AOML Keynotes

NOAA'S ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

April-June 2020

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

Gliders Deployed to Obtain Ocean Observations for Hurricane Studies and Forecasts

NOAA and US Navy hurricane gliders were deployed in July off the coasts of Puerto Rico, the Gulf of Mexico, and US eastern seaboard to improve the representation of the upper ocean in numerical models used for hurricane forecasts. These sturdy unmanned gliders will measure temperature and salinity down to a half mile below the ocean surface. They operate in hurricane conditions and have even survived shark attacks as they collect and transmit their data via satellite.

During the 2019 Atlantic hurricane season, the gliders collected approximately 100,000 ocean profiles. For the 2020 Atlantic hurricane season, NOAA, the US Navy, US Integrated Ocean Observing System (IOOS), IOOS Regional Associations, and academic partners will conduct approximately 30 glider missions that are expected to obtain 50 percent more ocean profile data compared to previous years. This is possible given enhanced support by NOAA and the ongoing and increased collaboration among glider partners.

To prepare for the 2020 hurricane season, AOML scientists trained new glider pilots and technicians from partner institutions in Puerto Rico, the Dominican Republic (Maritime Authority, ANAMAR), and US Virgin Islands. Additionally, NOAA and IOOS hosted an online workshop in April to plan glider deployments in the tropical North Atlantic Ocean, Caribbean Sea, south and mid-Atlantic Ocean bights, and Gulf of Mexico (see page 10 for maps and more information about the workshop). This preparation was crucial for helping NOAA continue the hurricane glider project in 2020 despite uncertainties related to the COVID-19 pandemic.

NOAA and US Navy gliders on the beach in southern Puerto Rico prior to their deployment in the Caribbean Sea from aboard the M/V *Marieangie*.

AOML researchers and partners with the Cooperative Institute for Marine and Atmospheric Studies at the University of Miami and CARICOOS deployed 11 underwater ocean gliders in July to collect data in support of improved hurricane forecast models. Image credit: NOAA/CIMAS/CARICOOS.

AOML is conducting this year's operations together with the IOOS Regional Associations in the Caribbean (CARICOOS) and southeast US (SECOORA), ANAMAR, the US Navy, University of Miami, University of Puerto Rico, and University of Georgia. The gliders will collect data in the upper ocean where the Florida Current, Gulf Stream, Loop Current, inflowing fresh water from rivers, cool subsurface waters, and other features may play a role in either strengthening or weakening tropical cyclones. The gliders will transmit their data in real-time to data distribution and forecast centers.

Recent research at AOML and NOAA's Environmental Modeling Center has shown that data from the gliders and floats are key to improving the representation of the upper ocean thermal and density structure in ocean models which, in turn, have been shown to improve the accuracy of hurricane intensity forecasts in several case studies. The data pinpoint areas where warm water pools at the sea surface, sometimes of riverine orgin, feed and increase the intensity of passing tropical cyclones or where cooler waters churned up from the deeper ocean weaken passing storms.

The hurricane glider project also helps meet the objectives of the Commercial Engagement Through Ocean Technology (CENOTE) Act of 2018, which requires NOAA to coordinate research, assessment, and acquisition of unmanned maritime systems with the US Navy, other federal agencies, industry, and academia.

Information about AOML's hurricane glider project can be found at https://www.aoml.noaa.gov/hurricane-glider-project/.

Two Bacteria Types Linked to Spread of Deadly Stony Coral Tissue Loss Disease

New research on stony coral tissue loss disease reveals similar "bacterial signatures" among sick corals and nearby water and sediment for the first time. Results hint at how this deadly disease might spread, and the bacteria associated with it, along Florida's coral reef tract.

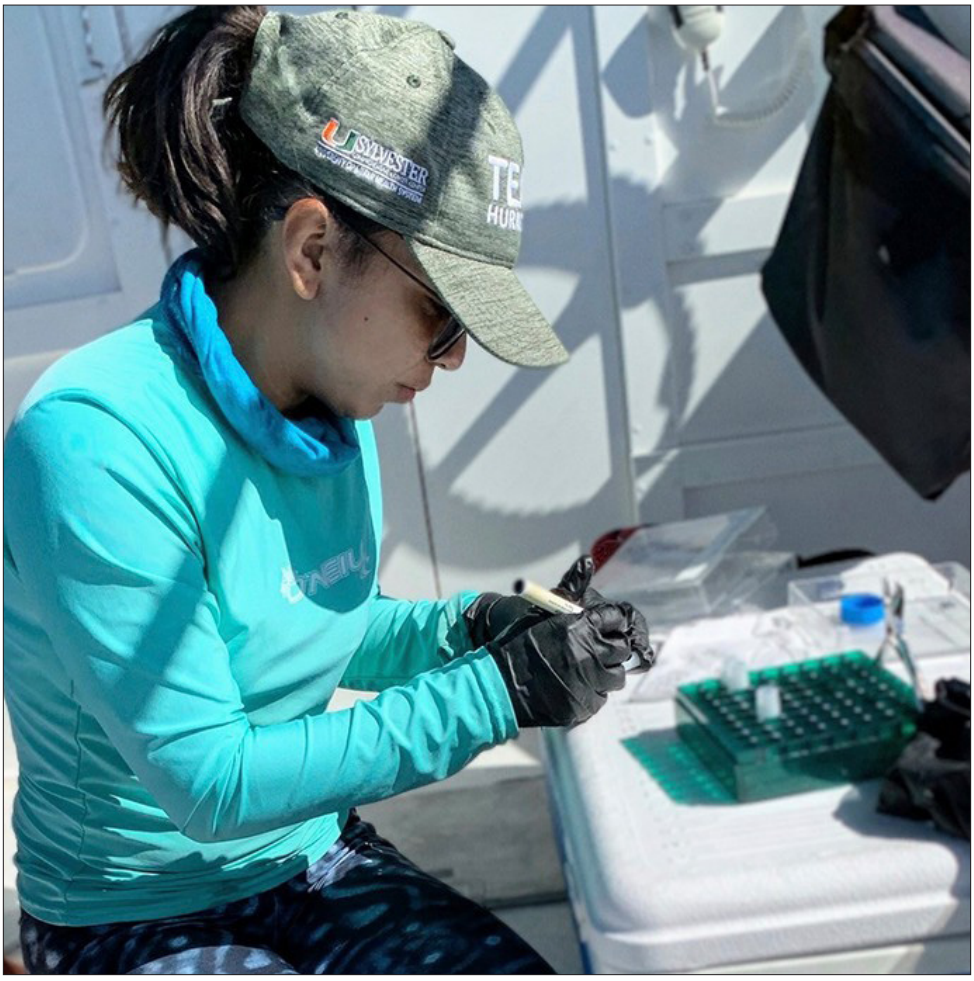
The study, published in *Frontiers in Microbiology*,* was led by Stephanie Rosales, PhD, a University of Miami-Cooperative Institute microbiologist at AOML. Dr. Rosales partnered with colleagues at the Mote Marine Laboratory and the Fish and Wildlife Research Institute to characterize the community of bacteria, i.e., the bacterial "microbiome," associated with sick corals.

Stony coral tissue loss disease was first detected in corals off the coast of Miami, Florida in 2014. It has since spread throughout much of the Florida reef tract, even reaching to corals in the Caribbean.

Corals develop blotches or bands of bleached tissue, followed by lesions that destroy soft tissue. Once infected, corals deteriorate and die within a matter of weeks to several months. The cause and mode of disease transmission are still unknown, but researchers have suspected a bacterium to be the culprit.

According to Rosales, "we had two big questions in this study: (1) could we detect which bacteria might be associated with this disease; and (2) could we also find these bacteria in nearby sediment and seawater, since these are two hypothesized sources of the disease."

Samples were collected from four susceptible coral species in the Florida Keys and nearby sediment and seawater, with DNA extracted to identify groups of bacteria. The research team found that the bacterial groups *Rhodobacterales* and *Rhizobiales* were associated more prevalently with disease lesions than healthy corals or healthy sections of sick corals.

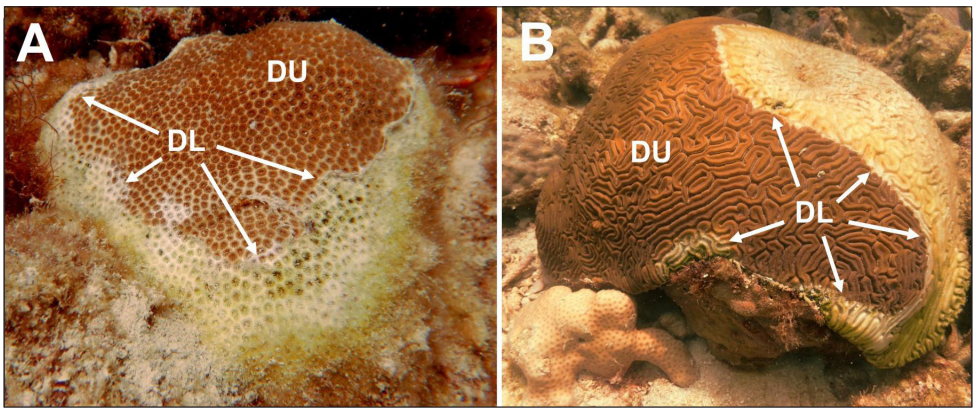


AOML coral researcher Stephanie Rosales sorts samples collected in the Florida Keys for future analysis. Photo credit: NOAA-AOML.

Although these bacteria might not be the primary pathogens, their presence is important nonetheless. For example, they could be capitalizing on corals already sickened by another pathogen.

The two bacterial groups were also found in the sediment and surrounding water, with *Rhodobacterales* elevated in areas with active or recent disease outbreaks compared with areas yet to show signs of the disease. While the study could not confirm the roles played by these two bacterial groups, it does narrow down key research targets. It also suggests that both water and sediment need to be considered in ongoing and future studies focused on how the disease spreads.

Funding in support of this research was provided by a grant from the US Environmental Protection Agency and by NOAA's 'Omics Initiative.



Two examples of coral species infected with stony coral tissue loss disease: (a) ***Stephanocoenia intersepta***; and (b) ***Diploria labyrinthiformis***. DU refers to tissue unaffected by the disease, whereas DL refers to tissue impacted by the disease, with arrows pointing to bleached lesion margins (Rosales *et al.*, 2020).

*Rosales, S.M., A.S. Clark, L.K. Huebner, R.R. Ruzicka, and E.M. Muller, 2020: *Rhodobacterales* and *Rhizobiales* are associated with stony coral tissue loss disease and its suspected sources of transmission. *Frontiers in Microbiology,* 11:681, https://doi.org/10.3389/fmicb.2020.00681.

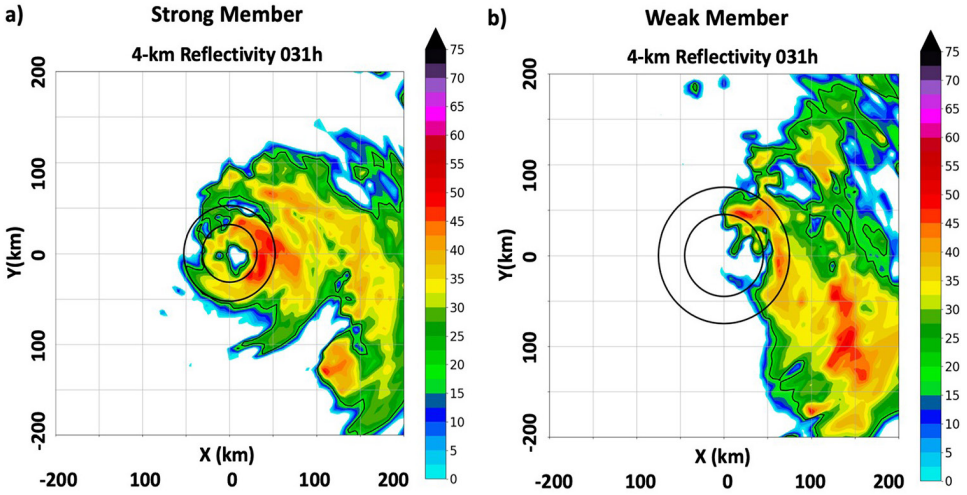
NOAA's HFV3 Model Reveals Rapid Intensification of Hurricane Michael

In a recently published study,* AOML hurricane researchers used multiple computer model forecasts to gain a better understanding of how Hurricane Michael rapidly intensified to 162 mph before making landfall along the Florida panhandle on October 14, 2018 as a powerful Category-5 storm. Michael intensified despite strong upper-level wind shear, which usually weakens hurricanes. By contrasting two sets of forecasts, the study found that Michael only rapidly intensified when rainfall completely surrounded Michael's center, and when the eye of the storm was located in nearly the same place at different heights.

NOAA's P-3 Hurricane Hunter aircraft flies through Hurricane Michael's massive eyewall. Image credit: NOAA-AOML.

Weather forecasters use computer models to make predictions based on the weather conditions they observe in the moment. However, forecasters are unable to measure the weather at every location on Earth at all times; instead, they run forecast models multiple times using different initial conditions that are similar to what they think is happening in regions where observations are unobtainable.

Researchers ran NOAA's HFV3 model, a model used to forecast weather over the entire globe, 40 different times to study the strengthening of Michael in the Gulf of Mexico. With multiple models, they were able to look at the differences between each forecast and identify the models that correctly showed the storm strengthening versus those that did not.



Side-by-side plots that show rapid intensification occurred when rainfall completely surrounded Hurricane Michael's center, i.e., in the center of the black circles. Image Credit: NOAA-AOML.

Most major hurricanes in the Gulf of Mexico tend to weaken prior to reaching land; this study showed how Michael was able to strengthen despite strong vertical wind shear, which usually weakens a storm. Wind shear is the difference in wind speed or direction over a short distance in the atmosphere.

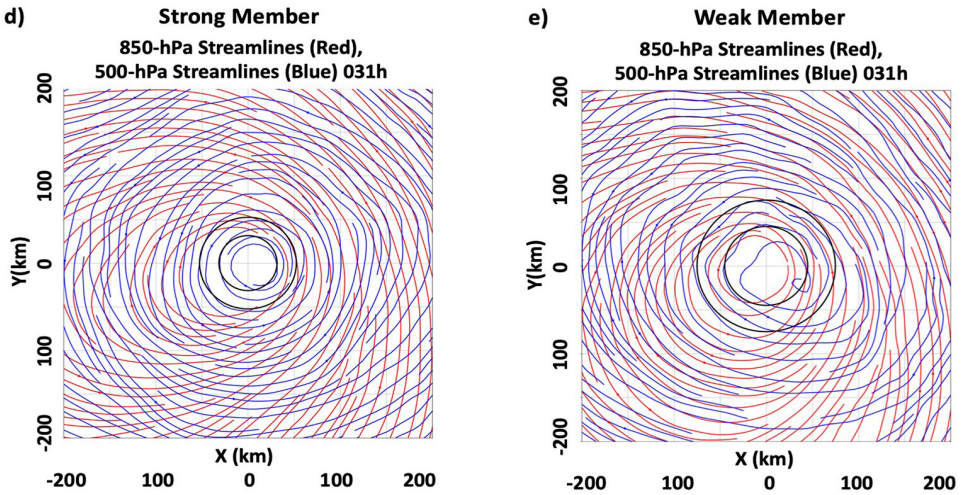
"Tropical cyclones tend to get stronger when the winds near the surface are similar to the winds higher in the atmosphere," said Andrew Hazelton, AOML hurricane scientist and lead author of the study. "Michael was unusual in that it was able to strengthen quickly despite winds changing fairly substantially higher up in the atmosphere."

Rapid intensification occurred when rainfall completely surrounded Michael's center, rather than occurring on only one side of the storm (i.e., in the center of the black circles, see images above).

When the wind blows through a hurricane at different levels it pushes the center of the hurricane in different directions so that the top and bottom centers are often not aligned. The forecasts that predicted Michael would rapidly intensify showed the centers aligned at different heights (see images below).

These models were validated through observations from NOAA's Hurricane Hunter aircraft that showed the center of the storm was aligned and that rainfall surrounded the eyewall when Hurricane Michael began rapidly intensifying.

The study shows the capability of NOAA's HFV3 model to simulate structure and intensity changes in moderate to high vertical wind shear. Timely, accurate track and intensity forecasts enable vulnerable communities to prepare and evacuate, saving lives and reducing the potential for catastrophic damage.



Side-by-side plots that show rapid intensification occurred when the wind surrounding Hurricane Michael's center was vertically aligned at different heights in the atmosphere (left image). Credit: NOAA-AOML.

*Hazelton, A.T., X. Zhang, S. Gopalakrishnan, W. Ramstrom, F. Marks, and J.A. Zhang, 2020: High-resolution ensemble HFV3 forecasts of Hurricane Michael (2018): Rapid intensification in shear. *Monthly Weather Review,* 148(5):2009-2032, https://doi.org/10.1175/MWR-D-19-0275.1.

Madden-Julian Oscillation Link to US Tornadoes may Provide Earlier Warning for Storms

Scientists at AOML and the University of Miami's Cooperative Institute for Marine and Atmospheric Studies recently explored the physical mechanism underlying the relationship between tornado activity in the US and the Madden-Julian Oscillation. Their study, published in the *Journal of Climate,** shows that a series of key ocean-atmosphere processes are involved in the remote impact of the Madden-Julian Oscillation on US tornado activity.

The Madden-Julian Oscillation is a patch of tropical thunderstorms that forms over the Indian Ocean near the equator. These storms move slowly eastward across the Pacific Ocean for periods of 30 to 90 days. Several studies have found a correlation between an increase in US tornado activity and how the thunderstorms of the Madden-Julian Oscillation pass across certain longitudinal bands in the tropical Pacific.

The science team found that when the thunderstorms pass across Indonesia to the Pacific, the air across Central America becomes very dry due to changes in the Walker circulation, which moves upper-level air westward and lower-level air eastward across the tropical Pacific. The drying air across Central America subsequently redirects the low-level air flow to enhance the supply of warm, moist air into the US east of the Rockies.

New research links tornado activity in the US with the movement of a band of tropical thunderstorms that forms across the Indian Ocean near the equator.

This enhanced supply of warm, moist air to the US destabilizes the atmosphere to produce favorable conditions for tornado activity. The study also found that the identified link is only applicable during May, June, and July, as the Madden-Julian Oscillation does not produce drying conditions across Central America in any other time frame.

Supported by a newly funded NOAA project, *Subseasonal to Seasonal Severe Weather Prediction*, the science team is currently exploring ways to apply this link to US long-range weather forecasts. This new project is a collaborative effort with NOAA's National Severe Storms Laboratory, Geophysical Fluid Dynamics Laboratory, Physical Sciences Laboratory, Climate Prediction Center, and Storm Prediction Center.

A successful application would help NOAA's National Weather Service provide earlier, more accurate warnings by extending weather forecasts beyond the usual time scale of ~8 days to a 2–4 week forecast targeting the May-July season, enabling vulnerable communities to better prepare for high impact weather events such as tornadoes.

More effective warnings and forecasts would ultimately aid NOAA in complying with the Weather Research and Forecasting Innovation Act of 2017 (HR 353). The bill requires NOAA "to prioritize weather research to improve weather data, modeling, computing, forecasts, and warnings for the protection of life and property and the enhancement of the national economy."

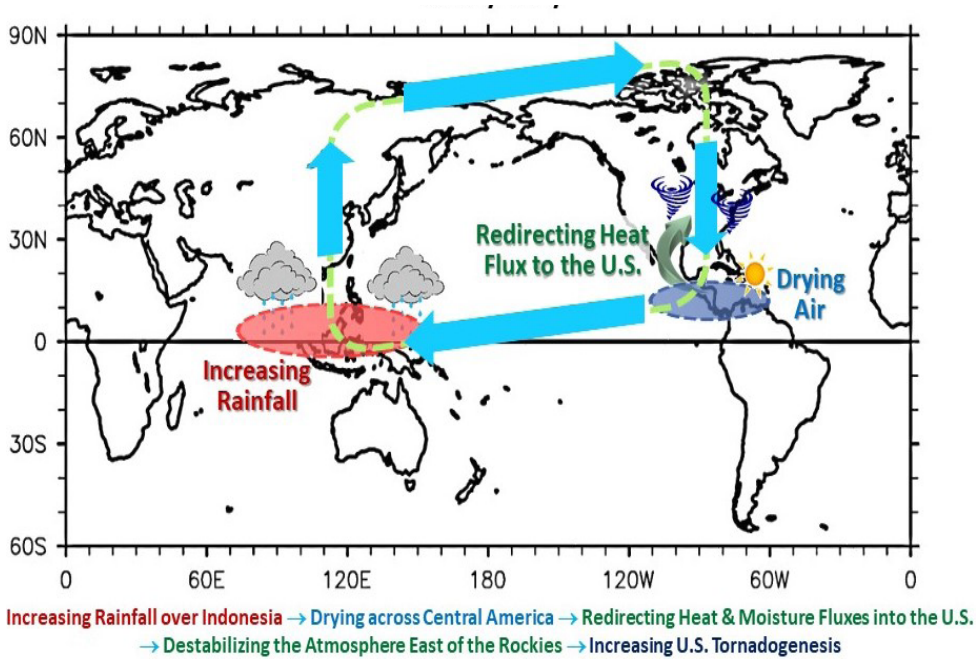


Diagram showing the atmospheric link between the Madden-Julian Oscillation and increased tornadogenesis in the US for May-July.

*Kim, D., S.-K. Lee, and H. Lopez, 2020: Madden-Julian Oscillation-induced suppression of northeast Pacific convection increases U.S. tornadogenesis. *Journal of Climate*, 33(11):4927-4939, https://doi.org/10.1175/JCLI-D-19-0992.1.

Ocean Acidification Varies Around North America, Hot Spots Found in Northeast and West Coast Waters

New research by NOAA and partners comparing ocean acidification around North America shows that the most vulnerable coastal waters are along the northern portions of the east and west coasts.

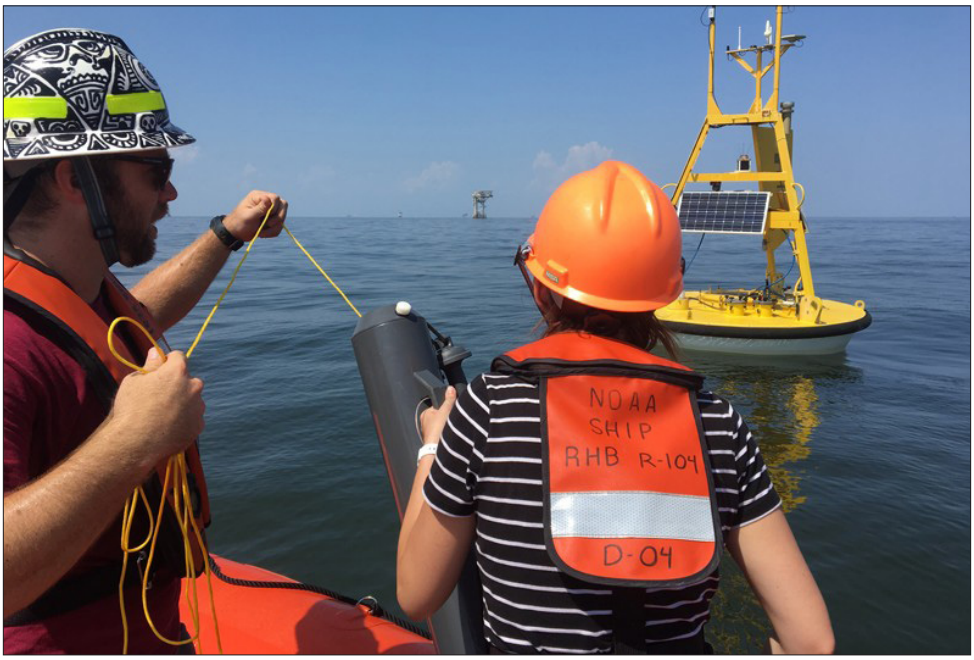
While previous research has examined specific regions, the new study appearing in *Nature Communications** is the first in-depth comparison of ocean acidification occurring in all North American coastal ocean waters.

"Ocean acidification is everywhere, but this synthesis basically shows that, depending on the location, it can manifest very differently," said Wei-Jun Cai, lead author and a professor at the University of Delaware's School of Marine Science and Policy.

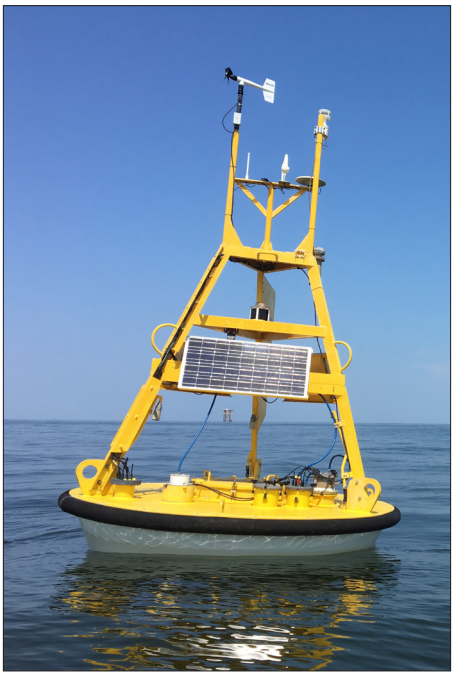
Ocean acidification, a global process in which the ocean absorbs carbon dioxide from the atmosphere, is occurring faster than at any time in the past 50 million years. The global rise in ocean acidity is fueled by human-created greenhouse gases. An estimated 25 percent of those emissions are absorbed by the ocean.

In ocean waters off the United States east coast, the Gulf Stream current transports warm water from the tropics northward while the Labrador Current shuttles cold water from the Arctic and subarctic regions southward. The colder ocean temperatures along the northern part of the east coast take up more carbon dioxide from the atmosphere than the warmer waters along the southeast coast and Gulf of Mexico. This uptake of carbon dioxide accelerates ocean acidification, which can hamper the ability of shellfish, corals, and other valuable marine species to build their shells and thrive.

On the west coast, ocean acidification is affecting the waters of the California Current, which extends from the United States-Canadian border to Baja California. The California Current is characterized by strong, cold currents and wind-driven upwelling events. Upwelling brings colder, carbon dioxide rich subsurface waters to the ocean's surface to replace surface water that has been pushed away by winds.



Jay Hooper and Leticia Barbero of AOML prepare to collect a water sample near an ocean acidification buoy in the Gulf of Mexico. Credit: NOAA.


An ocean acidification buoy in the Gulf of Mexico measures carbon dioxide at both the sea surface and near the ocean bottom. Credit: NOAA.

"The water from the subsurface has low pH and high carbon dioxide, which causes stress to the biological system," said co-author Richard Feely of NOAA's Pacific Marine Environmental Laboratory. "The combination of the uptake of anthropogenic carbon dioxide from the atmosphere and the upwelling of carbon dioxide-rich low-pH water from below leads to enhanced acidification in this region."

The research team from NOAA, the University of Delaware, and scientists from Canada, Mexico, the United Kingdom, China, and Taiwan based the new findings on data gathered during several research cruises between 2007 and 2018.

A number of these cruises were either led or supported by researchers with the Pacific Marine Environmental Laboratory, AOML, and NOAA's Ocean Acidification Program.

This article is derived from a NOAA Research news item taken from a press release issued by the University of Delaware:

https://www.udel.edu/udaily/2020/june/north-american-ocean-acidification-wei-jun-cai-noaa/

*Cai, W.-J., Y.-Y. Xu, R.A. Feely, R. Wanninkhof, B. Jönsson, S.R. Alin, L. Barbero, J.N. Cross, K. Azetsu-Scott, A.J. Fassbender, B.R. Carter, L.-Q. Jiang, P. Pepin, B. Chen, N. Hussain, J.J. Reimer, L. Xue, J.E. Salisbury, J.M. Hernández- Ayón, C. Langdon, Q. Li, A.J. Sutton, C.-T.A. Chen, and D. Gledhill, 2020: Controls on surface water carbonate chemistry along North American ocean margins. *Nature Communications,* 11:2691, https://doi.org/10.1038/s41467-020-16530-z.

NOAA Provides Critical Support for *Bourbon Rhode* Search and Rescue Effort

NOAA provided critical assistance to an international search and rescue effort in September 2019 after the tugboat *Bourbon Rhode* sank during Hurricane Lorenzo. This intra-agency NOAA effort included Hurricane Hunters from the Aircraft Operations Center, scientists from AOML and the National Environmental Satellite, Data, and Information Service, and marine forecasters from the Tropical Analysis and Forecast Branch of the National Hurricane Center.

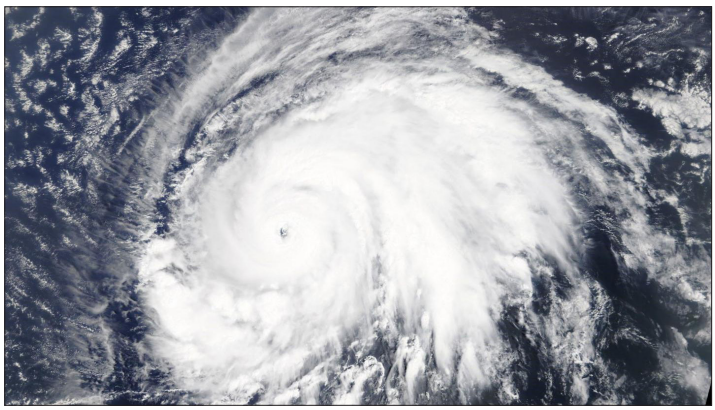
On the morning of Thursday, September 26, French authorities received a distress signal from the *Bourbon Rhode*, a 160-foot offshore tug in the central Atlantic en route from the Canary Islands to Guyana with 14 crew members aboard. The *Bourbon Rhode* had made a dangerously close approach to the eye of Hurricane Lorenzo and was taking on water toward the stern of the vessel.

The M/V *Bourbon Rhode*. Credit: Bourbon Offshore.

At 0200 Atlantic Standard Time (AST) on September 26, Lorenzo was a Category 2 hurricane with 95 knot winds and 12+ foot seas that extended 240–330 nautical miles outward from its center. At 0800 AST, a NOAA sea state analysis issued about the same time as the last automatic identification system signal from the *Bourbon Rhode* showed peak significant wave heights in Lorenzo of up to 41 feet. By 1400 AST, Lorenzo had strengthened to a Category 4 hurricane with maximum sustained winds of 115 knots. The *Bourbon Rhode* ultimately sank on September 26 in the central Atlantic Ocean.

Both of NOAA's two WP-3D Hurricane Hunter aircraft—NOAA42 and NOAA43—were preparing to fly dedicated research missions into Lorenzo. As NOAA43 transited from Lakeland, Florida, to Barbados on September 26, the French government and US Coast Guard reached out to the aircraft to request search and

NOAA's two WP-3D Hurricane Hunter aircraft in Barbados for Hurricane Lorenzo research missions. Both aircraft provided critical search and rescue support during the *Bourbon Rhode* incident. Credit: LCDR Sam Urato, NOAA Corps.

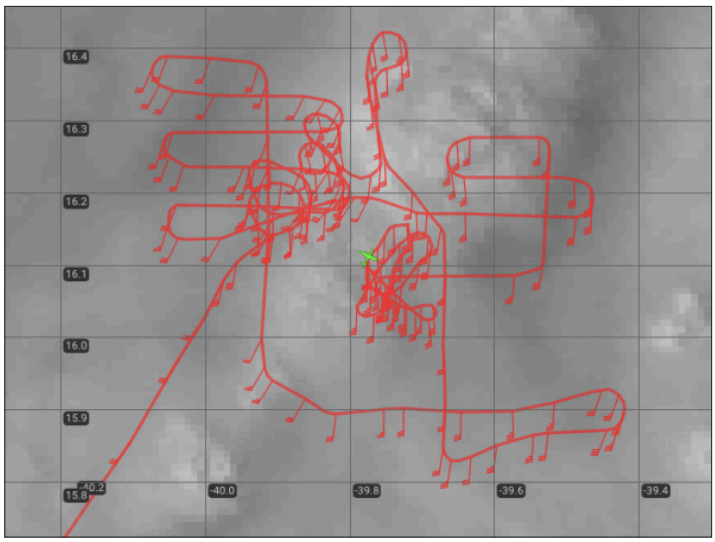


Hurricane Lorenzo in the North Atlantic Ocean on September 26, 2019. Credit: NASA Worldview/Terrra MODIS.

rescue assistance. The nearest marine vessel to the incident site—a bulk carrier called the SSI *Excellent*—was also contacted and diverted its course toward the last known position of the *Bourbon Rhode*. Later that day, NOAA marine forecasters were asked by the US Coast Guard Rescue Coordination Center in Miami to begin providing spot forecasts for surface wind and wave conditions that might impact vessels aiding in the search and rescue effort. The first forecast detailed dangerous marine conditions still ongoing in the wake of Lorenzo, with gusty tropical-storm-force winds and combined seas of 20 feet near the incident site.

The NOAA43 departed from Barbados on September 27 for its research mission into Hurricane Lorenzo. As requested, the crew would first fly over the locations of the last *Bourbon Rhode* distress signals and report its findings. If nothing was sighted, the crew was to continue with its planned mission into Lorenzo. Although the NOAA43 was the first search and rescue capable asset to reach the incident site, the crew found nothing upon arrival.

With growing concern for the fate of the *Bourbon Rhode* crew, the NOAA43 aborted its Lorenzo mission to focus on search and rescue support. With little information, except for the last-known location of the *Bourbon Rhode*, they quickly adapted and developed a search and rescue flight plan (see below). **(*cont. page 7*)**



Flight track of the NOAA43 Hurricane Hunter aircraft during its *Bourbon Rhode* search and rescue mission over the central Atlantic Ocean on September 27. Credit: NOAA-AOML.

Cont. from page 6

Crew members arranged themselves by all available windows and called out locations of suspected targets and/or debris while surveying in the vicinity of the last known *Bourbon Rhode* position. Poor visibility, extremely large waves, and turbulence from strong rainbands posed difficult challenges as the NOAA43 received sporadic emergency beacon signals. With only minutes left before the plane's imminent need to return to Barbados due to fuel limitations, crew members spotted debris and what appeared to be a life raft. This information was relayed to the SSI *Excellent,* still en route to the search and rescue area.

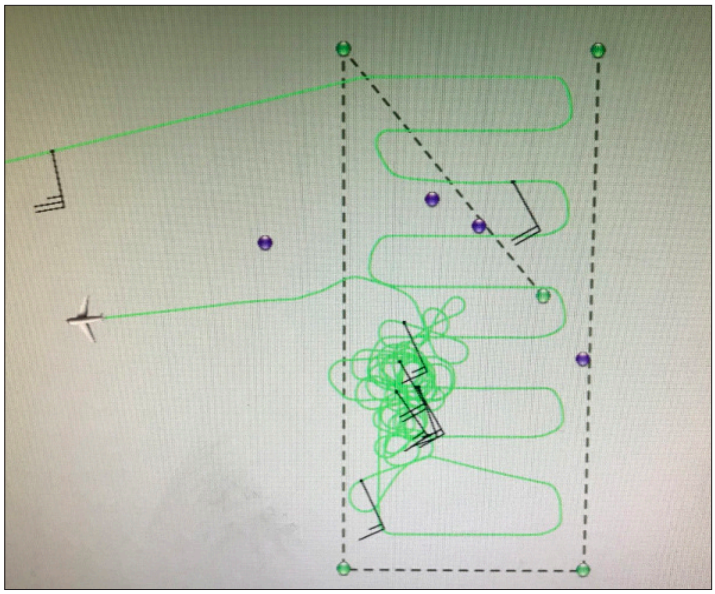
The bulk carrier SSI *Excellent* enroute to the the search and rescue area as viewed from the NOAA43 Hurricane Hunter aircraft on September 27, 2019. Rough seas and blustery weather were due to a convective cell (visible in the upper left portion of the image) from an outer rainband of Hurricane Lorenzo. Credit: NOAA- AOML.

On September 28, the NOAA42 aircraft flew a search and rescue mission in coordination with the SSI *Excellent* and other supporting marine vessels across the search area. Weather and marine conditions had improved as Hurricane Lorenzo moved farther away, enabling the plane to fly as low as 200 feet above the ocean surface.

The NOAA42 crew conducted visual searches while listening for emergency beacon signals, guided by previous reports from the NOAA43, as well as by new information from supporting ships. At long last, NOAA42 crew members spotted a large debris field and the remains of a few sailors. Ships were directed to these locations to recover the victims.

The dedicated surveillance efforts of NOAA's Hurricane Hunter crews and science teams significantly helped to narrow the search region, ultimately guiding ships to an area where a life raft was discovered later that day. After close to 48 hours adrift at sea, three *Bourbon Rhode* crew members were rescued from the Atlantic.

NOAA assets played a pivotal role in the early *Bourbon Rhode* search and rescue effort, led by the Maritime Rescue Coordination Center at Fort-de-France on the island of Martinique. As the international effort to locate survivors continued, NOAA's marine forecasters provided 6-hourly forecast updates of wind, wave, and weather conditions, producing a total of 35 forecasts in support of search and rescue operations.



Flight track of the NOAA42 Hurricane Hunter aircraft during its *Bourbon Rhode* search and rescue mission over the central Atlantic Ocean on September 28. Credit: NOAA-AOML.

Over a 2-week period, 21 ships and four aircraft surveyed more than 40,000 square miles of the central Atlantic Ocean. The effort officially ended on October 5, 2019. Of the *Bourbon Rhode's* 14-member crew, three survived and were rescued, four drowned and their bodies recovered, and seven were declared lost at sea.

Tragedies like the sinking of the *Bourbon Rhode* highlight the critical importance of NOAA's marine forecasts. The valiant surveillance efforts of the Aircraft Operations Center's flight crews and scientists aboard from AOML and the National Environmental Satellite, Data and Information Service also played a key role in the international effort that ultimately saved three lives.

Aerial image of the life raft carrying the three surviving crew members of the *Bourbon Rhode,* rescued from the Atlantic on September 28, 2019. Credit: Marine Nationale (French Navy, via Facebook).

This article is adapted from an article prepared by Brad Reinhart, a meteorologist with the Tropical Analysis and Forecast Branch of NOAA's National Hurricane Center (NHC) in Miami, Florida. It appears in Keynotes courtesy of NHC and can be found in its original form at https://noaanhc.wordpress.com/blog-posts/ (blog post for May 19, 2020).

New Web Tool Gauges Trends in the Florida Keys National Marine Sanctuary

The Florida Keys Integrated Ecosystem Assessment (IEA) team, led by AOML in partnership with managers and scientists from NOAA's Office of National Marine Sanctuaries, National Centers for Coastal Ocean Science, Southeast Fisheries Science Center, and the Cooperative Institute for Marine and Atmospheric Studies, launched a new Ecosystem Status Report web tool on May 13.* The IEA approach aims to balance the needs of nature and society through ecosystem-based management. It provides scientific knowledge of the Florida Keys National Marine Sanctuary ecosystem to scientists, policy makers, stakeholders, and resource managers.

The web tool highlights key indicators that illustrate the condition of the Florida Keys National Marine Sanctuary, including human activities, ecosystem services, habitat, living resources, sanctuary waters, and maritime heritage. It enables stakeholders, resource managers, and researchers to easily visualize the status and trends of these key indicators over time and across disciplinary fields.

AOML scientists and Andy Bruckner, the research coordinator for the Florida Keys National Marine Sanctuary, launched the new tool by presenting it to sanctuary research coordinators nationwide. "One of the most valuable aspects of the website are the visualization tools that allow the user to see changes in resource condition over time," Bruckner said.

A finding of the Ecosystem Status Report is an increasing trend in public participation and appreciation for the Florida Keys National Marine Sanctuary's cultural heritage resources. Key findings for human activities were drawn from the status and trends of Florida Keys resident populations, cruise ship visitors, registered vessels, and housing units connected to wastewater treatment.

The number of registered vessels accessing the Florida Keys National Marine Sanctuary decreased following the Great Recession of 2008, but has witnessed a steady uptick over the ensuing years. Credit: NOAA.

Florida Keys resident populations have increased over the last century, putting pressure on the ecosystem. However, populations have leveled off since the 1980s, and these leveled or decreasing populations have changed the human activities occurring in the Keys.

Ecosystem services include commercial and recreational fishing, tourism, and coastal protection. Trends in the total number of commercial fishing trips and the total number of trips targeting economically important species show that there is a stable, or decreasing, pressure on these resources.

Tourism has increased in the last 30 years, placing greater strain and pressure on sanctuary waters. However, sanctuary resources can help to support the tourism value of the Florida Keys as an ecosystem service to the community. The report also notes a decrease in the total tourism value in Monroe County, as well the number of registered vessels, in response to the 2008 Great Recession.

Additionally, the IEA team found that there has been a decline in five coral species at monitoring sites. Seagrass is currently in a period of continued decline since 2014. However, coral resilience to bleaching and disease has been observed at some patch reefs.

Lastly, a reduction in pressure on marine sanctuary water quality was found due to an increase in Florida Keys housing units connected to a central sewer system rather than aging septic tanks and cesspools.

The Florida Keys Integrated Ecosystem Assessment is led by AOML-University of Miami Cooperative Institute researcher Kelly Montenero, and the web tool was built by Sean Regan from NOAA's National Center for Coastal Ocean Science.

The Ecosystem Status Report was compiled by NOAA's Florida Keys Integrated Ecosystem Assessment Program team in collaboration with academic partners, sanctuary resource managers and scientists, non-governmental organizations, and colleagues from other government and state agencies.

A reduction in pressure on sanctuary water quality has resulted from an increased percentage of Florida Keys housing units connected to a central sewer system, rather than aging septic tanks and cesspools. Credit: NOAA.

*The Florida Keys Ecosystem Status Report web tool can be accessed at

https://www.aoml.noaa.gov/esr_fknms/home.html

NOAA Predicts Busy Atlantic Hurricane Season for 2020

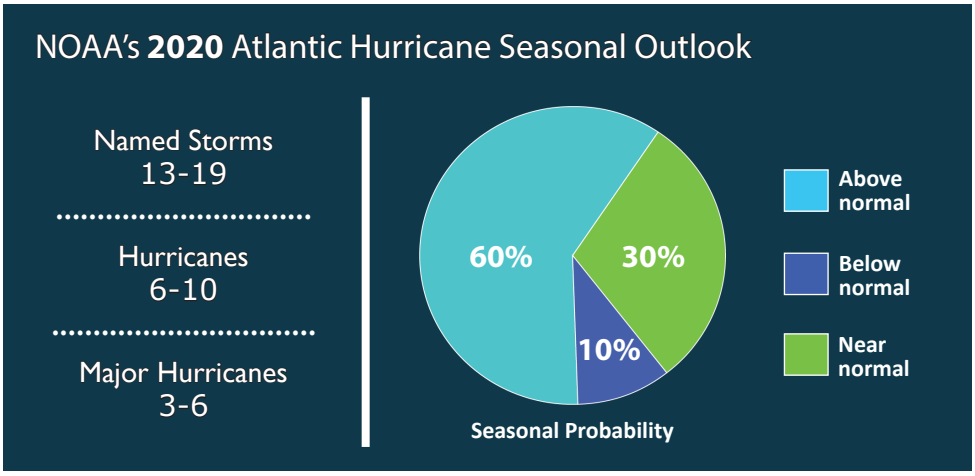
Multiple climate factors indicate above-normal activity is most likely.

An above-normal 2020 Atlantic hurricane season is expected, according to NOAA's pre-seasonal outlook issued on May 21. The outlook predicts a 60% chance of an above-normal season, a 30% chance of a near-normal season, and only a 10% chance of a below-normal season. The Atlantic hurricane season runs from June 1 through November 30.

NOAA's seasonal outlook is forecasting a likely range of 13–19 named storms (39 mph winds or higher), of which 6–10 could become hurricanes (74 mph winds or higher), with 3–6 hurricanes reaching major hurricane status (category 3, 4, or 5; 111 mph winds or higher). NOAA provides these ranges with a 70% confidence. Average seasonal activity includes 12, 6, and 3 named storms, hurricanes, and major hurricanes, respectively.

A combination of several climate factors predicted to be present during August-September-October, the peak months of hurricane season, is driving the strong likelihood for above-normal activity in the Atlantic this year. El Niño Southern-Oscillation conditions are expected to either remain neutral or to trend toward La Niña, meaning there will not be an El Niño event present to suppress hurricane activity.

Warmer-than-average sea surface temperatures in the tropical Atlantic Ocean and Caribbean Sea, coupled with reduced vertical wind shear, weaker tropical Atlantic trade winds, and an enhanced West African monsoon, are also factors increasing the likelihood for an above-normal Atlantic hurricane season. Similar conditions have been producing seasons with above-normal activity for a majority of the years since the current high-activity era began in 1995.



This year, as during previous hurricane seasons, NOAA remains ready to provide life-saving forecasts and warnings to the public. And as storms show signs of developing, NOAA's Hurricane Hunter aircraft and scientists will collect critical data for forecasters and computer models, as well as for research studies to improve the models in the future.

In addition to this high level of science and service, NOAA is also launching new upgrades to products and tools that will further improve critical services during the hurricane season.

NOAA will upgrade the Hurricane Weather Research and Forecast (HWRF) model and the Hurricanes in a Multi-scale Ocean coupled Non-hydrostatic model (HMON) this summer. HMON will undergo enhancements to include higher resolution, improved physics, and coupling with ocean models.

HWRF will incorporate new data from satellites, including the new COSMIC-2 satellites, and radar data from NOAA's coastal Doppler network to help produce better forecasts of hurricane track and intensity during the critical watch and warning time frame. COSMIC-2 satellites gather air temperature, pressure, and humidity observations from tropical regions where hurricanes and tropical storm systems form.

Additionally, during the 2020 hurricane season, NOAA and the US Navy will deploy a fleet of autonomous underwater gliders to observe conditions in the tropical Atlantic Ocean and Caribbean Sea in areas where hurricanes have historically traveled and intensified.

The Atlantic hurricane outlooks are an official product of NOAA's Climate Prediction Center, produced in collaboration with the National Hurricane Center and AOML. The outlooks provide a general guide to the overall expected level of activity for the season; they are not landfall forecasts.

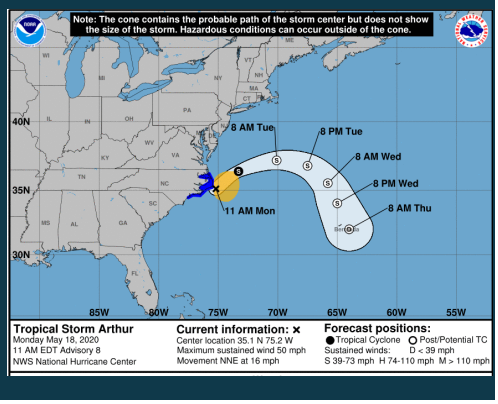
NOAA will issue an updated seasonal outlook in early August prior to the peak months of the season. Coastal communities are urged to monitor the tropics, examine their preparedness plans, and be ready to activate those plans if needed.

2020 Atlantic Storm Names

Arthur	Hanna	Omar
Bertha	Isaias	Paulette
Cristobal	Josephine	Rene
Dolly	Kyle	Sally
Edouard	Laura	Teddy
Fay	Marco	Vicky
Gonzalo	Nana	Wilfred

Tropical Storm Arthur Jumpstarts the 2020 Atlantic Hurricane Season

Tropical Storm Arthur formed off the east central coast of Florida on May 16, marking the sixth straight year the Atlantic's first named storm developed before the official June 1 start of hurricane season. Although short-lived, Arthur brought heavy rainfall, strong surf, and blustery winds to portions of coastal North Carolina before moving eastward and dissipating at sea on May 21.



Virtual Glider Workshop Highlights Advances in Hurricane Intensity Studies

AOML researchers, along with colleagues with the US Integrated Ocean Observing System (IOOS) and their Regional Associations and university scientists, hosted a virtual Hurricane Glider Workshop on April 29 focused on the deployment of underwater gliders this summer in multiple regions—the tropical North Atlantic Ocean, Caribbean Sea, south and mid-Atlantic bights, and Gulf of Mexico—in support of hurricane studies and forecasts.

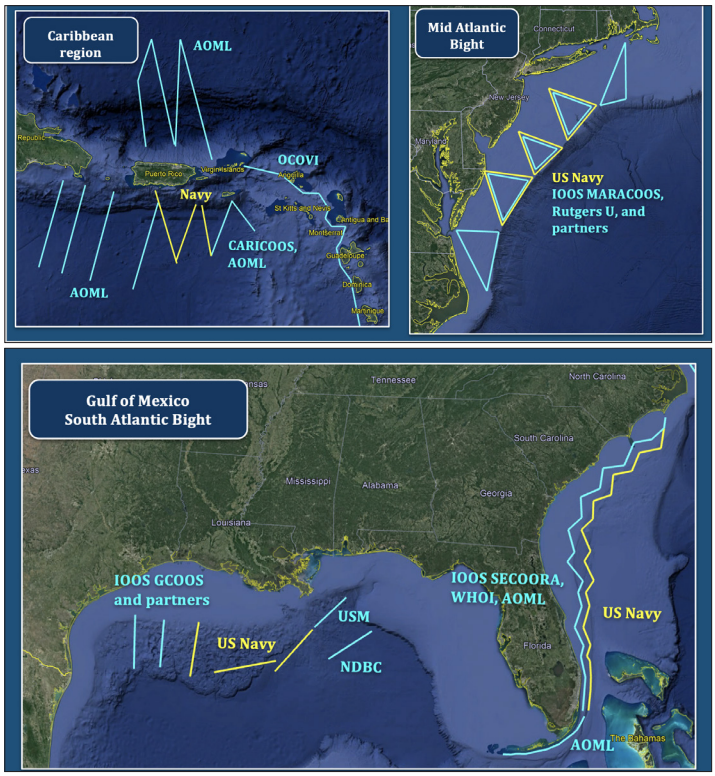
The morning session focused on the accomplishments of glider operations during the 2019 Atlantic hurricane season, as well as plans for the 2020 season, with about 35 researchers and engineers in attendance. The session featured 15 oral presentations and discussions highlighting the cooperation among partners currently in place. In 2019, AOML partnered with more than 20 institutions in acquiring and transmitting more than 140,000 upper ocean profiles for a total of 2,200 days at sea by the gliders while observing the ocean along 24 transects.

AOML highlighted its strong partnership with CARICOOS (the IOOS Regional Association in the Caribbean region) and its new partnerships with the Ocean and Coastal Observing of the Virgin Islands (CARICOOS-OCOVI) and Autoridad Nacional de Asuntos Marítimos (ANAMAR) of the Dominican Republic. Glider ports established in the Virgin Islands and Dominican Republic, plus training for new glider pilots and technicians in both regions and the opening of a state-of-the-art glider port at AOML, will expand the operational capacity of the project in 2020.

During 2019, AOML carried out a total of seven missions, extending operations for the first time into the Caribbean Sea off the Dominican Republic and US Virgin Islands, as well as the Florida Current. In total, more than 9,000 individual profiles of temperature, salinity, and dissolved oxygen were collected, the equivalent of 640 glider days of operations. New products initiated included the evaluation of the Real-Time Ocean Forecast System (RTOFS) using glider data, which are the US Navy-NOAA ocean fields used to initialize coupled hurricane forecasts.

Since 2014, more than 35,000 individual profiles of temperature and salinity have been collected by AOML gliders between the sea surface and approximately 1 km depth, including observations obtained directly under or in the vicinity of 12 tropical cyclones. All observations have been transmitted in real-time to the Global Telecommunication System for assimilation into ocean forecast models.

The afternoon session, attended by more than 150 participants from NOAA and several national and international institutions, was dedicated to discussing scientific advances made possible by glider observations. Presentations from the session are available at https://www.aoml.noaa.gov/phod/goos/gliders/videos/.

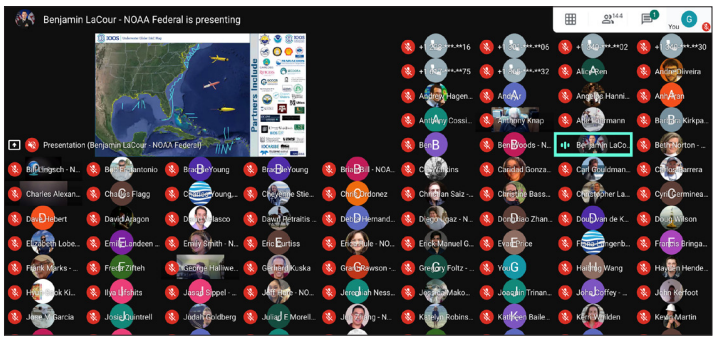


Maps showing planned hurricane gliders operations for 2020 in multiple regions by AOML, IOOS, the US Navy, and other partners.

Despite uncertainties related to the COVID-19 pandemic, the hurricane glider project will continue working toward obtaining glider observations during the 2020 Atlantic hurricane season, including the incorporation of new missions by AOML, IOOS, and the US Navy. As AOML builds a more robust capacity to observe the ocean in support of improved hurricane forecasts, it is also enhancing its relationship with AOML's Hurricane Research Division, NOAA's Environmental Modeling Center, the IOOS Regional Associations, and US Navy.

Looking forward, several factors—understanding physical processes, advancing numerical modeling and data assimilation schemes, and technology development—will continue to be central to increasing knowledge of how the ocean and atmosphere interact during high wind events.The project is funded by NOAA's Hurricane Supplemental Funds, as well as by AOML and IOOS.

Hurricane glider operations are conducted in areas where hurricanes travel and that contain ocean features that may lead to hurricane intensification and/or weakening.



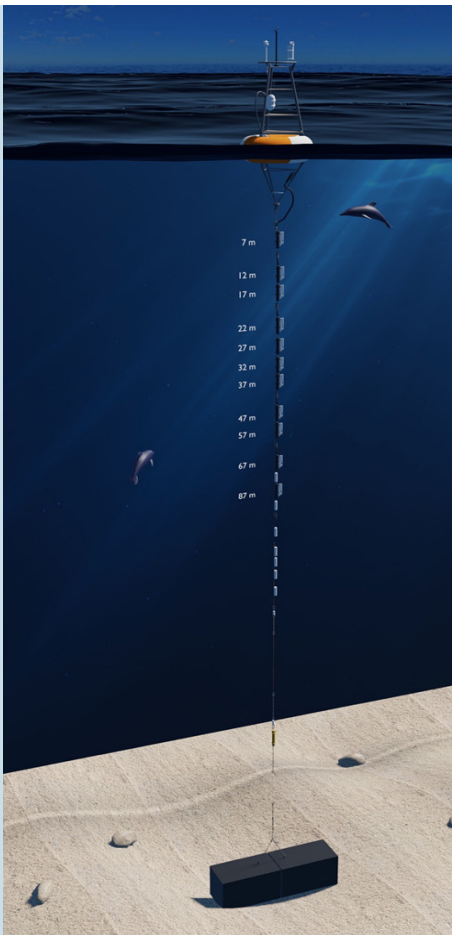
More than 150 individuals attended the virtual AOML-IOOS Hurricane Glider Workshop in April.

TACOS Program Celebrates Three-Year Anniversary

In March, NOAA's Tropical Atlantic Current Observations Study (TACOS) celebrated its three-year anniversary of measuring upper ocean velocity profiles in the tropical Atlantic. TACOS began as a pilot project to measure currents with high vertical resolution (5–10 m) in one of the regions sampled by the Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) program (see image at right). The first phase of TACOS sampled 4˚N, 23˚W, a region influenced by coupled ocean-atmosphere modes which modulate winds, rainfall patterns, the north-south movement of the intertropical convergence zone, and higher frequency phenomena such as tropical instability waves, near-inertial waves, internal waves, and tides. Instruments have been deployed at this location for the past three years.

From this data, researchers are learning about the time-mean and variability of upper ocean velocity. The weak mean flow (~10 cm/sec) is northeastward near the surface and southeastward below 20 m, with the largest changes near the base of the mean mixed layer (30 m). The flow is modulated by year-to-year variability in large-scale currents and coupled air-sea climate modes. This year-to-year variability can double the speed of the eastward currents. Subseasonal (diurnal to 30-day) variations dominate the time series, and tropical instability waves cause vertical banding of alternating velocity each year. Analysis shows that tropical instability waves, as well as near-inertial waves and diurnal motions, have a large impact on the shear, stratification, and vertical turbulent cooling. Thus, ocean dynamics influence the evolution of sea surface temperature at this location.

Once the instruments are recovered, TACOS will be relocated to either the Atlantic hurricane development region (20˚N, 38˚W PIRATA mooring) or to the oxygen minimum zone (11.5˚N, 23˚W PIRATA mooring) with their anticipated redeployment in 2021-2022.



Schematic of upper ocean current meters on the PIRATA mooring at 4˚N, 23˚W during the first Tropical Atlantic Current Observations Study (TACOS) deployment (figure courtesy of Bertrand Dano).

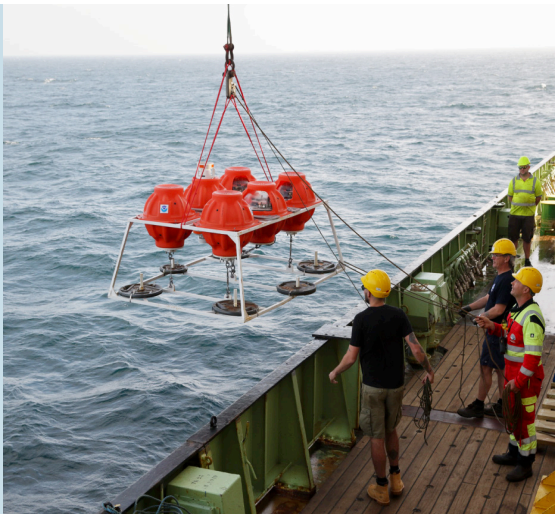
Study Explores Water Quality Changes due to COVID-19 Pandemic

AOML microbiologists are collaborating with the Miami-Dade County Division of Environmental Resource Management to study the impact of beach closures due to the COVID-19 pandemic on coastal water quality in the region. In May, they collected sand and water samples at closed recreational beaches throughout the county to characterize fecal bacteria and associated microbial communities. Sand and water samples were also collected in June and early July when beach closures were lifted and then re-imposed. A final set of comparative samples will be collected once beaches are again opened and beachgoer activity returns to normal use and crowd density. This data will be used to document the comparative changes in water quality during beach closures, reoccupation, and normal use.

AOML microbiologist Maribeth Gidley prepares to store a water sample for later processing and microbial analysis at AOML.

Data Pod System Remotely Retrieving Deep Ocean Observations for Weather/Climate Studies and Models

A first-of-its-kind data pod system developed by AOML engineers and deployed in the northeast Atlantic Ocean, off the Azore Islands, in March 2020 is now acquiring deep ocean data that will feed weather and climate models for the next 4 years. The pods are recording data from pressure-inverted echo sounder instruments moored on the ocean floor. At pre-programmed intervals, the pods self release, rise to the surface, and transmit their stored data via satellite. Due to the uncertainty of scheduling research cruises in the near future, this system is key to exploring new ways for retrieving ocean data, even from the deep oceans, with a minimum need for ship time. The first data pod release is scheduled for December 30, 2020.



One of two pressure-inverted echo sounder-data pod packages was deployed in March 2020 in the northeastern Atlantic Ocean.

AOML Staff Recognized for Going Above and Beyond during COVID-19

NOAA suspended its monthly tradition of highlighting employees and team members in March due to the disruption caused by the spread of COVID-19. In April, however, NOAA resumed the practice but with a twist. Instead of recognizing a single employee and team member, NOAA chose to begin sharing stories of how its workforce has "demonstrated an incredible spirit of resolve, tenacity, and creativity that has allowed NOAA to continue its critical mission during this time of national crisis." The following AOML staff members were recognized by NOAA for going above and beyond the call of duty:

The GO-SHIP A13.5 science team aboard the NOAA Ship *Ronald H. Brown* was recognized for collecting critical samples and measurements across the Atlantic Ocean in spite of the cruise being curtailed due to COVID-19.

Leticia Barbero, Leah Chomiak, Charles Featherstone, James Hooper, Patrick Mears, and Ian Smith—AOML-University of Miami Cooperative Institute science team members for the GO-SHIP (Global Ocean Ship-based Hydrographic Investigations Program) A13.5 Cruise.

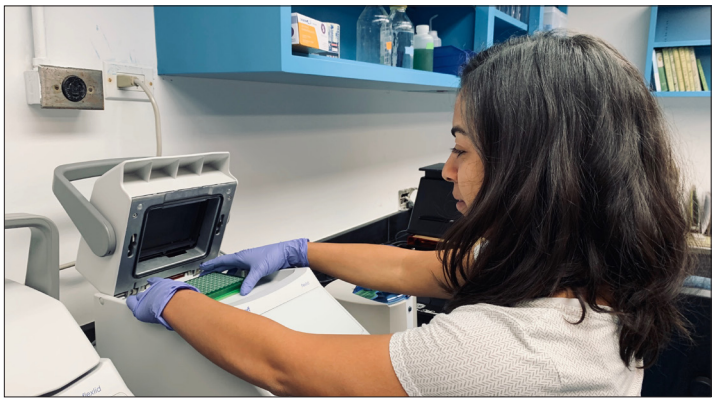
GO-SHIP cruises provide the foundation for estimating carbon and heat uptake in the world's oceans. One such cruise aboard the NOAA Ship *Ronald H. Brown* was to begin from South Africa in mid-March, but became caught in the cross-hairs of the coronavirus outbreak. Much of the science crew was in South Africa as the country began closing its borders. The *Brown* stayed within range of Cape Town for several days to ensure no one was a COVID-19 carrier, and then steamed to Norfolk, Virginia to return everyone to their families and homes. Despite these hardships, the science team collected basinwide underway samples and measurements, as well as deployed floats and drifters. Their creativity and perseverance resulted in cross-basin, multi-disciplinary samples that support critical NOAA research, while the deployment of long-term observing platforms will provide data for years to come.

Stephanie Rosales and Alyssa Thompson—AOML-Ocean Chemistry and Ecosystems Division.

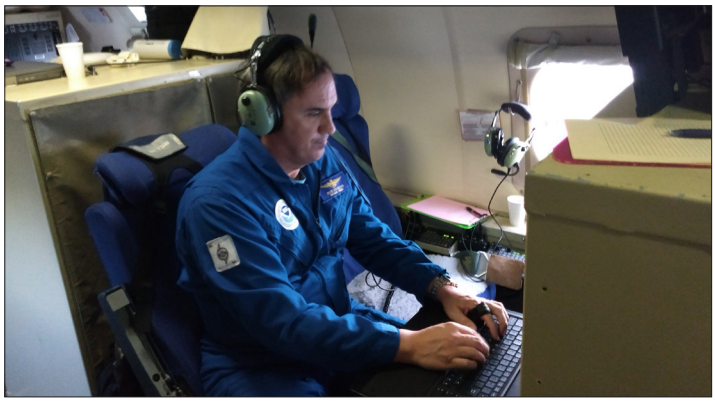
Stephanie Rosales, an AOML-University of Miami Cooperative Institute microbiologist, learned that the University of Miami's Health System was looking for ways to increase its capacity to conduct COVID-19 testing. Luckily, through NOAA's 'omics program, AOML recently purchased a KingFisher instrument capable of providing automated high-throughput biological sample processing. After obtaining buy-in from key management at AOML, Stephanie worked with University of Miami scientists and staff, who were grateful for the opportunity to borrow the instrument. NOAA Corps Officer LTJG Alyssa Thompson worked tirelessly to complete the necessary paperwork to loan the instrument to the University of Miami for three months. Their extraordinary hard work and coordination directly led to the development of high-throughput protocols for COVID-19 testing capacity in Miami, Florida.

Robert Rogers—AOML-Hurricane Research Division.

During his participation in NOAA's Leadership Competencies Development Program, meteorologist Rob Rogers worked with NOAA's Budget Formulation and Execution Team to minimize and mitigate the impacts of COVID-19 to NOAA's budget function. Despite the challenges associated with full-time telework, the team oversaw the day-to-day execution of NOAA's FY-2020 budget and worked with Congress on the upcoming FY-2021 budget. The team also coordinated a massive effort to identify and secure funding to assist NOAA and its partners in responding to COVID-19. Working with line and staff offices, NOAA leadership, the Department of Commerce, the Office of Management and Budget, and Congress, the team identified, justified, and secured substantial funding through the CARES (Coronavirus Aid, Relief, and Economic Security) Act. Due in no small part to their efforts, NOAA obtained $20 million for staffing, cleaning, and IT support needed to ensure the continuity of its operations, as well as $300 million in direct assistance for impacted members of the American fishing industry.



AOML-University of Miami Cooperative Institute coral researcher Stephanie Rosales was recognized for her efforts to increase COVID-19 testing capacitity in Miami.



AOML meteorologist Robert Rogers was recognized for his contributions to NOAA's Budget Formulation and Execution Team while participating in the Leadership Competencies Development Program.

AOML Remembers Jack Kofoed, First Deputy Director

John W. Kofoed, AOML's first Deputy Director, died in April after an extended battle with Parkinson's disease. He was 88 years old. Known to all as Jack, he played a pivotal role in the founding of AOML on Virginia Key.

Jack began as a marine geologist with what is now NOAA in 1961. In 1966, he became the deputy director of first the US Coast and Geodetic Survey and then the Institute of Oceanography under the leadership of Dr. Harris Stewart. Both organizations were housed within the Environmental Science Services Administration, ESSA (predecessor of NOAA), in Silver Spring, Maryland.

He moved to Miami in 1967, along with more than 100 scientists, technicians, and administrative staff, after ESSA announced it would build a state-of-the-art oceanographic research facility on Virginia Key with Dr. Stewart as its director. As Stewart's right-hand man, Jack tended to the logistics and countless aspects entailed in settling the workforce for the fledgling Atlantic Oceanographic and Meteorological Laboratories temporarily into rented office space until the new facility could be built.

By the autumn of 1969, contracts had already been awarded to both an architectural firm and a construction company when a last-minute cut to the FY-1970 federal budget eliminated funding for all new construction projects. Jack and Dr. Stewart waged a vigorous campaign to rally Miami's community leaders for their help in getting the funds reinstated.

Construction began a year later in October 1970 with Jack at the nerve center of daily discussions and decisions as the AOML facility rose from the ground. Two years later the project was completed, but Jack's work continued, first in managing the multiple aspects of preparing the new facility for occupancy and then in overseeing the movement and placement of people, equipment, and furniture into the new facility.

After 10 years of serving as Dr. Stewart's deputy director, Jack returned to his roots as a scientist. In 1976 he became the director of the Marine Geology and Geophysics Laboratory at AOML, a research powerhouse in its day.

He retired from federal service in 1983 but remained a steadfast supporter of AOML throughout his life. His diligent work and dedicated efforts in tending to the details helped place AOML on the map, both literally and figuratively. Jack's invaluable contributions lie at the foundation of the AOML we know today.

Spotlight on Commerce: Dr. John Cortinas, AOML Director

In June, AOML Director Dr. John Cortinas was featured on the Department of Commerce website in honor of LGBT Pride Month. Here is his guest blog post in its entirety.

My name is John Cortinas, and I am the director of NOAA's Atlantic and Oceanographic Meteorological Laboratory (AOML) within NOAA Research. The laboratory is a world leader in conducting oceanographic and meteorological research in the areas of oceanic and atmospheric observing systems, tropical storms, marine ecosystems, and ocean chemistry, particularly in the Atlantic Ocean. In this position, I am responsible for leading approximately 70 federal employees who work with another 70 employees from the University of Miami and other universities across Florida at a facility in Miami.

I was born in Grand Island, Nebraska, but grew up in Omaha, Nebraska, with American parents of mixed ethnic backgrounds, proudly representing previous generations from Mexico, Spain, and Germany. I received a BS degree in meteorology from Metropolitan State College of Denver, then went on to complete a PhD in geophysical sciences at the Georgia Institute of Technology in 1992.

I am a member of several national organizations, including the American Meteorological Society and the Society for the Advancement of Chicanos and Native Americans in Science in which I am actively engaged in activities that focus on underrepresented racial, ethnic, and sexual minorities. These activities often focus on helping students and early career scientists, who are members of underrepresented minorities, learn about career options, networking opportunities, and advice for a successful career.

There are three books that are part of a series that have influenced my life significantly. The series "Conversations with God," books 1, 2, and 3 by Neale Donald Walsch, profoundly changed my life.

These books helped me recognize opportunities for creating change that have led to success and happiness in my life and helped me to appreciate my interactions with others.

To me, LGBT pride month is an opportunity to celebrate the importance of diversity within our society and the workforce. Using this month to highlight accomplishments in the LGBT community helps those in the community feel accepted and those outside feel more comfortable with others that are not like them. Highlighting LGBT issues during this month can also improve broader acceptance of sexual minorities.

When preparing for a federal service career, I recommend that anyone who is interested in such a position try to talk to a federal employee about their position to learn more about it and what skills are necessary. Focus on building such a skill set to ensure you are well qualified for the position you want. In addition to meeting specific education requirements and having experience with specific skills associated with the position, anyone considering federal employment should practice their oral and written communication skills to ensure you communicate extremely well.

In addition to communication, any experience that shows motivation and the ability to manage your work, including good time management, is critical to being successful. Lastly, having a positive attitude and exceptional people skills will help anyone do well when applying for federal service.

Being a career civil servant, to me, is a privilege that provides an amazing opportunity to serve and improve the lives of the American public. A career in federal service is an honor that is not easy to obtain, but worth the investment in time and effort to secure such a position.

Congratulations

Lisa Bucci, a federal Pathways intern with the Hurricane Research Division, earned a PhD in Atmospheric Science from the University of Miami's Rosenstiel School in June. Lisa's dissertation, *Assessment of the utility of Doppler Wind Lidars for tropical cyclone analysis and forecasting,* explored the use of observations from airborne and space-borne wind profilers to the numerical prediction of a tropical cyclone.

AOML's drifter Data Assembly Center was recognized in April by the World Meteorological Organization as an official component of its Marine Climate Data System, which provides the international science community with marine observations for climatological studies and services. The drifter Data Assembly Center at AOML has been processing and quality controlling drifting buoy delayed mode data for more than 30 years.

Allyson DeMerlis, a University of Miami-Rosenstiel School marine biology PhD student with the Ocean Chemistry and Ecosystems Division, received a 2020 David Rowland Endowed Fellowship in May from the University of Miami. Allyson was awarded the fellowship in recognition of her research on restoration-focused coral 'omics.

Sarah Ditchek, a University of Miami-Cooperative Institute post-doctoral scientist with the Hurricane Research Division, received the University of Albany's Distinguished Doctoral Dissertation Award in June. Sarah earned her PhD in Atmospheric Science from the University of Albany in July 2019. Her dissertation focused on research to document the frequency, structure, and characteristics of tropical cyclone diurnal pulses.

Ricardo Domingues, a University of Miami-Cooperative Institute research associate with the Physical Oceanography Division, was invited in June to serve as the editor for the fall edition of the US CLIVAR Program's *Variations* newsletter. The edition will focus on recent advances in sea level research and coastal resilience efforts, with contributions from researchers working at the forefront of these topics.

Ian Enochs and Derek Manzello, research ecologists with the Ocean Chemistry and Ecosystems Division, received 2020 Department of Commerce Bronze Medals in May as members of a team of NOAA scientists and managers honored for leading the federal response to stony coral tissue loss disease in Florida. The team worked with state and local governments, academia, and non-governmental organizations to address the initial outbreak of the disease off the coast of Miami in 2014. It has since monitored its spread along the Florida reef tract and conducted research into its cause and treatment.

Marlos Goes, a University of Miami-Cooperative Institute scientist with the Physical Oceanography Division, was invited in May to serve as the guest editor for a special issue of the journal *Geosciences* entitled *Large-scale ocean circulation*. The issue will focus on the use of in situ and satellite data and numerical model output to improve understanding of the oceanic and atmospheric drivers of large-scale ocean circulation, as well as the effects of ocean circulation variability on heat and freshwater convergences that impact climate variability and society (see https://www.mdpi.com/journal/geosciences/special_issues/Ocean_Circulation).

Kelly Goodwin, a microbiologist with the Ocean Chemistry and Ecosystems Division, received a 2020 Department of Commerce Bronze medal in May for her leadership in the development of the 'Omics program within NOAA. Kelly was honored as one of the principal architects of NOAA's new 'Omics Strategy and for her research that has advanced 'Omics science, including the use of environmental DNA (eDNA) and autonomous 'Omics applications in the field. She has also been instrumental in the development of the 'Omics-related bioinformatics computing capacity at AOML and NOAA's Southeast Fisheries Science Center in Miami.

Sundararaman Gopalakrishnan, aka Gopal, a meteorologist with the Hurricane Research Division, was invited in May to serve as the Chair for NOAA's High Performance Computing User Group. As the Chair, Gopal will be responsible for guiding the group's discussions on topics ranging from computing requirements to program policy. More importantly, he will also lead the group's annual survey, which provides direct input for the priorities of the program.

Renellys Perez, an oceanographer with the Physical Oceanography Division, was appointed to the US National Committee for Geodesy and Geophysics in April for a term that began on April 15, 2020 and will end on April 14, 2024. The committee serves as a focal point for US discussions on how to best maintain the viability and relevance of geodesy and geophysics internationally. The committee also provides guidance and input to the International Union of Geodesy and Geophysics on these issues, as well as plans and implements US participation in its programs.

Heidi Van Buskirk, a University of Miami-Cooperative Institute communications intern with the Office of the Director, earned a Masters of Professional Science degree from the University of Miami's Rosenstiel School in April. Heidi virtually presented her internship defense, *Using visual media to enhance science communication and outreach at NOAA/AOML,* which provided an overview of the primary goals and outcomes during her year-long internship, including social media platforms and digital visual mediums.

Farewell

Dr. David Bates, a University of Miami-Cooperative Institute assistant scientist with AOML's Hurricane Research Division, departed from AOML in April. During David's time at the lab, he worked with the Observing System Simulation Experiments (OSSEs) team on the simulation of satellite observations from current and proposed observing technologies. He additionally led development work on the simulation and assimilation of all-sky satellite radiances to improve NOAA's global and regional weather forecasts.

Dr. Hui Christopherson, a University of Miami-Cooperative Institute post-doctoral scientist with AOML's Hurricane Research Division, resigned in June to accept a federal meteorologist position with the Naval Research Laboratory in Monterey, California. During Hui's 5 years at AOML, she flew numerous missions aboard NOAA's Hurricane Hunter aircraft in support of AOML's annual Hurricane Field Program. She also conducted research on the impacts of unmanned aircraft systems and microsat radiometers on numerical modeling and data assimilation for high-impact weather predictions through Observing System Experiments.

Dr. Jonathan Christopherson, a University of Miami-Cooperative research associate with AOML's Physical Oceanography Division, successfully defended his doctoral dissertation in March and earned a PhD in Meteorology from Florida State University's Department of Earth, Ocean and Atmospheric Science. Jon subsequently accepted a National Research Council post-doctoral position with the Naval Research Laboratory in Monterey, California. He resigned in May after 4 years at AOML, with studies focused on the Atlantic meridional overturning circulation in the North Atlantic Ocean and near-surface atmosphere/upper-ocean diurnal cycles in the tropical Atlantic.

Dr. Steven Diaz, a University of Miami-Cooperative Institute senior research associate with AOML's Hurricane Research Division, departed in April. During Steve's almost 6 years at AOML, he supported the Modeling Group's efforts to develop the next generation of the Hurricane Weather Research and Forecasting system, as well as supported the Observation Systems Analysis Group's work on the impact of satellite data latency on global and hurricane weather prediction.

Vicki Halliwell, a University of Miami-Coooperative Institute senior research associate with AOML's Physical Oceanography, retired in May. Vicki joined AOML in 2007, bringing with her a solid background and experience in computer programming from her previous work with the Remote Sensing Group at the University of Miami's Rosenstiel School and Oregon State University. During her years at AOML, Vicki led some of the aspects of real-time Argo data processing, specifically processing several tens of thousands of Argo ocean profiles per year, which are the new basis for long-term global observations for temperature, salinity, and other ocean parameters.

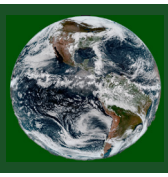
Dr. Andrew Kren, a University of Miami-Cooperative Institute research scientist with AOML's Hurricane Research Division, resigned in June to accept a federal position with NOAA's National Weather Service in Raleigh, North Carolina. During Andrew's 2+ years at AOML, he worked as a member of the Global Observing Systems Analysis Group led by Dr. Lidia Cucurull in Boulder, Colorado. His research focused primarily on Observing System Simulation Experiments using the Hurricane Weather Research and Forecasting model to improve hurricane prediction.

James Nowotny, a University of Miami-Cooperative Institute research associate with AOML's Ocean Chemistry and Ecosystems Division, resigned in June to prepare for his new graduate studies program at the University of Maryland next semester. During his time at AOML, James worked with Drs. Chris Sinigalliano and Maribeth Gidley on 'omics-related research, including studies of pathogens and harmful algae in the coastal environment, microbial water quality, and marine microbiome biodiversity.

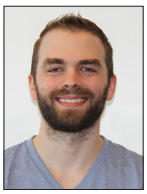
Dr. Michael Rudko, a University of Miami-Cooperative Institute scientist with AOML's Physical Oceanography Division, completed his 2-year post-doctoral appointment in April. During his time at AOML, Michael worked with Dr. Denis Volkov on a project to study the mechanisms responsible for variability in the regional heat content and sea level of the Pacific and Indian oceans using satellite and in situ observations, as well as ocean models. He has accepted a position at the University of Miami's Rosenstiel School.

Erik Valdes, a University of Miami-Cooperative Institute research associate with AOML's Physical Oceanography Division, resigned in May to join the Miami-Dade Police Department. Erik diligently supported the Global Drifter Program's Data Assembly Center at AOML for 15 years. Among his duties, he reviewed, processed, and quality controlled tens of thousands of data records from drifting buoys deployed worldwide to ensure their accuracy. The data are used by the international scientific community for climate studies, weather forecasts, and a host of applications that include tracking oil spills, marine debris, and larval fish dispersion.

April 22, 2020
Celebrating 50 Years of Earth Day
1970-2020



Welcome Aboard

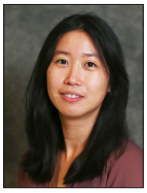


Dr. Sean Anderson joined the staff of AOML's Ocean Chemistry and Ecosystems Division in March as a post-doctoral researcher with the Northern Gulf Institute. Sean comes to AOML from the University of Georgia Skidaway Institute of Marine Science, where he recenty completed his PhD dissertation on plankton dynamics in the Skidaway River Estuary. He will work with Drs. Luke Thompson and Chris Kelble to develop and apply methods for environmental DNA analysis of fish populations and harmful algal blooms, as well as other 'omics-related projects.

Dr. Bertrand Dano joined the staff of AOML's Physical Oceanography Division in April as a University of Miami-Cooperative Institute research associate. Bertrand will support the Global Drifter Program's Data Assembly Center by managing its data flow and creating value-added products. He holds both an MS degree in Mechanical Engineering and a PhD in Fluid Flow Dynamics from Oregon State University.

Kristina Kiest rejoined AOML in April as a digital communications specialist with the contractor CollabraLink. In her current role, Kristina will use a combination of science communication best practices, analytics data, and web development skills to curate AOML's web content for a diverse audience. Kristina enjoys teaching other communications staff in NOAA Research how to creatively use analytics data to inform their own web site improvements. Her goal is to deliver AOML's research and data products to multiple stakeholder audiences to increase awareness and engagement in support of NOAA's mission.

Rebecca Kravetz joined AOML's Office of the Director in May as a new communications intern. Rebecca will work for the next year with Erica Rule, the communications director at AOML, by writing news highlights for the AOML website, as well as by managing AOML's social media accounts on Twitter, Instagram, and YouTube. She recently earned an MBA degree from the University of Miami's Business School and is working on a second Master's degree from the University of Miami's Abess Center for Ecosystem Science and Policy.



Dr. Jean Lim joined the staff of AOML's Ocean Chemistry and Ecosystems Division in April as a University of Miami-Cooperative Institute post-doctoral scientist. Jean will work with Drs. Chris Kelble and Luke Thompson to analyze large environmental DNA datasets and develop bioinformatic pipelines and cloud-based analysis platforms to extract actionable information. She recently received her PhD from the Department of Biological Sciences at Clemson University where she used field studies and 'omics methods to study the taxonomic and functional adaptation of chemosymbiotic bacteria and marine bivalves.

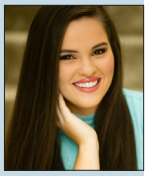
Dr. Peter Marinescu joined the staff of AOML's Hurricane Research Division in May as a Colorado State University-Cooperative Institute for Research in the Atmosphere (CIRA) post-doctoral scientist. Peter will support AOML's Observing Systems Analysis group, working with Dr. Lidia Cucurull in Colorado, to improve data assimilation algorithms for optimizing Aeolus 3D wind data to improve hurricane prediction. He recently earned his PhD from Colorado State University, focusing on cloud microphysics and dynamics in deep convective clouds.

Dr. Michael Mueller joined the staff of AOML's Hurricane Research Division in April as an AOML-UCAR (University Corporation for Atmospheric Research) scientist. Michael will work as a member of AOML's Observing Systems Analysis Group led by Dr. Lidia Cucurull in Boulder, Colorado where he will support the evaluation of potential future satellite architectures to improve weather forecasts at NOAA. He holds a PhD in meteorology from Saint Louis University.

Rayne Sabatello joined AOML's Office of the Director in May as a new communications intern. Rayne will work under the guidance of Erica Rule, the communications director at AOML, for the next year but will focus her efforts on crafting communication outreach activities and products for the Physical Oceanography Division. Specifically, Rayne will work with staff to prepare research highlights in plain language and develop content for the AOML website. She is currently a graduate student at the University of Miami's Rosenstiel School.

AOML Welcome NOAA Hollings Scholars

AOML proudly welcomed three NOAA Hollings Scholars in May, all of whom began virtual summer internships with mentors to learn new skills, improve their knowledge, and assist with ongoing research:



Samantha Michlowitz, a meteorology major at the University of South Alabama, will work with Dr. Joe Cione to update sea surface temperature cooling algorithms he developed in 2004 that are used in the Statistical Hurricane Intensity Prediction Scheme (SHIPS).

Nikolaus Rentzke, a senior majoring in meteorology and computational mathematics at Embry-Riddle Aeronautical University, will work with Drs. Jason Sippel and Sarah Ditchek to evaluate the relative value of Global Hawk dropsonde observations launched at different altitudes on tropical cyclone prediction.

Grant Sanderson, a marine science and oceanography major at the University of Hawaii, will work with Drs. Kelly Goodwin and Luke Thompson to develop statistical workflows and software tools for environmental DNA observational data.

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

Keynotes editor: Gail Derr

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

ALAKA, **G.J.**, **X. ZHANG**, **S.G. GOPALAKRISHNAN**, Z. Zhang, **F.D. MARKS**, and **R. ATLAS**, 2019: Track uncertainty in high-resolution ensemble forecasts of Hurricane Joaquin. *Weather and Forecasting,* 34(6):1889-1908.

Bhalachandran, S., D.R. Chavas, **F.D. MARKS**, S. Dubey, A. Shreevastava, and T.N. Krishnamurti, 2020: Characterizing the energetics of vortex-scale and sub-vortex-scale asymmetries during tropical cyclone rapid intensity changes. *Journal of the Atmospheric Sciences,* 77(1): 315-336.

CUCURULL, **L.**, and M.J. Mueller, 2020: An analysis of alternatives for the COSMIC-2 constellation in the context of global Observing System Simulation Experiments. *Weather and Forecasting,* 35(1):51-66.

Fan, S., B. Zhang, A.A. Mouche, W. Perrie, **J.A. ZHANG**, and G. Zhang, 2020: Estimation of wind direction in tropical cyclones using C-band dual-polarization synthetic aperture radar. *IEEE Transactions on Geoscience and Remote Sensing,* 58(2):1450-1462.

FISCHER, **M.S.**, **R.F. ROGERS**, and **P.D. REASOR**, 2020: The rapid intensification and eyewall replacement cycles of Hurricane Irma (2017). *Monthly Weather Review,* 148(3):981-1004.

Garcia-Pineda, O., Y. Androulidakis, **M. LE HÉNAFF**, V. Kourafalou, L.R. Hole, H.-S. Kang, G. Staples, E. Ramirez, and L. DiPinto, 2020: Measuring oil residence time with GPS drifters, satellites, and Unmanned Aerial Systems (UAS). *Marine Pollution Bulletin,* 150:110644.

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GOPALAKRISHNAN, **S.G.**, K.K. Osuri, **F.D. MARKS**, and U.C. Mohanty, 2019: An inner-core analysis of the axisymmetric and asymmetric intensification of tropical cyclones: Influence of shear. *Mausam: Quarterly Journal of Meteorology, Hydrology and Geophysics,* 70(4):667-690.

Gravinese, P.M., **I.C. ENOCHS**, **D.P. MANZELLO**, and R. van Woesik, 2019: Ocean acidification changes the vertical movement of stone crab larvae. *Biology Letters*, 15(12):20190414.

HARPER, **K.J.**, **K.D. GOODWIN**, L.R. Harper, E.L. LaCasella, A. Frey, and P.H. Dutton, 2020: Finding Crush: Environmental DNA analysis as a tool for tracking the green sea turtle *Chelonia mydas* in a marine estuary. *Frontiers in Marine Science,* 6:810.

Jiang, M., C. Pan, **L. BARBERO**, J. Reed, J.E. Salisbury, J.H. VanZwieten, and **R. WANNINKHOF**, 2020: Variability of bottom carbonate chemistry over the deep coral reefs in the Florida Straits and the impacts of mesoscale processes. *Ocean Modelling*, 147:101555.

JOHNS, **E.M.**, **R. LUMPKIN**, N.F. Putman, **R.H. SMITH**, F.E. Muller-Karger, D. Rueda-Roa, C. Hu, M. Wang, M.T. Brooks, **L.J. GRAMER**, and F.E. Werner, 2020: The establishment of a pelagic Sargassum population in the tropical Atlantic: Biological consequences of a basin-scale long distance dispersal event. *Progress in Oceanography,* 182:102269.

Kelly, E., **M. GIDLEY**, **C. SINIGALLIANO**, N. Kumar, L. Brand, R.J. Harris, and H.M. Solo-Gabriele, 2020: Proliferation of microalgae and enterococci in the Lake Okeechobee, St. Lucie, and Loxahatchee watersheds. *Water Research,* 171:115441.

LEE, **S.-K.**, **D. KIM**, **G.R. FOLTZ**, and **H. LOPEZ**, 2020: Pantropical response to global warming and the emergence of a La Niña-like mean state trend. *Geophysical Research Letters,* 47(3):e2019GL086497.

McCarthy, G.D., P.J. Brown, C.N. Flagg, **G.J. GONI**, L. Houpert, C.W. Hughes, R. Hummels, M. Inall, K. Jochumsen, K.M.H. Larsen, P. Lherminier, **C.S. MEINEN**, B.I. Moat, D. Rayner, M. Rhein, A. Roessler, **C. SCHMID**, and D.A. Smeed, 2020: Sustainable observations of the AMOC: Methodology and technology. *Reviews of Geophysics*, 58(1):e2019RG000654.

ROSALES, **S.M.**, M.W. Miller, D.E. Williams, N. Traylor-Knowles, B. Young, and X.M. Serrano, 2019: Microbiome differences in disease-resistant vs. susceptible *Acropora* corals subjected to disease challenge assays. *Scientific Reports,* 9:18279.

Shutler, J.D., **R. WANNINKHOF**, P.D. Nightingale, D.K. Woolf, D.C.E. Bakker, A. Watson, I. Ashton, T. Holding, B. Chapron, Y. Quilfen, C. Fairall, U. Schuster, M. Nakajima, and C.J. Donlon, 2020: Satellites will address critical science priorities for quantifying ocean carbon. *Frontiers in Ecology and the Environment,* 18(1):27-35.

Sun, Z., B. Zhang, **J.A. ZHANG**, and W. Perrie, 2019: Examination of surface wind asymmetry in tropical cyclones over the northwest Pacific Ocean using SMAP observations. *Remote Sensing*, 11(22):2604.

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