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AOML Keynotes

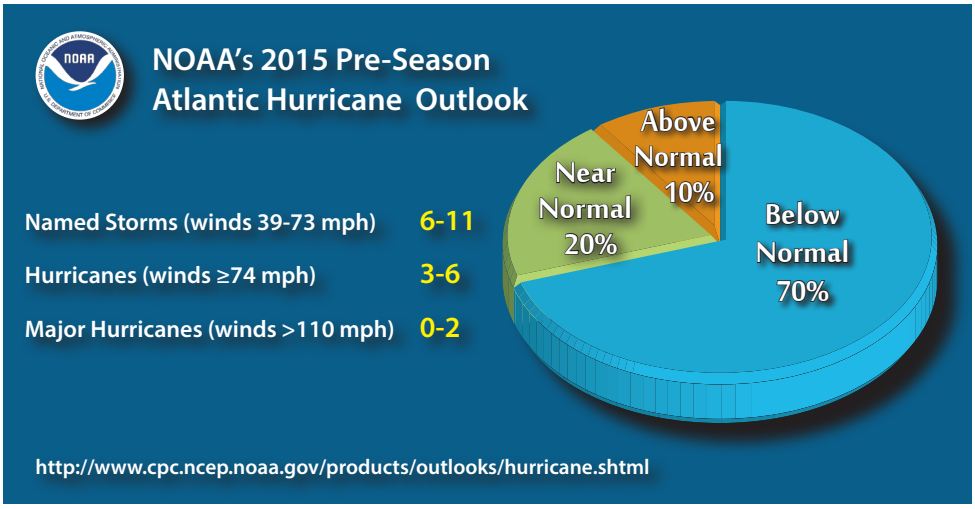
ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

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

Below-Normal Hurricane Activity Likely for 2015 Atlantic Season

"The main factor expected to suppress hurricane season this year is El Niño, which is already affecting wind and pressure patterns. El Niño may intensify; it is expected to have its greatest influence during the peak months of the season. We also expect sea surface temperatures in the tropical Atlantic to be close to normal, whereas warmer waters would have supported storm development."

Dr. Gerry Bell
NOAA-Climate Prediction Center



The 2015 Atlantic hurricane season will likely be marked by below-normal storm activity, according to NOAA's team of hurricane specialists who released their first outlook on May 27th.

For hurricane season, which runs from June 1-November 30, NOAA is predicting a 70% likelihood of 6 to 11 named storms (winds of 39 mph or higher), of which 3 to 6 could become hurricanes (winds of 74 mph or greater). NOAA further predicts zero to 2 hurricanes could intensify into major hurricanes (categories 3, 4, or 5 on the Saffir-Simpson scale; winds of 111 mph or higher). While a below-normal season is expected (70%), there is also a 20% chance of a near-normal season and a 10% chance of an above-normal season.

2015 Atlantic Storm Names		
Ana	Henri	Odette
Bill	Ida	Peter
Claudette	Joaquin	Rose
Danny	Kate	Sam
Erika	Larry	Teresa
Fred	Mindy	Victor
Grace	Nicholas	Wanda

"A below-normal season doesn't mean we're off the hook. As we've seen before, below-normal seasons can still produce catastrophic impacts to communities," said NOAA Administrator Dr. Kathryn Sullivan. Sulllivan was referring to the 1992 Atlantic season in which only seven named storms formed, yet the first was Andrew, a major category 5 hurricane that devastated South Florida.

Included in the outlook is Tropical Storm Ana, but its pre-season development is not an indicator of the season's overall strength. Ana's development was typical of pre-season named storms, which often form along frontal boundaries in association with a trough in the jet stream. This method of formation differs from the named storms during the peak of the season, which originate mainly from low-pressure systems moving westward from Africa that are independent of frontal boundaries and the jet stream.

With the 2015 hurricane season comes a new storm surge watch and warning graphic from NOAA's National Hurricane Center. The graphic is intended to highlight areas along the Gulf and Atlantic coasts of the US that are at significant risk from life-threatening inundation due to storm surge from tropical cyclones. It introduces the concept of watches and warnings that are specific to the storm surge hazard.

Storm surge is often the greatest threat to life and property from tropical cyclones, and it can occur at various times and distances from the location of a storm's destructive winds. While coastal residents can sometimes remain in their homes and be safe from a tropical cyclone's winds, evacuations are most often needed to keep people safe from storm surge. Having separate warnings for these two hazards should provide emergency managers, the media, and the general public with better guidance on the dangers posed when a tropical cyclone threatens.

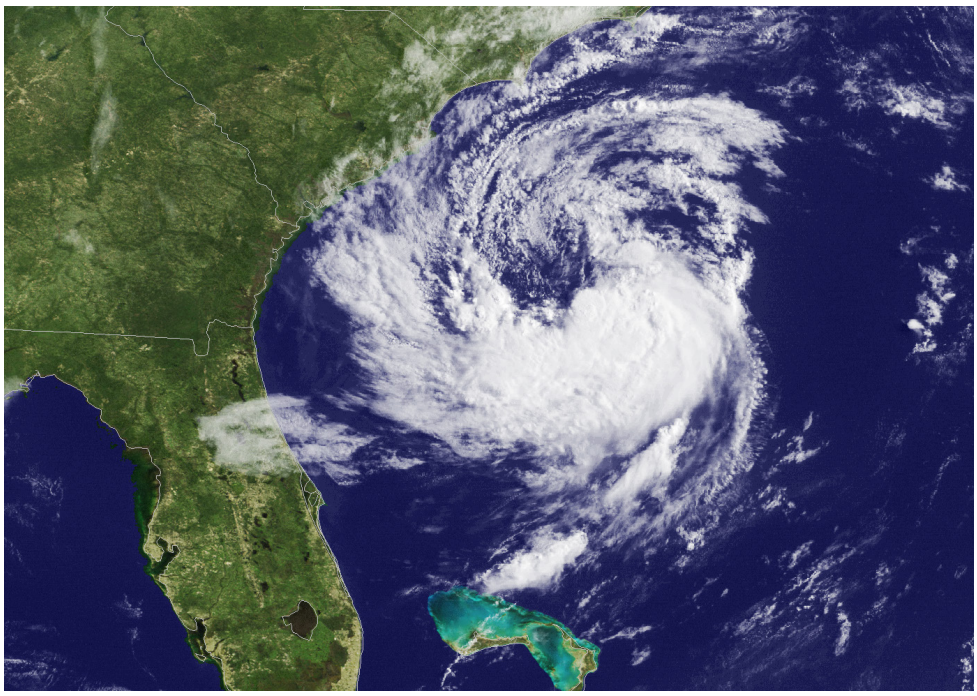
The 2015 Atlantic pre-season hurricane outlook is an official product of NOAA's Climate Prediction Center, produced in collaboration with the National Hurricane Center and AOML's Hurricane Research Division.

NOAA will issue an updated outlook for the Atlantic hurricane season in early August, just prior to the historical peak of the season.

NOAA Continues Focus to Improve Hurricane Track and Intensity Forecasts

"Our goal is to give communities the forecasts they need to be ready, responsive, and resilient to severe weather."

Dr. Frank Marks, Director
Hurricane Research Division



Tropical Storm Ana, the first Atlantic named storm of 2015, developed off the southeast coast of the US three weeks before the official June 1st start of hurricane season. The slow-moving system came ashore near Myrtle Beach, South Carolina on May 10th. Ana's 45 mph sustained winds brought blustery weather to the Carolinas, drenching local communities with up to 6 inches of rain and flooding low-lying areas.

During the 2015 hurricane season, scientists with NOAA's Office of Oceanic and Atmospheric Research and National Weather Service will work together to upgrade weather forecast models and conduct research with unmanned air and water craft to improve hurricane track and intensity forecasts.

A highlight this season is the upgrade of NOAA's operational Hurricane Weather Research and Forecast (HWRF) system, an advanced hurricane prediction model. The upgraded version of HWRF features a higher resolution, from 3 to 2 kilometers, and will incorporate tail Doppler radar data from NOAA's P-3 hurricane hunter aircraft to obtain a more accurate depiction of the winds found in tropical cyclones. Retrospective testing of the 2015 HWRF model upgrades have demonstrated a 5% improvement in intensity forecasts over forecasts from the 2014 version.

"With each upgrade to a higher resolution, the model helps improve predictions of hurricane intensity because we're able to more closely model features such as clouds that can significantly affect storm intensity," said Dr. Frank Marks, director of AOML's Hurricane Research Division. "Our goal is to give communities the forecasts they need to be ready, responsive, and resilient to severe weather."

Not only does the operational HWRF model have better resolution, but NOAA is also running HWRF globally in support of the Joint Typhoon Warning Center, the center responsible for issuing tropical cyclone warnings for the U.S. Department of Defense in the northwest Pacific Ocean, South Pacific Ocean, and Indian Ocean. There is also a new data assimilation system that uses the HWRF ensemble to incorporate tropical cyclone inner core data gathered by hurricane hunter aircraft.

Scientists with AOML's Hurricane Research Division and NOAA's Unmanned Aircraft Systems Program will work together with scientists from NOAA's Environmental Monitoring Center to transition GPS dropsonde data collected by the NASA Global Hawk unmanned aircraft into operational use by NOAA's National Hurricane Center. This project will also demonstrate the potential of new observing technologies such as the Global Hawk, Coyote unmanned aircraft drone, Doppler wind lidar, and underwater ocean gliders to improve track and intensity forecasts.

NOAA is also adding a Doppler wind lidar to the P-3 aircraft which will collect, process, and transmit atmospheric data from within a hurricane. The lidar will complement the P-3 tail Doppler radar, allowing NOAA to sample the winds inside the hurricane, even within the eye of the storm, which may be driving rapid changes in hurricane intensity. ***Cont. page 3***

NOAA will continue testing the use of remote, unmanned observing technologies during the 2015 hurricane season as part of its effort to improve track and intensity forecasts. These technologies include (a) the Coyote unmanned aircraft drone that gathers data in the lowest, most turbulent reaches of the tropical cyclone environment, (b) underwater ocean gliders to aid researchers in better understanding the dynamics of the upper ocean and air-sea interaction processes during the passage of tropical cyclones, and (c) the NASA Global Hawk unmanned aircraft that gathers data at higher altitudes, broader ranges, and longer periods than manned aircraft.

Continued from page 2

Building upon earlier collaborative research with NASA, NOAA will direct ten flights of the Global Hawk in late August through early September to gather data on hurricanes. The Global Hawk will carry instruments to measure temperature, moisture, wind speed, and direction to profile tropical systems from an altitude of 60,000 feet down to the surface of the ocean. This new mission for the Global Hawk, called the Sensing Hazards with Operational Unmanned Technology (SHOUT), is funded in part by the Disaster Relief Appropriations Act of 2013.

"Flying the Global Hawk with weather observing sensors above a storm is like putting the storm under a microscope. We can gather high-resolution data to see more clearly inside the storm and better capture changes in wind speed and intensity," said Robbie Hood, director of NOAA's Unmanned Aircraft Systems Program. "We are also testing how unmanned aircraft can be a reliable observation tool to augment weather observations from satellites and, in the event of an unplanned gap in satellite coverage, to provide severe weather forecast information."

Not only can the Global Hawk fly at higher altitudes than manned aircraft, it can also fly for 24 hours, a time frame much longer than the capability of manned aircraft, allowing it to gather data on the evolution of a hurricane over an entire day.

During the 2014 Atlantic hurricane season, NOAA successfully deployed the Coyote unmanned aircraft drone from a hurricane hunter plane into the eye of Hurricane Edouard. The use of the small Coyote aircraft will be expanded during the 2015 hurricane season. Planned flights timed to tropical cyclones will measure the regions of the most turbulent, violent winds found at the lowest altitudes and send the data in real-time to forecasters at NOAA's National Hurricane Center.

NOAA is also planning to deploy two underwater gliders in the northern and southern coastal waters of Puerto Rico to collect upper ocean data before, during, and after a storm passes. These measurements will provide researchers with a better understanding of how the ocean responds to a hurricane's passage, which, in turn, will improve the ocean models used in hurricane forecasts.

"We must continue to push the boundaries of science to increase lead times for tropical cyclones, floods, and other severe weather," said Marks. "This season's research is designed to find earlier clues to when storms rapidly intensify to help build a more weather ready nation."

Tail Doppler radar data gathered by NOAA's G-IV hurricane hunter jet will be tested this year by the Environmental Modeling Center to determine their impact upon track and intensity forecasts. If all goes well, they will be used operationally during the 2016 hurricane season, providing more accurate information about the strength and extent of the damaging winds found in tropical systems.

NOAA's two P-3 hurricane hunter aircraft—Miss Piggy and Kermit—underwent major refurbishments in May thanks to funding from the Disaster Relief Appropriations Act of 2013. The planes were outfitted with new engines, as well as upgraded tail, fuselage, and nose radar. This year Kermit is also being outfitted with new wings and will be out of commission for the 2015 hurricane season. Next year Miss Piggy will receive her new wings and be grounded for the 2016 hurricane season. The $42 million upgrade should keep the 38-year old planes airborne for years to come.

AOML's Hurricane Research Division
www.aoml.noaa.gov/hrd

AOML's Underwater Glider Project
www.aoml.noaa.gov/phod/goos/gliders/index.php

Environmental Modeling Center
www.emc.ncep.noaa.gov

NASA Global Hawk
www.nasa.gov/centers/armstrong/aircraft/GlobalHawk/index.html

National Hurricane Center
www.nhc.noaa.gov

Unmanned Aircraft Systems Program
uas.noaa.gov

Article adapted from NOAA's Office of Oceanic and Atmospheric web site (research.noaa.gov)

Research Transitions to Operations

The following projects led by AOML hurricane researchers and developed through the Joint Hurricane Testbed program have been accepted by the National Hurricane Center for transition into operational use during the 2015 hurricane season:

Improvements to the SHIPS (Statistical Hurricane Intensity Prediction Scheme) Rapid Intensification Index

John Kaplan, AOML; Christopher Rozoff, University of Wisconsin; Charles Sampson, Naval Research Laboratory; James Kossin, National Climatic Data Center; Christopher Velden, University of Wisconsin

New statistical probabilistic prediction models have been developed for both the eastern North Pacific and Atlantic basins. These models will aid in the operational forecasting of tropical cyclone rapid intensification during the critical 48-hour period when the National Hurricane Center is required to issue watches and warnings.

Improved Stepped-Frequency Microwave Radiometer Surface Wind Measurements in Intense Rain Conditions

Eric Uhlhorn-Bradley Klotz, AOML

This project addresses a known bias in hurricane sea surface wind data measured by airborne stepped-frequency microwave radiometers (SFMRs). By analyzing aircraft data from several SFMR instruments, the wind speed bias in heavy precipitation has been corrected by modifying an algorithm. This modification will provide a significant improvement to a data product the National Hurricane Center uses to analyze the intensity of tropical cyclones.

Development of a Probabilistic Tropical Cyclone Genesis Prediction Scheme

Jason Dunion-John Kaplan, AOML; Andrea Schumacher, Colorado State University; Joshua Cossuth, Florida State University

A new model has been developed for predicting the probability of tropical cyclone genesis in the North Atlantic Ocean. This model, the Tropical Cyclone Genesis Index, or TCGI, provides forecasters with an objective tool for forecasting tropical cyclone formation in the two-day and five-day time frames.

Research Shows Indian Ocean Plays Key Role in Global Warming Hiatus

The earth is warming, but atmospheric and oceanic temperatures that rose steadily over the last half century have leveled off and slowed this past decade, causing the appearance of an imbalance in the Earth's heat budget. Scientists looking to the deep ocean for where the additional heat energy might be stored recently traced a pathway that leads to the Indian Ocean.

In a study published May 18th in *Nature Geoscience*,* researchers with AOML, the University of Miami's Cooperative Institute for Marine and Atmospheric Studies (CIMAS), and their colleagues identified a key mechanism that explains an apparent contradiction associated with the recent pause in global warming.

Building upon previous studies that targeted the tropical Pacific Ocean's enhanced heat uptake as the major source of the imbalance, the new study tracks the excess heat out of the Pacific Ocean and into the Indian Ocean via the Indonesian Throughflow, a current that shuttles water between the two basins. Researchers had theorized the Pacific was storing a large portion of the global heat imbalance over the last decade, thereby causing the atmosphere to warm less.

Natural climate variability processes such as the El Niño/Southern Oscillation (ENSO) phenomenon, a cycle of warm and cold sea surface temperatures in the tropical Pacific Ocean, drive wind patterns and ocean currents across the region. Since the start of the 21st century, the cold phase of ENSO, known as La Niña, has persisted, increasing the uptake of warm surface waters in the subtropics. This process and others have enhanced the uptake of heat from the atmosphere into the top 2,000-3,000 feet of the ocean.

While uptake in the Pacific as a result of La Niña-like conditions may have answered the initial question regarding the missing heat from the atmosphere, the study indicates that stored heat in the Pacific has been slowly decreasing and that the excess heat has been transported elsewhere.

"When I first saw from the data that Pacific heat was going down, I was very curious and puzzled," said the study's lead author Dr. Sang-Ki Lee, a CIMAS scientist with AOML's Physical Oceanography Division.

Results from the study suggest the excess heat is being stored in the Indian Ocean, which has experienced an unprecedented rise in heat over the past decade. To determine this, the research team studied observations dating back to the 1950s and observed that heat uptake in the Indian Ocean was relatively low until about 2003. From 2003 onward, however, heat began building in the Indian Ocean, although no evidence supported the source of the heat as being from the atmosphere.

By running simulations from a global ocean-sea ice model to track the pathway of heat, the research team found that heat originally stored in the Pacific was being transported via the Indonesian Throughflow into the Indian Ocean. This heat flux transfer points to the increasingly important role played by the Indian Ocean in modulating global climate variability, as it now accounts for more than 70% of all heat absorbed by the global oceans over the past decade.

Thus, the study resolves an important debate regarding the warming slow down. While scientists have theorized the Pacific is a major player in the warming hiatus, total heat in the Pacific basin has not increased, as expected. Instead, the study reveals the Pacific has been an intermediary in the heat storage process, not its final destination, which explains the lack of change in Pacific heat.

Lee has several thoughts about the future effects of this warm, deep ocean water. In its current location, Lee thinks it's possible the warm water in the Indian Ocean could potentially affect the Indian Monsoon, an important climate pattern that impacts more than 1 billion people annually. What it means for future El Niño cycles is not immediately clear. However, Lee noted that the warm water in the western Pacific, which provides the energy needed to produce intense El Niño events, has been partially discharged into the Indian Ocean, suggesting weaker El Niño events in the near future.

Lee also indicated that the heat content is likely to continue moving with global ocean currents and may find its way into the Atlantic basin in the coming decades. "If this warm body of water in the upper Indian Ocean is transported all the way to the North Atlantic, it could affect the melting of Arctic sea ice," stated Lee. "It could also increase hurricane activity and influence the effects of drought in the US, but future studies are required to validate these hypotheses."

Global average surface air temperatures have increased steadily since the 1950s, with the warming attributed to greenhouse gases from human activities. Since the start of the 21st century, however, global surface warming has almost stalled. This contradicts the amount of net radiation entering Earth at the top of the atmosphere, which continues to suggest an increasingly warming planet. The slowdown of surface warming has been the focus of a series of studies seeking to identify and track the cause(s) of this process.

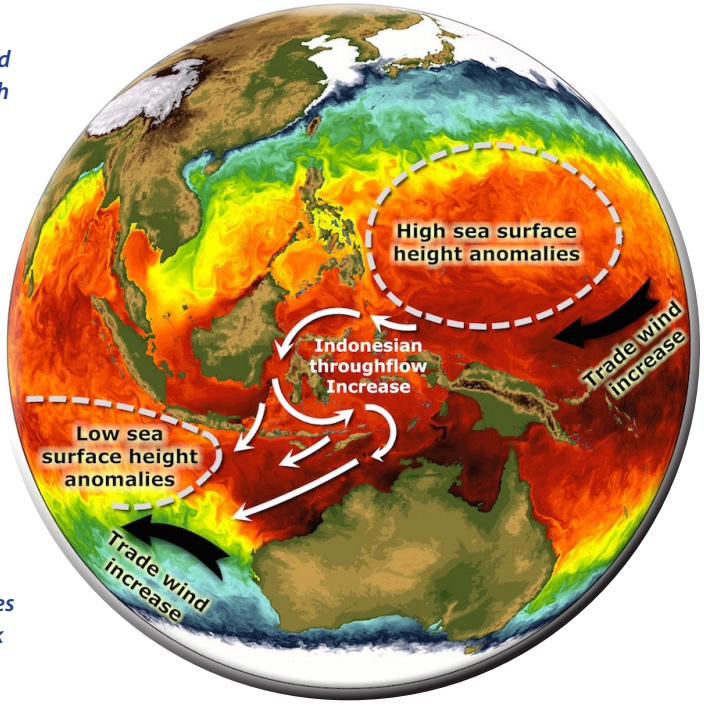


Illustration of how increased trade winds in the Pacific and Indian oceans during the recent warming hiatus have increased the inter-ocean pressure gradient, enhancing the transfer of warm water out of the western Pacific via the Indonesian Throughflow. The result has been an abrupt increase in Indian Ocean heat content.

*Lee, S.-K., W. Park, M.O. Baringer, A.L. Gordon, B. Huber, and Y. Li, 2015: Pacific origin of the abrupt increase in Indian Ocean heat content during the warming hiatus. *Nature Geoscience*, doi:10.1038/ngeo2438.

Dr. Molly Baringer Selected as AOML's Next Deputy Director

Dr. Molly Baringer, a veteran oceanographer with AOML's Physical Oceanography Division, was selected in May as the new AOML deputy director. Molly assumed the role of deputy director after having served in an acting capacity since October 2014. She also served as AOML's acting deputy director in 2010 during the Deepwater Horizon oil spill, skillfully managing resources to support AOML's scientific response.

Molly brings a wealth of experience, expertise, and leadership skills to her new position. During her 21-year tenure at AOML, she has managed research teams and forged partnerships with national and international research institutions. These partnerships have included, among others, the National Science Foundation, National Space and Aeronautics Administration, and the National Environmental Research Council in the UK. Additionally, Molly has participated in more than 20 national and international panels, providing advice and direction on national science policy and program management.

As a sea-going oceanographer at AOML, Molly has participated in more than 30 hydrographic research cruises since 1998, often serving as the chief scientist. Her research portfolio and expertise are strongly rooted in the Atlantic Ocean, where she has linked ocean circulation patterns and changes to global and/or regional climate patterns.

Over the past 10 years, Molly has been a principal or co-principal investigator on numerous externally-funded research programs totaling more than $30 million dollars. Her research has led to more than 75 peer-reviewed publications in journals such as *Science*, the *Journal of Climate*, and the *Journal of Geophysical Research*. For her role on the Western Boundary Time Series Team, she received a Department of Commerce Bronze Medal.

Molly holds a PhD in physical oceanography earned in 1994 from the Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. She is also a graduate of NOAA's Leadership Competency Development Program and the National Weather Service's Building Leaders for a Solid Tomorrow (BLAST) program.

In fulfilling her duties as the deputy director of AOML, Molly will work closely with AOML director Dr. Bob Atlas to supervise the administrative, facilities and security, computer networks, and communications staff housed within the Office of the Director. She will also continue her scientific leadership roles for the Western Boundary Time Series and Argo projects.

NOAA Awards First of its Kind Contract

On May 29th, NOAA awarded a Utility Energy Service Contract (UESC) to Florida Power and Light to replace AOML's 30-year-old chiller, upgrade the building's control system, and decommission the thermal energy storage system. This project took nearly two years to develop and contract; once completed, it should reduce AOML's energy consumption by about 24% annually, with a resulting energy and maintenance cost savings of about $75K annually over the first five years. It should also improve AOML's ability to control employee comfort.

The project is especially significant because AOML is the first NOAA entity to use a UESC. UESCs provide federal agencies with the means to partner with utilities and implement energy efficiency projects, with the utility providing analysis, design, construction, and, often, financing services.

Facilities operations specialist Manny Fraga with the aging, rusting chiller at AOML, an essential component of the air conditioning system.

AOML's energy savings will be reported to the Office of Management and Budget and scored as part of the Department of Commerce's performance contracting efforts to reduce building energy usage by 2.5% annually, as required by a March 2015 Executive Order on Federal Sustainability.

Thanks are due to CDR Stephen Meador, AOML's Associate Director, the staff of AOML's Admin Office, and the staff of NOAA's Aquisition and Grants Office in Kansas City, Missouri, for their diligent efforts in bringing this project to fruition.

AOML Microbiologists Participate in International Ocean Sampling Day

Researchers with AOML's Environmental Microbiology Lab joined the global effort to sample the smallest members of the ocean ecosystem on June 21st during International Ocean Sampling Day. The event was organized and led by the European Union's MicroB3 organization and the Ocean Sampling Day Consortium. Ocean Sampling Day is a simultaneous sampling campaign of the world's oceans and coastal waters. The cumulative samples gathered, related in time, space, and environmental parameters, aid in determining a baseline for global marine biodiversity and function on a molecular level.

What are scientists looking for?

The organisms of scientific interest for the Ocean Sampling Day campaign include microscopic bacteria, archaea, fungi, protists, and viruses, collectively known as microbes. Microbes comprise 98% of the biomass in Earth's oceans and are responsible for most of the biological activity that occurs within it. Microbes are found everywhere, from the ocean surface to deep within rocks beneath the ocean floor. They are pervasive and can evolve rapidly in response to changes in the environment. In fact, many scientists consider microbes to be the "canary in the coal mine," signaling local and global changes in the oceans. It is, therefore, important to acquire information from across the globe on this vast community of organisms, against which future changes can be observed and measured.

2014: The first global Ocean Sampling Day effort

During the 2014 Ocean Sampling Day event, over 180 scientific teams participated from all continents, ranging from subtropical waters in the Caribbean to extreme environments in the Antarctic Ocean. On this day, more than 600 people all around the world gathered water samples from the ocean to identify the microbes within. Scientists used the data collected to support projects focusing on environmental microbiology parameters that describe the relationship between marine microbes and human health and the health of local marine ecosystems. These data also provided insights into the ocean economy through the identification of novel, ocean-derived biotechnologies.

A Girl Scout troop processes a water sample at AOML's Ocean Sampling Day site in La Jolla, California.

An AOML student intern with a water sample obtained at Tennessee Reef in the Florida Keys National Marine Sanctuary.

Where are AOML scientists sampling?

This year, AOML will coordinate and sample ten Ocean Sampling Day sites across the country. In addition to the 2014 sites in the Florida Keys, Ft. Lauderdale, Tampa Bay, La Jolla, California, and Horn Island, Mississippi, AOML will coordinate five new sites spread across the Florida peninsula from Pensacola to Miami. Sampling sites are expected to be monitored long-term as part of the international Genomic Observatories Network, and the resulting database will be accessible to the public.

MyOSD: The citizen scientist component

Ocean Samping Day organizers amended the citizen science component for this year's event, allowing individuals from all over the globe to collect samples in their backyard using handy sampling kits. This component, called MyOSD, gave individuals the chance to help scientists unravel the mysteries of the marine microbial world by collecting important environmental data such as latitude, longitude, temperature, salinity, pH, and wind speed.

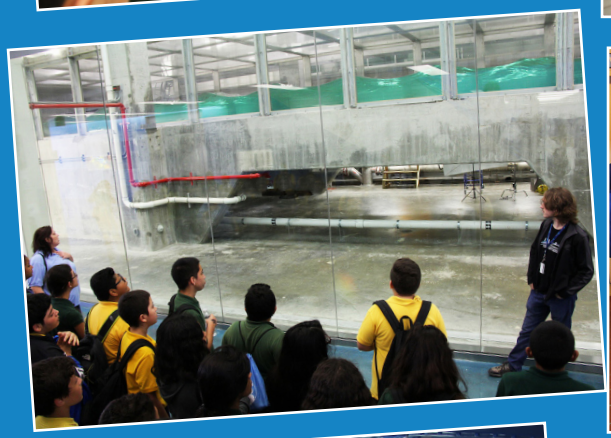
AOML coordinated and provided kits to a number of citizen science groups in Florida and California, including organized youth groups, citizen science organizations, educational centers, and outreach groups. Samples collected will represent a variety of marine ecosystems, including the open ocean, beaches, coral reefs, and estuaries. "We are excited to be working with a number of citizen scientists this year to expand our sampling effort and help contribute to our understanding of the ocean's biodiversity," said AOML microbiologist Dr. Chris Sinigalliano.

A baseline for the future

With the combined effort of researchers and citizen scientists, Ocean Sampling Day 2015 continued the initiative to collect and share crucial information that can be used as a reference for generations of experiments to follow in the coming decades. Additionally, the data analysis procedures developed for Ocean Sampling Day are driving the field forward, but it is clear that much remains to be discovered about the microbial world. Scientists hope that such large-scale projects that provide an "ecological snapshot" become increasingly more common, as they are essential for understanding the complexity of Earth's systems.

For more info about Ocean Sampling Day, visit www.microb3.eu/osd.

Record Numbers Participate in Virginia Key Open House



AOML and NOAA's Southeast Fisheries Science Center (SEFSC) partnered with the University of Miami's Rosenstiel School and the Maritime and Science Technology (MAST) Academy to host an open house on May 14-16. The three-day event brought an estimated 1300 people to Virginia Key to learn about a variety of scientific topics including hurricanes, climate change, oceanography, local fisheries, coral ecosystems, and endangered species. NOAA and Rosenstiel School scientists were on-hand to describe their research projects, conduct hands-on experiments, and answer questions.

More than 700 students from 14 local schools participated in the event on Thursday and Friday, May 14-15. Student groups toured the AOML and SEFSC facilities, MAST Academy Land SHARC and Weather-on-Wheels mobile outreach buses, and the Rosenstiel School's new Marine Technology and Life Sciences Seawater Complex. The doors were then opened to the public on Saturday, May 16th. Saturday's event was an interactive experience for all age groups, with visitors rotating throughout each NOAA facility, the MAST mobile outreach buses, and the Rosenstiel School's experimental hatchery. Among the visitors were over 225 Boy Scouts and Girl Scouts from local troops, each of whom earned a special science patch for their participation in the open house.

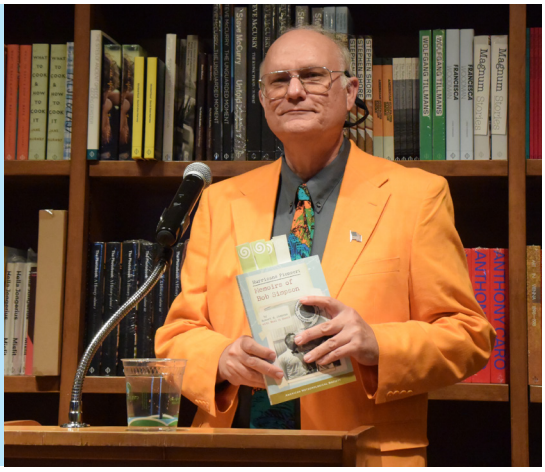
This event brought marine and atmospheric science to the local Miami community and further enhanced Science, Technology, Engineering and Math (STEM) education. Thanks are due Erica Rule of AOML and Essie Coleman-Duffie of SEFSC for co-organizing the event, as well as to the many researchers and volunteers whose participation made the 2015 Virginia Key science community's open house both exciting and successful!

AOML staff—Erica Rule and Drs. Hua Chen and Sundararaman Gopalakrishnan—participated in the First Annual 2015 Broward STEM (Science-Technology-Engineering-Mathematics) Family Expo on Sunday, May 3rd. The one-day event brought together more than 1500 adults and children from across South Florida for a fun, educational day geared towards sparking interest in STEM-related activities and careers. The expo featured interactive, hands-on activities sponsored by local businesses, community partners, and post-secondary institutions. AOML hosted a booth to highlight the upcoming hurricane season and to explain how NOAA scientists use both manned and unmanned aircraft to observe hurricanes. They also explained how these observations improve operational hurricane models that are the foundation for track and intensity forecasts.

Erica Rule (seated) and Hua chen (standing) staff a booth to share information about how NOAA scientists gather observations in tropical cyclones.

AOML meteorologist Neal Dorst made a special guest appearance on May 21st at Books & Books in Coral Gables. Neal was there to promote *Hurricane Pioneer: Memoirs of Bob Simpson*, a new book about the life and career of Dr. Robert H. Simpson. During the last few years of Bob Simpson's life, Neal worked with Bob to edit his memoir and assist Bob in having it published. At the event, Neal read selected excerpts from the book, followed by a discussion with audience members about the contributions of both Bob and Joanne Simpson in mentoring several generations of tropical meteorologists. Neal's presentation was preceded by a meeting of the Greater Miami Chapter of the American Meteorological Society. Additional Information about the event is available at www.booksandbooks.com/event/neal-dorst-hurricane-pioneer-gables.

AOML meteorologist Neal Dorst at Books & Books on May 21st.



AOML hurricane researcher Dr. Eric Uhlhorn participated in the 10th annual Weather Day event at Marlins Park hosted by the local CBS4 news affiliate on May 21st. Thousands of elementary and middle school students from Broward, Miami-Dade, and Palm Beach counties filled the ballpark stadium for a pre-game program to learn about the basic concepts of weather and climate and how they relate to living in South Florida. Eric discussed NOAA's use of emerging new unmanned technologies, among them the Coyote unmanned aircraft drone and underwater ocean gliders. These technologies will be used during the 2015 Atlantic hurricane season to aid researchers in their efforts to better understand how tropical cyclones form and intensify.

Eric Uhlhorn with a Coyote unmanned aircraft drone (left) and an underwater ocean glider (right).

Scientists with AOML's Hurricane Research Division participated in the annual "Feel the Force: Hurricanes and Other Hazards" interactive exhibit at the Patricia and Philip Frost Museum of Science on Saturday, May 30th. The one-day event drew an estimated crowd of 1000 people who attended to learn how to better prepare their homes and families for disaster, especially due to hurricanes, and to better understand how hurricanes and other weather hazzards form and develop. AOML's hurricane researchers staffed an exhibit dedicated to explaining how scientists fly into storms to gather data that are crucial for accurate forecasts. In addition to chatting about what it's like being a hurricane hunter, they also answered questions about the latest innovations in technology that NOAA will test during the 2015 Atlantic hurricane season as part of its efforts to improve hurricane track and intensity forecasts.

Frank Marks, director of AOML's Hurricane Research Division, chats with young visitors at the Patricia and Philip Frost Museum of Science.

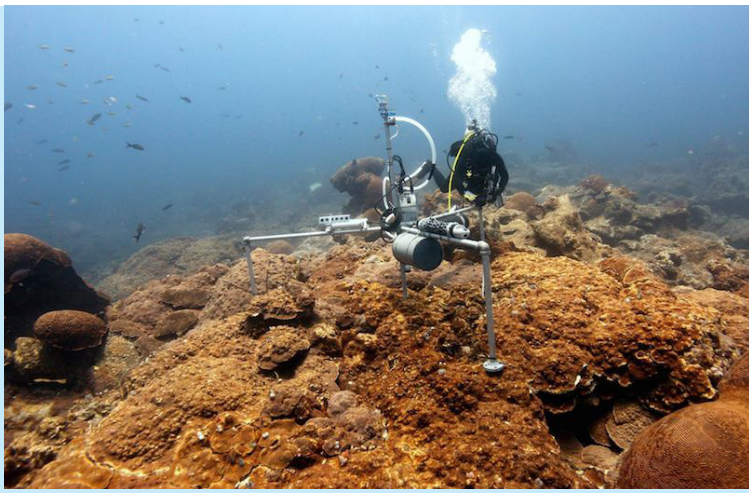
In early May, AOML coral researchers Ian Enochs and Graham Kolodziej conducted work in Puerto Rico associated with the NOAA-Coral Reef Conservation Program's National Coral Reef Monitoring Plan. Together with colleagues Dr. Daniel Moses Holstein and Viktor Brandtneris from the University of the Virgin Islands, they installed three subsurface temperature recorder arrays at Vieques, Culebra, and Isla Palominos. Ian and Graham also installed additional arrays off of Arecibo and Jobos Bay National Estuarine Research Reserve in the northern and southern coastal waters of Puerto Rico, respectively. A final array was installed in Rincon in June. Each subsurface temperature recorder array consists of highly accurate Sea-Bird temperature loggers, deployed by divers at 1-, 5-, 15-, and 25-m depths. Temperature will be recorded every 5 minutes at these locations for a three-year period, at which point the instruments will be replaced. At Jobos Bay, Ian and Graham worked closely with Angel Dieppa, the reserve's scientific coordinator, who provided field support and advice concerning site location. Following instrument deployment, they received a tour of the park's laboratory capabilities and monitoring programs, as well as the diverse ecosystems present there.

A subsurface temperature recorder is wrapped in anti-fouling tape and secured to reef rock with a stainless steel stake, hose clamps, and cable ties.

Coral reef in the Chagos Archipelago: *Left:* Normally pigmented; *Right:* Completely bleached.

AOML coral researchers Derek Manzello and Renee Carlton returned from a successful voyage to the Indian Ocean's Chagos Archipelago in May in collaboration with the Living Oceans Foundation. Derek and Renee obtained coral cores and seawater chemistry measurements to establish ocean acidification baselines for this remote area with almost no human impacts, as well as to determine if there have been any recent declines in coral growth that may be attributable to ocean acidification. During the course of the mission, mass coral bleaching was observed on many reefs, primarily impacting tabulate acroporid corals, as well as corals in the genera *Pocillopora* and *Seriatopora*. Seawater temperatures were warm during the entire trip, ranging from 29 to >31°C at all 54 reefs surveyed. Sea conditions were very calm, exhibiting doldrum-like characteristics. These conditions likely contributed to the bleaching due to enhanced penetration of light into the water column.

In June, the Ocean Chemistry and Ecosystem Division's ACCRETE (Acidification, Climate and Coral Reef Ecosystems TEam) group—Derek Manzello, Ian Enochs, Renee Carlton, Graham Kolodziej, Lauren Valentino, and Paul Jones—successfully established the last of three climate and ocean acidification sentinel monitoring sites at the Flower Garden Banks National Marine Sanctuary in the Gulf of Mexico. ACCRETE completed the ambitious suite of ocean acidification eco-response activities owing to the exemplary work of the team and quiescent seas. The eco-response metrics included calcium carbonate budget surveys, measurement of benthic ecosystem calcification and productivity using BEAMS (Benthic Ecosystem Acidification Monitoring System), and deployment of the ARMS (autonomous reef monitoring structures), CAUs (calcification accretion units), and BMUs (bioerosion monitoring units) instruments. Sixty coral cores were obtained from the species *Orbicella faveolata*, *Siderastrea siderea*, *Diploria strigosa*, *Colpophyllia natans*, *Porites astreoides*, and *Montastraea cavernosa*. These cores will be analyzed with the new CT scanner being installed at AOML to determine historical growth and calcification rates.



***Top:* ACCRETE researcher Lauren Valentino collects a water sample adjacent to the BEAMS system; *Bottom Left:* NOAA RV *Manta* at port in Galveston, Texas; *Bottom Right:* Closeup of the groves on a brain coral head in the Flower Garden Banks National Marine Sanctuary.**

AOML Augments its Ranks with Talented Student Interns

AOML welcomed 23 new and returning high school, undergraduate, and graduate students to its ranks beginning in May, all of whom will be completing 6- to 10-week internships at the lab this summer. Student interns will work with mentors in the Hurricane Research, Ocean Chemistry and Ecosystems, and Physical Oceanography science divisions, as well as specialists with the Office of the Director's Computer Networks and Services, Administration, and Communications groups.

AOML's internship opportunities provide students with experiences that motivate and prepare them for careers aligned with NOAA and its industry and university partners. For many students, these internships are unique experiences that provide an opportunity to learn from some of the nation's leading scientists. They participate in activities that support ongoing AOML research and, sometimes, create new opportunities that become the foundation for their first scientific publication.

Each intern's activities are matched to their educational interests and background. Typical assignments include experimental data collection and processing, equipment design and testing, field research and sampling, computer software development, and website design.

A few more specific internship research projects this summer include:

- Gathering samples from a variety of sites to test water quality and assess/characterize microbial contaminants using molecular techniques.
- Examining storm characteristics that influence hurricane development as part of the effort to improve hurricane intensity forecasts.
- Observing and modeling climate fluctuations found in the central and northeastern tropical Atlantic Ocean.

These projects are at the cutting edge of science and technology, and all are important to future NOAA research efforts.

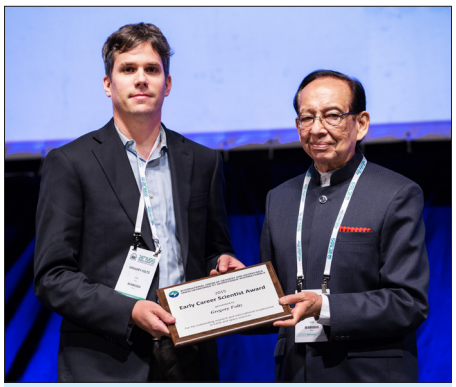
AOML's 2015 group of student interns also contains three undergraduate students from the prestigious Hollings Scholarship Program administered by NOAA. The Hollings program provides support and multidisciplinary learning experiences for students interested in pursuing research, public service, and/or teaching careers in the atmospheric and oceanic sciences.

AOML's 2015 summer interns in the NOAA Miami Regional library at AOML.

2015 Student Interns	AOML Mentors
Casey Almendaraz Miami Lakes Educational Center	Chris Sinigalliano/Maribeth Gidley Ocean Chemistry and Ecosystems Division
John D'Alessandro Northern Illinois University	Eric Uhlhorn Hurricane Research Division
Daniella Documet MAST Academy	Chris Kelble/Lindsey Visser Ocean Chemistry and Ecosystems Division
Austin Erben Boulder High School	Ulises Rivero/Grant Rawson Physical Oceanography Division
Emily Franco MAST Academy	Shaun Dolk/Renellys Perez Physical Oceanography Division
Eileen Garcia G. Holmes Braddock Senior High School	Alejandra Lorenzo/Erica Rule Computer Networks and Services/Communications
Michael Goldberg Emory University	Chris Sinigalliano/Maribeth Gidley Ocean Chemistry and Ecosystems Division
Barbara Groh TERRA Environmental Research Institute	Ulises Rivero Physical Oceanography Division
Aaron Hale University of Miami	Jack Stamates Ocean Chemistry and Ecosystems Division
Kurt Hansen, NOAA Hollings Scholar State University of New York-Albany	Sim Aberson Hurricane Research Division
David Herrera G. Holmes Braddock Senior High School	Alejandra Lorenzo/Erica Rule Computer Networks and Services/Communications
Yunyeol Lee Palmetto Senior High School	Chris Labbe Computer Networks and Services
Ciro Liutti Rio Grande Federal University	Molly Baringer Physical Oceanography Division
Daniel Morales Miami-Dade College	Chris Sinigalliano/Maribeth Gidley Ocean Chemistry and Ecosystems Division
John Morris University of Miami	Derek Manzello/Ian Enochs Ocean Chemistry and Ecosystems Division
Maxime Pierrot Coral Reef Senior High School	Pedro Pena Physical Oceanography Division
Kayla Pineda MAST Academy	Shaun Dolk/Renellys Perez Physical Oceanography Division
Sofia Roca G. Holmes Braddock Senior High School	Alejandra Lorenzo/Gail Derr Computer Networks and Services/Communications
Allyson Rugg, NOAA Hollings Scholar University of Colorado	Greg Foltz/Renellys Perez Physical Oceanography Division
Jordan Seijo MAST Academy	Alejandra Lorenzo/Dalynne Julmiste Computer Networks and Services/Administration
Kristina Thoren Cornell University	Chris Sinigalliano/Maribeth Gidley Ocean Chemistry and Ecosystems Division
Joshua Wadler, NOAA Hollings Scholar University of Oklahoma	Robert Rogers Hurricane Research Division
Vinicius Webber University of Miami	Marlos Goes Physical Oceanography Division

Congratulations

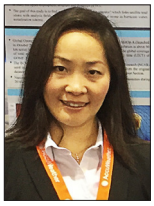
Jay Harris, an information technology specialist with AOML's Physical Oceanography Division (PhOD), was named as the May 2015 NOAA Employee of the Month. For the past 28 years, Jay has managed computer and information technology operations for PhOD's group of 50+ scientists, engineers, programmers, and administrative personnel. He has kept PhOD's computer systems functioning and operational, efficiently troubleshooting problems and emergencies as they arise. Jay's dedicated, long-term efforts have enabled PhOD to successfully conduct mission-critical science on behalf of NOAA with only minimal computer-related interruptions.



Dr. Gregory Foltz of AOML accepts an Early Career Scientist Award from Dr. Harsh Gupta, president of the IUGG.

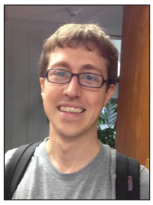
Four scientists with AOML's Physical Oceanography Division attended the 26th General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Prague, Czech Republic from June 22-July 2. Drs. Shenfu Dong, Gregory Foltz, Christopher Meinen, and Hosmay Lopez led sessions and made presentations at this important quadrennial conference. On a special note, Dr. Gregory Foltz was one of 10 individuals who received an IUGG Early Career Scientist award. The award is presented every four years in recognition of outstanding research and international cooperation in the earth and space sciences. Additionally, Dr. Christopher Meinen was elected to a second four-year term on the Executive Council of IUGG's International Association for the Physical Sciences of the Ocean (IAPSO).

Welcome Aboard



Dr. Hui Christophersen joined AOML's Hurricane Research Division in June as a post-doctoral scientist with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies (CIMAS). Hui will work with Dr. Altug Aksoy and Jason Dunion on a project funded by NOAA's Sensing Hazards with Operational Unmanned Technology (SHOUT) program. Together they will investigate the impacts of unmanned aircraft systems such as the Global Hawk on numerical modeling and data assimilation for high-impact weather predictions. These impacts will be studied through Observing System Experiments with unmanned observations collected during prototype operational field missions and Observing System Simulation Experiments based on expected/hypothetical unmanned observing capabilities. Hui recently graduated from Florida State University with a PhD in meteorology.

Dr. Evan Kalina joined the staff of AOML's Hurricane Research Division (HRD) in June as a National Research Council post-doctoral scientist. Evan is a past NOAA Hollings Scholar who interned with HRD during the summer of 2009; he recently graduated from the University of Colorado with a PhD in atmospheric science. Over the next two years, Evan will work with Dr. Joseph Cione of HRD at NOAA's Earth System Research Laboratory in Boulder, Colorado. Evan has a diverse background that includes air-sea interaction research in tropical cyclones, field work with the VORTEX2 program to better understand the dynamics of tornadoes, and HRD's Hurricane Field Program, as well as model evaluation of cloud microphysical processes associated with severe convective systems.



Dr. Matthieu Le Hènaff joined the staff of AOML's Physical Oceanography Division (PhOD) in May as an assistant scientist with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies (CIMAS). Matthieu is an ocean modeler who uses advanced data assimilation methods to perform ocean predictability studies. He also has broad experience in the analysis of ocean models and observations to study the dynamics of mesoscale variability. At AOML, Matthieu will work with Dr. George Halliwell to perform ocean observing system evaluation studies and apply his expertise to determine how ocean predictability can be improved through observing system enhancements. Matthieu will also augment existing capabilities within PhOD by analyzing models and observations to address a broad range of scientific questions. He holds a PhD in physical oceanography from the Université Paul Sabatier in Toulouse, France.

NOAA Corps Officer LTJG Benjamin VanDine joined the staff of AOML's Ocean Chemistry and Ecosystems Division in June to provide field and diving support for ecosystem research conducted throughout south Florida and the Caribbean. Ben will also assist with property audits and the maintenance of AOML's small fleet of government vehicles. He recently recertified his emergency medical technician license so may likely be called upon in the event of a medical emergency at AOML. Prior to his assignment to AOML, Ben served as the Medical, Safety, and Dive Officer aboard the NOAA Ship *Oscar Dyson* stationed in Kodiak, Alaska. He holds a BS degree in biology from Cedarville University.

NOAA Corps Officer LT Marc Weekley joined the staff of AOML's Ocean Chemistry and Ecosystems Division in May to serve as the research operations manager for coastal ecosystem field sampling efforts at AOML, as well as provide diving and logistical support. Marc will also be responsible for operating and maintaining two small boats used for coastal research activities and assist with AOML-wide safety inspections. He was the Operations Officer aboard the NOAA Ship *Gordon Gunter* based in Pascagoula, Mississippi prior to his assignment to AOML. Marc holds a BS degree in environmental science from the University of South Florida.

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

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

AKSOY, A., 2014: Parameter estimation. In *Encylopedia of Atmospheric Sciences* (2nd edition), G.R. North, J. Pyle, and F. Zhang (eds.). Academic Press, Volume 4, 181-186.

AMORNTHAMMARONG, N., P.B. Ortner, **J. HENDEE,** and R. Woosley, 2014: A simplified coulometric method for multi-sample measurements of total dissolved inorganic carbon concentration in marine waters. *Analyst,* 139(20):5263-5270.

Balaguru, K., S. Taraphdar, L.R. Leung, **G.R. FOLTZ,** and J.A. Knaff, 2014: Cyclone-cyclone interactions through the ocean pathway. *Geophysical Research Letters,* 41(19):6855-6862.

COOK, G.S., P.E. Parnell, and L.A. Levin, 2014: Population connectivity shifts at high frequency within an open-coast marine protected area network. *PLoS ONE,* 9(7):e103654 (doi:10.1371/journal.pone.0103654).

Crespo-Medina, M., C.D. Meile, K.S. Hunter, A.-R. Diercks, V.L. Asper, V.J. Orphan, P.L. Tavormina, L.M. Nigro, J.J. Battles, J.P. Chanton, A.M. Shiller, D.-J. Joung, R.M.W. Amon, A. Bracco, J.P. Montoya, T.A. Villareal, **A.M. WOOD,** and S.B. Joye, 2014: The rise and fall of methanotrophy following a deepwater oil-well blowout. *Nature Geoscience,* 7(6):423-427.

DUNION, J.P., C.D. Thorncroft, and C.S. Velden, 2014: The tropical cyclone diurnal cycle of mature hurricanes. *Monthly Weather Review,* 142(10):3900-3919.

GOES, M., I. Wainer, and N. Signorelli, 2014: Investigation of the causes of historical changes in the subsurface salinity minimum of the South Atlantic. *Journal of Geophysical Research,* 119(9):5654-5675.

Happell, J.D., Y. Mendoza, and **K. GOODWIN,** 2014: A reassessment of the soil sink for atmospheric carbon tetrachloride based upon static flux chamber measurements. *Journal of Atmospheric Chemistry,* 71(2):113-123.

KLOTZ, B.W., and **E.W. UHLHORN,** 2014: Improved stepped frequency microwave radiometer tropical cyclone surface winds in heavy precipitation. *Journal of Atmospheric and Oceanic Technology,* 31(11):2392-2408.

Kumar, B.P., J. Vialard, M. Lengaigne, V.S.N. Murty, **G.R. FOLTZ,** M.J. McPhaden, S. Pous, and C. De Boyer Montegut, 2014: Processes of interannual mixed layer temperature variability in the thermocline ridge of the Indian Ocean. *Climate Dynamics,* 43(9-10): 2377-2397.

MARKS, F.D., 2014: Hurricanes: Observations. In *Encylopedia of Atmospheric Sciences* (2nd edition), G.R. North, J. Pyle, and F. Zhang (eds.). Academic Press, Volume 6, 35-56.

Montgomery, M.T., **J.A. ZHANG,** and R.K. Smith, 2014: An analysis of the observed low-level structure of rapidly intensifying and mature Hurricane Earl (2010). *Quarterly Journal of the Royal Meteorological Society,* 140(684):2132-2146.

Negron-Juarez, R.I., J.Q. Chambers, G.C. Hurtt, **B. ANNANE,** S. Cocke, **M. POWELL,** M. Stott, S. Goosem, D.J. Metcalfe, and S.S. Saatchi, 2014: Remote sensing assessment of forest disturbance across complex mountainous terrain: The pattern and severity of impacts of tropical cyclone Yasi on Australian rainforests. *Remote Sensing,* 6(6):5633-5649.

Nolan, D.S., **J.A. ZHANG,** and **E.W. UHLHORN,** 2014: On the limits of estimating the maximum wind speeds in hurricanes. *Monthly Weather Review,* 142(8):2814-2837.

PEREZ, R.C., V. HORMANN, R. LUMPKIN, P. Brandt, W.E. Johns, F. Hernandez, **C. SCHMID,** and B. Bourles, 2014: Mean meridional currents in the central and eastern equatorial Atlantic. *Climate Dynamics,* 43(11):2943-2962.

Prive, N.C., Y. Xie, S. Koch, **R. ATLAS,** S.J. Majumdar, and R.N. Hoffman, 2014: An observing system simulation experiment for the unmanned aircraft system data impact on tropical cyclone track forecasts. *Monthly Weather Review,* 142(11):4357-4363.

Qian, Y.-K., S. Peng, C.-X. Liang, and **R. LUMPKIN,** 2014: On the estimation of Lagrangian diffusivity: Influence of non-stationary mean flow. *Journal of Physical Oceanography,* 44(10):2796-2811.

SERRANO, X., I.B. Baums, K. O'Reilly, T.B. Smith, R.J. Jones, T.L. Shearer, F.L.D. Nunes, and A.C. Baker, 2014: Geographic differences in vertical connectivity in the Caribbean coral *Montastraea cavernosa* despite high levels of horizontal connectivity at shallow depths. *Molecular Ecology,* 23(17):4226-4240.

Song, Z., **H. LIU, C. WANG,** L. Zhang, and F. Qiao, 2014: Evaluation of the eastern equatorial Pacific SST seasonal cycle in CMIP5 models. *Ocean Science,* 10(5):837-843.

WANG, X., C. WANG, G. Han, W. Li, and X. Wu, 2014: Effects of tropical cyclones on large-scale circulation and ocean heat transport in the South China Sea. *Climate Dynamics,* 43(12):3351-3366.

ZHANG, J.-Z., and **C.J. FISCHER,** 2014: Carbon dynamics of Florida Bay: Spatiotemporal patterns and biological control. *Environmental Science and Technology,* 48(16):9161-9169.