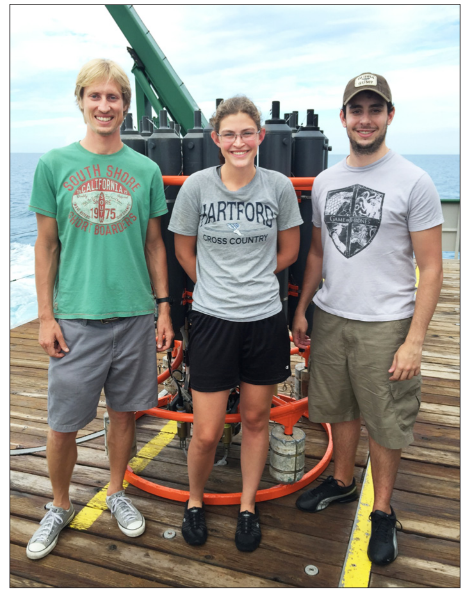
Vinicius (Vinny) Webber, originally from Brazil, received his undergraduate degree in environmental engineering in Brazil before coming to the US to attend the University of Miami. He is currently enrolled at the Rosenstiel School working on a Professional Masters Degree in meteorology and physical oceanography. As part of his degree, Vinny is participating in a semester-long internship with PhOD, working with Marlos Goes and Gustavo Goni.

Allyson Rugg is currently an undergraduate student at the University of Colorado at Boulder. She is majoring in mathematics and plans to minor in atmospheric and oceanic science. Allyson is a NOAA Hollings Scholar and interned with PhOD this summer as part of the requirements of the program. She worked with Greg Foltz and Renellys Perez while at AOML.

Ciro Liutti is currently an undergraduate student at the Rio Grande Federal University in Brazil. Ciro participated in a summer internship at AOML, working with Molly Baringer.

Project Background

Since 1982, AOML scientists have regularly monitored the transport of the Florida Current at 27°N in the Florida Straits. Well suited for observation, this location is effectively the last choke point of the current before it enters the open North Atlantic Ocean and becomes the Gulf Stream.



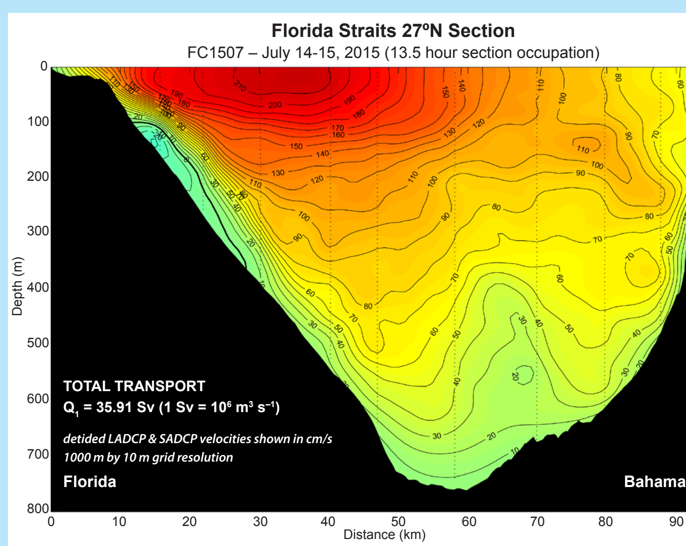
Student interns Vinicius Webber, Allyson Rugg, and Ciro Liutti pose with the CTD package en route to Miami after completing the 27°N section in July.

The Florida Current is comprised of Sverdrup flow from the North Atlantic Subtropical Gyre along the western boundary, as well as the upper limb of the Atlantic Meridional Overturning Circulation (AMOC). The AMOC is the major mechanism for distributing heat from lower to higher latitudes in the North Atlantic Ocean, and variability in its water properties and magnitude have direct implications for climate studies.

Since the 1980s, shipboard survey data, regularly collected using dropsonde devices (initially Pegasus and later GPS dropsondes) have been used, together with voltages observed from a submarine telephone cable spanning the Straits between Florida and the Bahamas, to derive a transport time series for the Florida Current. Beginning in 2000, AOML's Western Boundary Time Series Program also initiated full hydrographic surveys of the current using the R/V *F.G. Walton Smith* on a quarterly basis. In 2015, this was expanded to bimonthly coverage.

During these cruises, the current velocity is measured using lowered and hull-mounted acoustic Doppler current profilers (ADCPs). The CTD package, configured with lowered ADCPs, also profiles temperature, conductivity (salinity), depth, and dissolved oxygen within the water column at nine locations across the Florida Straits. To date, AOML scientists have conducted more than 50 of these surveys.

The powerful Florida Current, which transports warm tropical water northward along the eastern coast of Florida, is comprised of Sverdrup flow from the North Atlantic Subtropical Gyre, as well as the upper limb of the Atlantic Meridional Overturning Circulation (AMOC). The AMOC is the major mechanism for distributing heat from lower to higher latitudes in the North Atlantic Ocean, and variability in its water properties and magnitude have direct implications for climate studies. AOML researchers have been measuring the volume transport of the Florida Current for more than 30 years.



Velocity section at 27°N in the Florida Straits, produced from lowered and hull-mounted ADCP data collected during the July 14-15, 2015 survey. Detided velocities are shown in cm/s (+ = flow towards the north; – = flow towards the south). The strongest (northward) velocities are visible in red in the upper 100 meters of the water column across the western half of the section. The total detided transport was found to be 35.9 Sverdrups (one Sverdrup or Sv is defined as one million cubic meters of water per second). This value is larger than the historical average transport of 31.9 Sv.

Student Interns Wrap Up Multi-Year Sampling Project at South Florida Beaches

Student interns with AOML's Microbiology Program conducted the final phases of a multi-year research project this summer to assess the presence and risk potential of microbial contaminants at South Florida recreational beaches. The project began in the summer of 2013 and continued during the summer of 2014, with different intern groups contributing to the effort.

Student interns participating in the project this summer included Kristina Thoren (an undergraduate from Cornell University), Daniel Morales (an undergraduate from Miami-Dade College), Michael Goldberg (an undergraduate from Emory University), and Casey Almendarez (a high school student from Miami Lakes Educational Center).

These students collected samples from a range of beaches in Miami-Dade and Broward counties and participated in a multi-day intensive sampling effort of beaches in the Florida Keys, with field work based out of the Keys Marine Laboratory on Long Key. As part of the effort, they measured live fecal bacteria by traditional culture methods (EPA method 1600 for enterococci) and fecal host-specific genetic markers by quantitative Polymerase Chain Reaction (qPCR) microbial source tracking (MST) methods.

Since 2013, student interns have investigated the presence, relative abundance, and distribution of a variety of fecal-indicating bacteria, their microbial source tracking markers, and pathogens in the bathing waters, air, beach sands, and seaweed wrack debris at selected South Florida beaches. They have also gathered observations of beach conditions and conducted beachgoer activity/beach user surveys to better understand the potential exposure to microbial contaminants at these beaches. An additional aspect of the project has been to investigate the potential persistence of these contaminating bacteria in the beach environment.

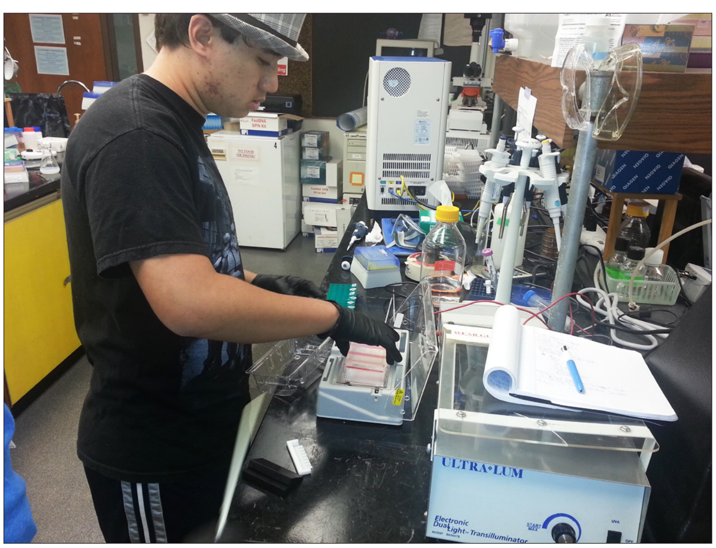
Overall, student interns observed that microbial contaminants were present in all of the environmental matrices at South Florida beaches, including the sand, seaweed wrack, nearshore waters, offshore bathing waters, and even in the air as suspended bio-aerosols. However, the specific patterns of abundance and exposure in these matrix types varied enormously on the short scale, both in time and space. Such contamination was found at many of the beaches, but was extremely patchy.

Most samples were relatively clean, but higher exposure levels were randomly present in samples from all of the beach sites. The lowest exposure areas were typically observed as the dry sand of the upper beach and deeper offshore waters of the swim zone, while the highest exposure areas were typically the shallow waters of the nearshore intertidal "swash zone," the beach sand just above the high-tide line, and the seaweed wrack debris that washes ashore. While observing beachgoer behavior, the students noticed that children and the elderly had the most interaction with the higher-risk zones, both populations likely to be at greater risk from exposure to microbial contaminants.

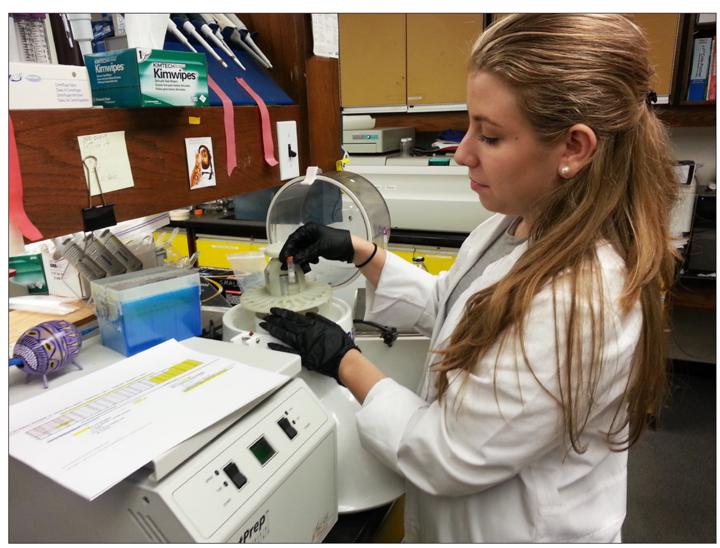
Bacterial aerosol samples are collected at Bill Baggs State Park on Key Biscayne.

Although the 2015 student interns have completed their field work and returned to their respective institutions, the final stages of analyzing the data and preparing to present the results at the 2016 Ocean Sciences Meeting continues. It is anticipated the research will also generate a peer-reviewed publication; thus, all of AOML's microbiology student interns for the past 3 years will have successfully contributed to the state of the science. These interns intend to pursue careers in environmental or bio-medical sciences and, based on their efforts at AOML, are off to a good start.

Their research mentors at AOML were Drs. Chris Sinigalliano, the principal investigator of AOML's Molecular and Environmental Microbiology Program, and Maribeth Gidley (DO/MPH), the principal investigator of AOML's Oceans and Human Health Program.



Student intern Michael Goldberg prepares an electrophoresis gel for DNA analysis.



Student intern Kristina Thoren extracts DNA from beach samples.

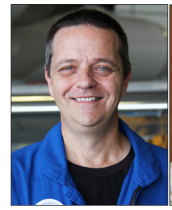
Farewell

Dr. Geoffrey Cook, a Cooperative Institute scientist with AOML's Ocean Chemistry and Ecosystems Division, resigned in August to join the faculty of the University of Central Florida's Department of Biology. Geoffrey will establish a marine science program to better understand the factors that impact the distribution, abundance, and dynamics of coastal marine ecosystem species. During his three years at AOML, he worked with the ecosystem assessment group to conduct risk analysis for marine ecosystems and contributed to the development of the Gulf of Mexico Ecosystem Status report.

NOAA Corps Officer LT Michael Doig departed AOML in July for his next assignment in Pascagoula, Mississippi as the Field Operations Officer aboard the NOAA Ship *Gordon Gunter*. During Mike's two years at AOML, he served as a Research Support Coordinator for coastal ecosystem research and field sampling activities conducted by AOML's Ocean Chemistry and Ecosystems Division. He also aided in managing both the small boat and diving programs at AOML. In support of the Office of the Director, Mike's diligent efforts resulted in the modernization of AOML's property management system and the disposal of a large quantity of obsolete equipment.

AOML participated in the Feds Feed Families food drive this summer sponsored by the South Florida Federal Executive Board. Shown above, AOML Director Dr. Bob Atlas contributes to the effort.

Congratulations



Dr. Joseph Cione, a meteorologist with AOML's Hurricane Research Division, and Erica Rule, the Communications Director at AOML, were members of a team that received a Department of Commerce Silver Medal in July. The team, which also included colleagues with NOAA's Office of Marine and Aviation Operations, was recognized for successfully executing the first-ever launch of an Unmanned Aircraft System from a manned aircraft into a major hurricane (Hurricane Edouard). During the 2014 Atlantic hurricane season, the team twice deployed a Coyote unmanned aircraft system into Edouard's eyewall from a NOAA P3 hurricane hunter aircraft. Data gathered by the Coyote at altitudes as low as 1200-2900 feet above the ocean surface, a sparsely-sampled region due to extreme turbulence, hold the potential to yield new insights into how tropical cyclones form and intensify.

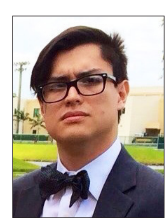
Dr. Rick Lumpkin, an oceanographer with AOML's Physical Oceanography Division, was selected in July to serve as PhOD's new deputy director. Rick began at AOML in 2002 as a University of Miami Cooperative Institute scientist and was made a Federal employee in 2004. He currently manages AOML's component of the NOAA Global Drifter Program, part of an international effort to maintain a global network of surface drifting buoys for climate and weather research, monitoring, and prediction. He also manages AOML's contribution to the international PIRATA project, and serves on the PIRATA Science Steering Committee. Additionally, Rick serves on several panels and working groups of the Data Buoy Cooperation Panel, an international program of the World Meteorological Organization and the Intergovernmental Oceanographic Commission that coordinates the use of data buoys used to observe the atmosphere and ocean. He holds a PhD in oceanography earned from the University of Hawaii in 1998.

Dr. Rick Spinrad, NOAA's Chief Scientist, with Joshua Wadler.

NOAA Hollings Scholar Joshua Wadler, who recently completed an internship with Dr. Robert Rogers of AOML's Hurricane Research Division, won an award at NOAA's 2015 Science and Education Symposium in Silver Spring, Maryland. The three-day event in July provided a venue for more than 100 Ernest F. Hollings and Educational Partnership Program scholars to present the results of their research conducted at NOAA facilities this past summer. Joshua's research, *Radial and azimuthal variations in the convective burst structure of tropical cyclones from airborne Doppler observations*, won first place for the best oral presentation in the Weather-Ready Nation category. He is currently an undergraduate student at the University of Oklahoma majoring in meteorology, as well as an associate with NOAA's National Severe Storms Laboratory in Norman, Oklahoma.

Welcome Aboard

Brittany Dahl joined AOML's Hurricane Research Division in July as a research associate with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies. Brittany will work with Dr. Altug Aksoy and Jason Dunion on a project funded by NOAA's Sensing Hazards with Operational Unmanned Technology (SHOUT) program to investigate the impact of unmanned aircraft systems on numerical modeling and data assimilation for high-impact weather predictions. She holds a MS degree in meteorology from the University of Oklahoma.



Thomas Sevilla joined AOML's Physical Oceanography Division (PhOD) in August as an electrical engineer with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies. Thomas will work with PhOD's engineering group to design, test, fabricate, and deploy new ocean-observing instruments. He will also help maintain existing instruments used for field projects and be a seagoing participant on research vessels and merchant ships to assist in the collection of scientific data. Thomas holds a BS degree in electrical engineering from the University of Miami.

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

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