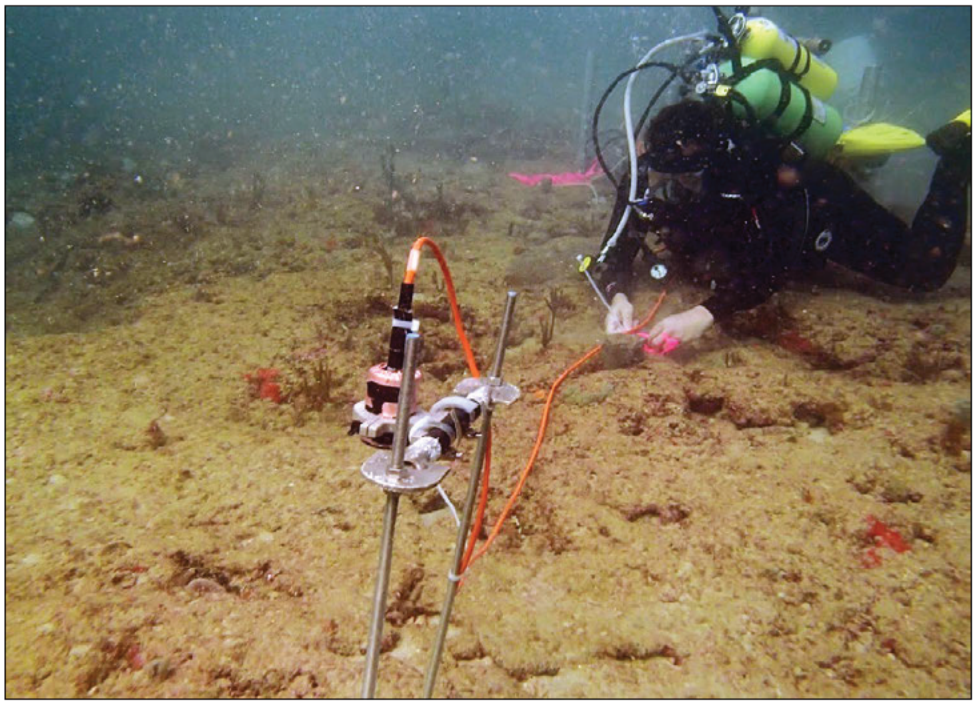
AOML is an environmental laboratory of NOAA's Office of Oceanic and Atmospheric Research located on Virginia Key in Miami, Florida

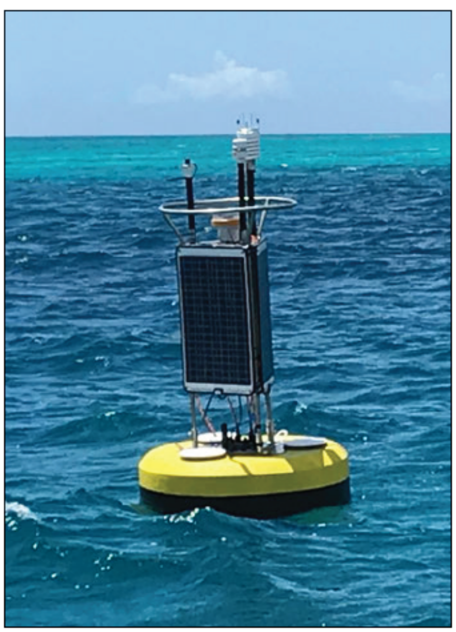
Artificial Intelligence Tool Tested at Port Everglades



Divers with the US Army Corps of Engineers deploy ecological sensors on the seafloor at Port Everglades. The sensors are part of an expert system that relay their data to a water quality monitoring buoy to ensure dredging operations cease if dredged material is likely to threaten nearby coral reefs.

Researchers are testing an artificial intelligence tool at Port Everglades in Fort Lauderdale, one of the busiest cruise ship ports in the world, for its ability to monitor water quality and oceanographic conditions. The collaborative effort between the US Army Corps of Engineers, AOML, and NOAA's Southeast Fisheries Science Center is focused around the use of the Environmental Information Synthesizer for Expert Systems, or EISES, an AI tool that automates and expedites the analysis of environmental data.

EISES is being tested during maintenance dredging operations in advance of a major project scheduled to begin in 2022 to deepen and widen Port Everglades. The overarching goal is to protect fragile coral reef ecosystems and other marine life in the area that could potentially be stressed, even damaged, during the project. This AI tool was originally developed at AOML in 1998 as an expert ecological forecasting system to detect environmental conditions conducive to coral bleaching.



A water quality monitoring buoy installed north of Port Everglades Channel by AOML researchers is part of an expert system being used to adaptively manage dredging operations at the port.

EISES is recording data from sensors mounted on the seafloor that measure turbidity, total suspended solids, sediment deposition, seabed light, waves, currents, temperature, and salinity. These data are relayed to a water quality monitoring buoy at the port that facilitates their transmission to EISES. If and when EISES encounters environmental conditions that are deemed to be hazardous, alerts are issued and sent to stakeholders with detailed information about the potential threat and its location.

Coral communities are particularly susceptible to dredging impacts, especially when the impacts go undetected or are not detected soon enough to take remedial action. For example, turbidity reduces water clarity which, in turn, reduces the amount of light available for corals and seagrass to carry out their life processes. Additionally, high levels of sedimentation can bury corals, increasing mortality rates among colonies and decreasing the ability of coral larvae to settle and survive.

Researchers hope to capitalize on the early detection capabilities of EISES during next year's deepening/widening project to minimize impacts potentially caused by dredging. By keeping researchers, managers, and other stakeholders abreast of changing water quality conditions, adaptive management actions can be taken, if needed, as the project progresses. Data collected throughout 2021 will help to establish baseline conditions at the port.

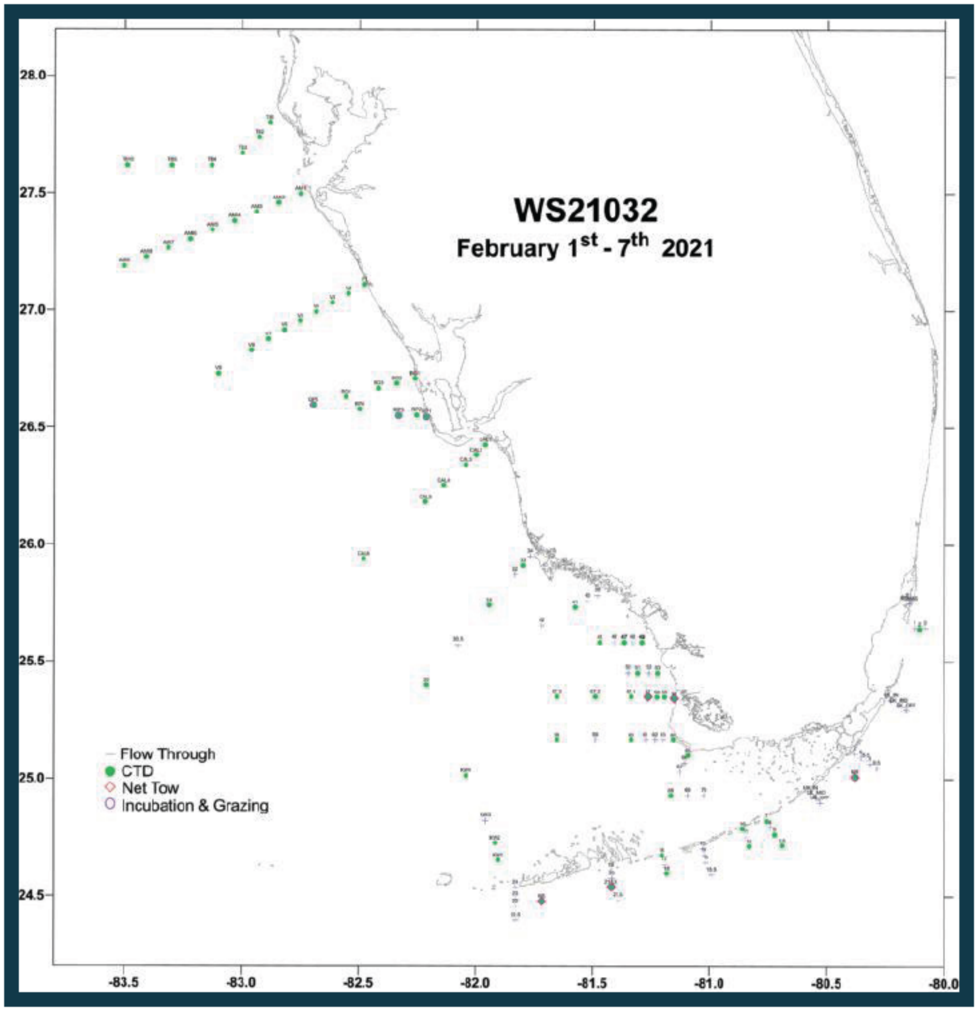
Science Team Samples West Florida Shelf for Red Tide

Scientists at AOML headed to sea in early February aboard the R/V *Walton Smith* to sample areas where red tide blooms are commonly present off the west Florida coast. They were joined by colleagues from the University of South Florida and the Fish and Wildlife Research Institute (FWRI) of Florida's Fish and Wildlife Conservation Commission.

Karenia brevis, the organism that causes red tide, forms blooms on the ocean surface when elevated concentrations (>100,000 cells per liter) are present in the water. *K. brevis* produces toxins called brevetoxins that can cause massive fish kills, weaken or kill marine mammals and, if the toxin becomes aerosolized and inhaled, cause respiratory distress in humans and marine mammals.

The research team sampled a series of transects along the West Florida Shelf (see image at right) with an Imaging Flow Cytobot to detect red tide. The instrument took high-resolution images every 20 minutes of all microscopic particles present in the water samples collected autonomously during the survey.

This survey was of particular interest because *K. brevis* has been observed along the southwest Florida coast since December 2020, and offshore chlorophyll patches have been observed in recent remote sensing imagery provided by the University of South Florida.



Map of the west Florida coast that shows where water quality samples were collected during the February 2021 red tide cruise aboard the R/V *Walton Smith*, as well as the locations where an *Imaging Flow Cytobot* was deployed to detect the presence or absence of *K. brevis*.

Dead fish litter a beach near Sarasota, Florida, that were killed by toxins from a 2018 red tide. Credit: NOAA-National Centers for Coastal Ocean Science.

Scientists at AOML have been conducting water quality sampling cruises along the west Florida coast as part of its South Florida Ecosystem Restoration Research project since 1998. The original mission of the project was to assess and evaluate the impacts and benefits of the Everglades Restoration project on downstream coastal ecosystems. The long-term dataset is critical for detecting degradations in water quality.

In recent years, however, the mission has expanded to include biodiversity measurements through partnerships with the Marine Biodiversity Observing Network, the FWRI's Harmful Algal Bloom Program, and the Southeast Coastal Ocean Regional Association (SECOORA).

"In partnership with colleagues at FWRI and SECOORA, the research area of our cruises has been increased to better examine the oceanography and chemistry of offshore areas inhabited by red tide. This has allowed us to incorporate new technologies such as the Imaging Flow Cytobot into our research cruises," said Chris Kelble, an AOML oceanographer. The surveys now include routine monitoring of oceanographic conditions and water chemistry of an area that stretches from the offshore region of Tampa Bay to offshore of Pine Island Sound.

Kate Hubbard, who leads the FWRI's Harmful Algal Bloom Program, additionally commented about the expanded coverage, stating that "adding more routine and comprehensive measurements offshore provides us with an unprecedented snapshot of current conditions and, at the same time, allows us to strengthen our foundation for examining changes and trends in harmful algal bloom severity over time."

This article is modified from an article on the SECOORA website of February 3, 2021

AOML Oceanographer Chris Kelble Selected to Lead Ocean Chemistry and Ecosystems Research at AOML

AOML is proud to announce the selection of oceanographer Christopher Kelble, PhD, as the new director of the Ocean Chemistry and Ecosystems Division (OCED). Chris steps into the role of director after having served in an acting capacity for the past 6 months. He succeeds Dr. Jim Hendee, the former OCED director, who retired from federal service in September 2020.

Chris began at AOML in August 1999 as a University of Miami-Cooperative Institute Research Associate after earning an undergraduate degree in marine science and biology from the University of Miami. He subsequently earned both graduate (2003) and doctoral (2010) degrees in marine biology and fisheries from the Rosenstiel School of Marine and Atmospheric Science, working his way up the ranks to become a Cooperative Institute Assistant Scientist. In 2011, Chris became a federal oceanographer.

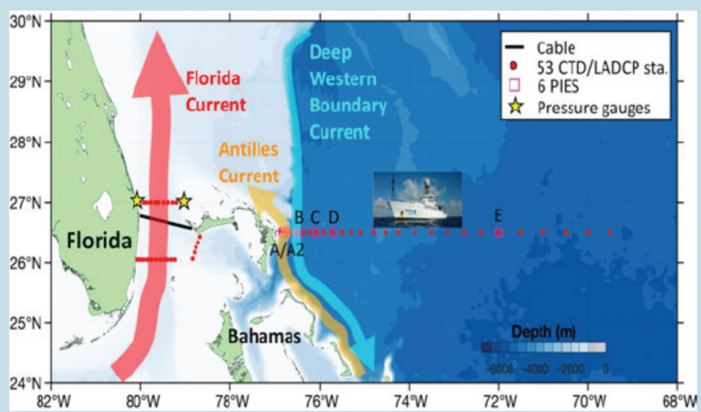
Throughout his career at AOML, Chris has served as the principal investigator for OCED's integrated ecosystem assessments and ecosystem restoration studies. His primary research interest is to holistically understand how humans alter coastal marine ecosystems and, in turn, how these coastal ecosystems help to support coastal communities.

Chris' studies have a heavy emphasis on transitioning research to applications by working closely with resource managers most likely to use these research results. His research has ranged from understanding how altered watersheds affect salinity variability, and thus habitat suitability, to understanding how natural and anthropogenic drivers of change affect the entire Gulf of Mexico ecosystem.

He currently serves on leadership committees for NOAA's Integrated Ecosystem Assessment Program, NOAA's Ecosystem Indicators Working Group, NOAA's Biscayne Bay Habitat Blueprint Focus Area, NOAA's Gulf of Mexico Regional Collaboration Team, the US Interagency Blue Carbon Working Group, and the Science Coordination Group of the South Florida Ecosystem Restoration Task Force. Congratulations to Chris!

Scientists at AOML Receive Ocean Observing Team Award for Western Boundary Time Series Project

NOAA's Western Boundary Time Series (WBTS) project, alongside partner projects RAPID and MOCHA, have received the inaugural Ocean Observing Team Award by The Oceanography Society. The award recognizes innovation and excellence in sustained ocean observing methods for scientific and/or practical applications. The WBTS/RAPID/MOCHA team was honored for significantly improving understanding of the Atlantic's circulation by way of a basinwide observing system. This observing system measures the variability of the Meridional Overturning Circulation (MOC) through a core array of moorings stretched across the Atlantic at 26°N. The MOC is one of the main components of the global ocean's circulation, constantly transporting heat, salt, carbon, and nutrients. Variations in the MOC have important impacts on many global scale climate phenomena such as sea level change, extreme weather, and precipitation patterns.



Map showing the major components of the WBTS project: Florida Current cable (black line), CTD/LADCP stations (red dots), pressure inverted echo sounders (squares), and pressure gauges (stars).

The WBTS/RAPID/MOCHA project is a collaborative research effort of AOML, the University of Miami's Rosenstiel School of Marine and Atmospheric Science, and the National Oceanography Centre. This international team has measured the MOC in the North Atlantic Ocean for more than 16 years, demonstrating that ship-based cruises to define trends in the Atlantic MOC have been biased due to errors in the highly variable system. It consequently changed its approach from ocean data acquisition to more targeted, high-resolution in-situ measurements. This approach provides continuous, cost-effective data that has led to a transformation in ocean observing methodology and advances in scientific knowledge.

Scientific advances directly attributable to the WBTS/RAPID/MOCHA project include knowledge that the Atlantic MOC varies on timescales of days to decades (rather than decades to centuries as previously assumed), and that wind-forcing (rather than buoyancy forcing) plays a dominant role in Atlantic MOC rates. The project has demonstrated how to build an ongoing international collaboration to address a critical climate problem, make data freely available, include students and early career professionals, and openly support interdisciplinary efforts that have resulted in partnerships with engineers, biogeochemists, and climate modelers. Over the years, a large team of AOML researchers has been involved with the WBTS project who have been instrumental to the project receiving this award, including Molly Baringer, Pedro Pena, Ulises Rivero, Denis Volkov, Ryan Smith, Andrew Stefanick, Rigoberto Garcia, James Hooper, George Berberian, Diego Ugaz, Grant Rawson, Ricardo Domingues, and many others.

BGC Argo Floats Provide First Year-Round Net Primary Production Estimates for the Western North Atlantic

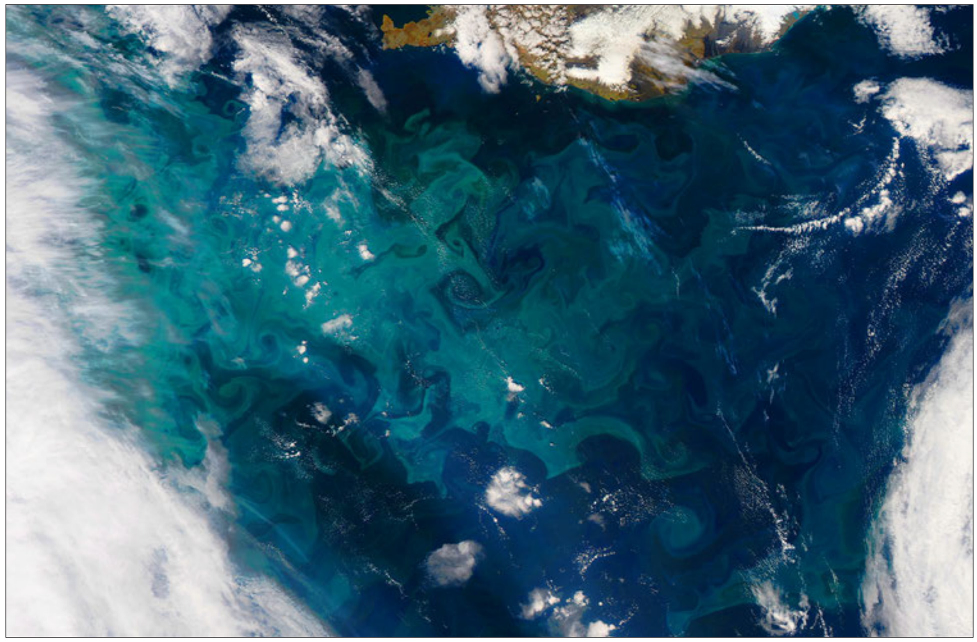


Image of a massive phytoplankton bloom in the North Atlantic Ocean observed from space on May 22, 2016 by the Moderate Resolution Imaging Spectroradiometer instrument (MODIS) on NASA's Aqua satellite. Phytoplankton are denoted by the bright turquoise color (photo credit: NASA).

Phytoplankton drifting near the ocean surface play a critical role in marine biogeochemistry, carbon cycling, and ecosystem health. But measuring the activity these microscopic organisms is challenging. Although scientists rely on ship-based sampling and satellites to quantify their abundance, both methods have limitations. In a study published recently in the *Journal of Geophysical Research-Biogeosciences*,* Argo profiling floats equipped with biogeochemical sensors, i.e., BGC Argo floats, were used to obtain the first year-long estimates of phytoplankton in the western North Atlantic Ocean.

The western North Atlantic produces one of the largest seasonal blooms of phytoplankton in the global ocean. Bo Yang, PhD, a University of Miami-Cooperative Institute researcher at AOML, led an effort to test the viability of using BGC Argo floats to quantify phytoplankton in this region.

"Our results highlight the utility of float bio-optical profiles," said Dr. Yang. "They indicate that environmental conditions, e.g., light availability and nutrient supply, are major factors controlling the seasonality and spatial (horizontal and vertical) distributions of NPP in the western North Atlantic Ocean."

Known as primary producers, phytoplankton are the foundation of the marine food web, directly or indirectly feeding ever larger organisms. Like plants on land, phytoplankton contain chlorophyll and, through photosynthesis, convert atmospheric carbon dioxide and sunlight into simple sugars for nourishment.

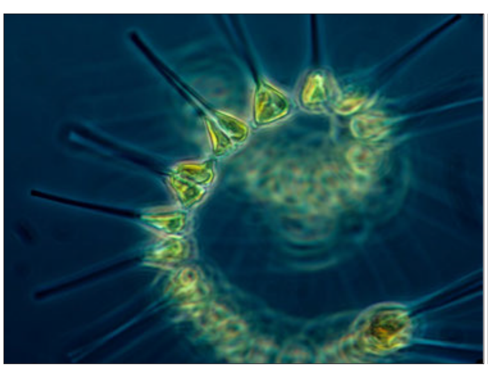
Phytoplankton multiply rapidly on sunlit days when nutrients are plentiful, creating dense swirling blooms that color the ocean surface (see above image). The total energy they collectively produce is their gross productivity. The energy left after their nutritional needs are met, referred to as net primary production or NPP, is available for other marine life to consume. NPP is a critical metric used to assess the ocean's biological productivity.

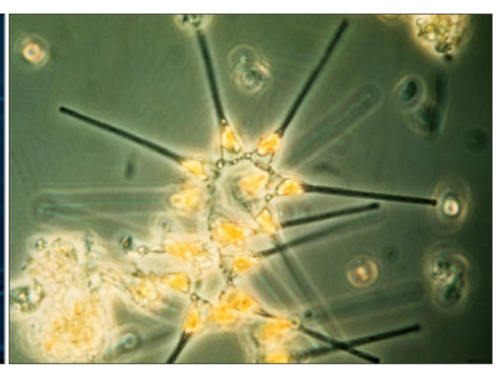
Ship-based measurements of NPP are specific to the area and time of sampling, providing only limited snapshots of the biological productivity occurring in the global ocean. Satellites measure NPP across large swaths of the sea surface but have difficulty capturing biological activity at depths below the surface and in regions obscured by clouds.

The science team used field data from five BGC Argo floats that gathered measurements during the North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) conducted from 2015-2018. Ship-based sampling for NPP was also conducted during the NAAMES project. All five BGC floats operated within close proximity to NAAMES cruise stations where ship sampling occurred, facilitating their comparison.

Using two bio-optical models, the team evaluated the performance of Argo-based NPP estimates against ship-based estimates, followed by an analysis of the spatial and temporal distributions of NPP in the western North Atlantic. Although the models exhibited both advantages and limitations, NPP derived from the Argo floats was found to be comparable to shipboard and satellite estimates.

With their ability to continually drift, gathering measurements at the surface to depths of 2000 m, BGC Argo-derived data complement ship and satellite approaches by filling gaps in coverage. Sampling over longer time frames and at a variety of the depths provides greater temporal and spatial information on phytoplankton carbon production, enabling year-round estimates of NPP.





Examples of phytoplankton, microscopic single-celled algae. Although tiny, phytoplankon are of vast importance to the health of the ocean and Planet Earth. They lie at the foundation of the marine food web, removing a significant amount carbon dioxide from the atmosphere through photosynthesis. Phytoplankton also produce more than 50 percent of Earth's oxygen, a byproduct of their photosynthesis (photo credit: NOAA).

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*Yang, B., J. Fox, M.J. Behrenfeld, E.S. Boss, N. Haëntjens, K.H. Halsey, S.R. Emerson, and S.C. Doney, 2021: In situ estimates of net primary production in the western North Atlantic with Argo profiling floats. *Journal of Geophysical Research-Biogeosciences*,126(2):e2020JG006116, https://doi.org/10.1029/2020JG006116.

Experimental Model Shows Skill in Predicting Seasonal US Tornado Activity

This article is modified from an AOML website blog post by Dr. Sang-Ki Lee

Year-to-year variations of US tornado activity are mostly driven by weather, and thus, are largely unpredictable beyond the time frame of several days. This can prove difficult for communities as they prepare for these hard-hitting weather disasters. By focusing on very active tornado seasons that are most likely linked to climate signals, researchers at AOML have made a small but important step in seasonal tornado forecasting—a model named SPOTter (Seasonal Probabilistic Outlook for Tornadoes)—that shows promise in predicting active tornado seasons 1-2 months in advance.

Researchers at AOML have been working to develop a seasonal outlook for tornadoes over the past decade.

In a new paper published in *Monthly Weather Review,*[1] a team of researchers from AOML, the Geophysical Fluid Dynamics Laboratory, and Climate Prediction Center introduce SPOTter and evaluate its prediction skill. They found that SPOTter holds the potential to predict subseasonal to seasonal tornado activity based on how key atmospheric parameters over the US respond to various climate signals, including El Niño and La Niña activity in the Pacific Ocean.

SPOTter provides an initial forecast in late February for March-April tornado activity and is updated in late March for April-May activity. This partly statistical and partly dynamic (i.e., hybrid) model was built based on the severe weather database of NOAA's Storm Prediction Center and NOAA's Climate Forecast System, version 2. SPOTter is the first of its kind to show fairly useful skill in predicting seasonal US tornado activity.

The study examined tornado activity for the period from 1982-2018. SPOTter predicted ten out of 14 active seasons for March-April and eight out of 14 active seasons for April-May, which indicates roughly 60-70 percent accuracy. The model also successfully identified the four most active tornado seasons during the study period: 1982, 1991, 2008, and 2011.

This project is the result of numerous collaborative efforts and more than 10 years of research. It began in May 2011 when a question was raised about whether La Niña contributed to the super tornado outbreak of that year. I later learned the question was in response to a remark made by then President Barack Obama, who wanted to know what could be done to better prepare the nation to anticipate and respond to deadly tornado outbreaks. This resulted in an implicit call for a seasonal outlook for tornadoes, just like there is for hurricanes.

My team and I have been working on this research since 2011. Our initial findings directly addressed whether the 2010-2011 La Niña contributed to that year's super tornado outbreak.[2] We found through model experiments that long-term climate signals, specifically the way the El Niño-Southern Oscillation (ENSO) transitions between El Niño and La Niña and how this affects sea surface temperatures in the tropical Pacific, could potentially provide seasonal predictability for tornado outbreaks. This connection influences winds in both the upper and lower atmosphere over the central and eastern United States.

We learned these anomalous winds transport more cold and dry upper-level air from the high latitudes and more warm and moist lower-level air from the Gulf of Mexico that converge east of the Rockies. These winds also increase lower-level vertical wind shear and convective available potential energy values, creating large-scale atmospheric conditions that are conducive to intense tornado outbreaks over the United States.

A number of excellent studies have been published since 2011. These studies provide the framework for predicting seasonal tornado activity before the severe weather season begins on March 1.

In January 2016, NOAA's Climate Prediction Center hosted the first experimental severe weather outlook forum. Representing AOML, I have participated in this forum ever since, working closely with its team members. This outlook forum has recently expanded with funding from NOAA's Office of Oceanic and Atmospheric Research. Last year, NOAA's Physical Science Laboratory and Geophysical Fluid Dynamics Laboratory, the two powerhouses in the nation for climate research, joined the team.

This year marks the 10-year anniversary of the 2011 super tornado outbreak that claimed more than 500 American lives. Over the past 10 years, researchers across NOAA, including myself, have been dutifully involved in answering the question posed by President Obama. This new advance, SPOTter, is a small but important milestone in our effort to create a subseasonal-to-seasonal outlook for tornado activity in the United States.

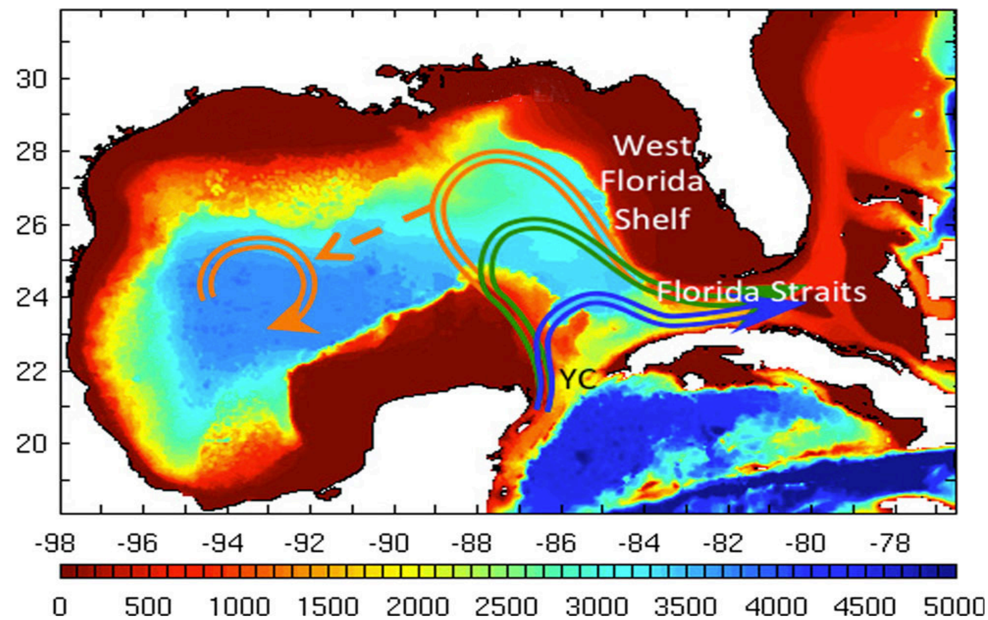
[1]Lee, S.-K., H. Lopez, D. Kim, A.T. Wittenberg, and A. Kumar, 2021: A seasonal probabilistic outlook for tornados (SPOTter) in the contiguous US based on the leading patterns of large-scale atmospheric anomalies. *Monthly Weather Review*, 149(4):901-919, https://doi.org/10.1175/MWR-D-20-0223.1.

[2]Lee, S.-K., R. Atlas, D.B. Enfield, C. Wang, and H. Liu, 2013: Is there an optimal ENSO pattern that enhances large-scale atmospheric processes conducive to major tornado outbreaks in the United States? *Journal of Climate*, 26(5):1626-1642, https://doi.org/10.1175/JCLI-D-12-00128.1.

Scientists Discover New Current Structure in Gulf of Mexico off Cuban Coast

Scientists at AOML, in collaboration with partners at the University of Miami's Rosenstiel School of Marine and Atmospheric Science, have identified Loop Current-related anticyclonic eddies along the northwest coast of Cuba in the southern Gulf of Mexico, named "CubANs" (Cuba anticyclones). These eddies play an important role in the ocean circulation associated with the Loop Current, and this team of scientists is the first to study them.*

An eddy is an independent circular current of water that can break off from an ocean current. In the northern hemisphere, anticyclonic eddies rotate clockwise and their center is often warmer than outer waters, leading to their referral as warm-core eddies. This discovery of new anticyclonic eddies has implications for how oil spills and pollution move throughout the Gulf, as well as how larval transport associated with these eddies affects fisheries populations in the region.



Topography of the Gulf of Mexico model domain (m), with the various stages of the Loop Current, including a shed Loop Current Eddy (orange). Adapted from Le Hénaff *et al.* (*J. Geophys. Res.*, 2012).

The Gulf of Mexico is a semi-enclosed basin connected to the Caribbean Sea and North Atlantic Ocean. Its main dynamical feature is the Loop Current, which is a portion of the North Atlantic western boundary current that carries ocean waters from the tropics towards higher latitudes.

The Loop Current changes its shape with time, sometimes moving directly from the Yucatan Channel (between Mexico and Cuba) to the Florida Straits (between Cuba and Florida), and sometimes growing until it forms a large loop that extends into the northern Gulf of Mexico, near the Mississippi Delta.

These different tracks are known as retracted and extended phases of the Loop Current. When extended, the Loop Current eventually forms a large, anticyclonic warm-core eddy known as a Loop Current Eddy that drifts westward inside the Gulf, while the main current returns to its retracted position (see image above).

"The identification of smaller anticyclonic eddies along the coast of Cuba, named CubANs, are different from the large Loop Current Eddies and add a level of complexity to the original picture we had of the Loop Current system. We found that these CubAN eddies are connected with the shape of the Loop Current and with coastal processes," said AOML Cooperative Institute scientist Matthieu Le Hénaff.

"These eddies appear to be connected to coastal upwelling taking place along the coasts of Cuba and the associated formation of small cyclonic eddies, i.e., cold core eddies that rotate counterclockwise. When there are pairs of eddies rotating in opposite directions of each other, they trap and transport coastal waters offshore, which is important for biological transport, or in the case of marine pollution," added Le Hénaff. This is similar to how gears in a machine work together.

Cuban waters inside the Gulf of Mexico are an area for oil exploration. In the case of an accidental oil spill, understanding these new processes can help scientists predict where the oil will travel.

There are also several marine protected areas along the Cuban coast that are reservoirs for biological productivity. When a pair of eddies form, larvae from these areas can be sent offshore and then transported by the Loop Current system, bringing them into the Gulf or towards Florida.

This research was a part of a Gulf of Mexico Research Initiative project entitled "Southeastern Gulf of Mexico processes affecting basinwide connectivity and hydrocarbon transport: The role of mesoscale eddies and upwelling near Cuba." As part of the project, scientists analyzed ocean observations collected in Cuban waters inside the Gulf of Mexico during NOAA Fisheries cruises to study bluefin tuna larvae, which provided details on the structure and evolution of these ocean processes taking place along the Cuban coasts.

*Kourafalou, V., Y. Androulidakis, M. Le Hénaff, and H.-S. Kang, 2017: The dynamics of Cuba anticyclones (CubANs) and interaction with the Loop Current/Florida Current system. *Journal of Geophysical Research: Oceans*, 122(10):7897-7923, https://doi.org/10.1002/2017JC012928.

Androulidakis, Y., V. Kourafalou, L.R. Hole, M. Le Hénaff, and H.-S. Kang, 2020: Pathway of oil spills from potential offshore Cuban exploration: Influence of ocean circulation. *Journal of Marine Science and Engineering*, 8(7):535, https://doi.org/10.3390/jmse8070535.

Androulidakis, Y., V. Kourafalou, M. Le Hénaff, H.-S. Kang, N. Ntaganou, and C. Hu, 2020: Gulf Stream evolution through the Straits of Florida: The role of eddies and upwelling near Cuba. *Ocean Dynamics,* 70(8):1005-1032, https://doi.org/10.1007/s10236-020-01381-5.

Le Hénaff, M., V.H. Kourafalou, Y. Androulidakis, R.H. Smith, H.-S. Kang, C. Hu, and J. Lamkin, 2020: In situ measurements of circulation features influencing cross-shelf transport around northwest Cuba. *Journal of Geophysical Research: Oceans*, e2019JC015780, https://doi.org/10.1029/2019JC015780.

Androulidakis, Y., V. Kourafalou, M. Le Hénaff, H. Kang, and N. Ntaganou, 2021: The role of mesoscale dynamics over northwestern Cuba in the Loop Current evolution in 2010, during the Deepwater Horizon Incident. *Journal of Marine Science and Engineering*, 9(2):188, https://doi.org/10.3390/jmse9020188.

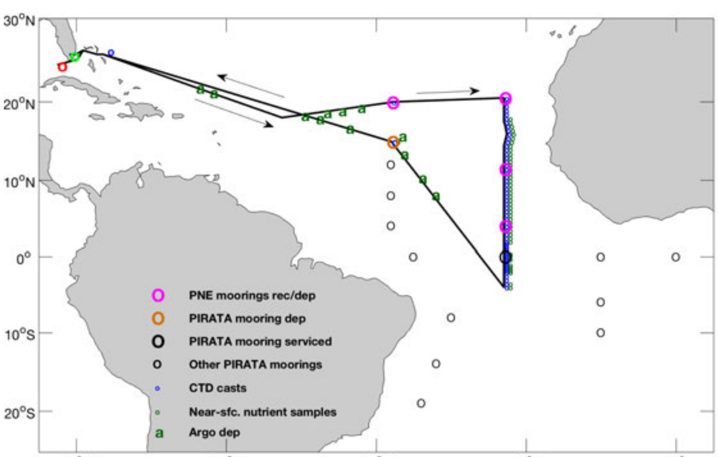
PIRATA Cruise Continues Tropical Atlantic Ocean-Atmosphere Monitoring, Provides Long-Awaited Refresh of Moorings

AOML and University of Miami-Cooperative Institute researchers departed Miami Beach, Florida on January 15 for the PIRATA (Prediction and Research moored Array in the Tropical Atlantic) Northeast Extension (PNE) cruise. The effort aboard the NOAA ship *Ronald H. Brown* was led AOML oceanographer Greg Foltz, PhD, as Chief Scientist. Diego Ugaz, an AOML-Cooperative Institute technician, served as the Night Watch Leader. The successful cruise ended on February 24 with the *Brown's* arrival in Key West, Florida.

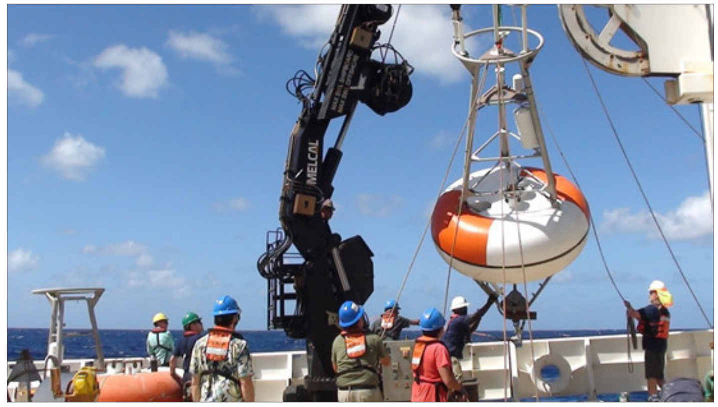
PIRATA consists of 18 open-ocean moorings and is a collaborative effort between Brazil, France, and the United States to study and improve predictability of ocean-atmosphere interactions that affect regional weather and climate variability on seasonal, interannual, and longer time scales. PNE is part of the US contribution to PIRATA and is a joint effort between NOAA's Pacific Marine Environmental Laboratory (PMEL) and AOML, funded through the Global Ocean Monitoring and Observation program.

During the 41-day cruise, four PNE buoys and one Brazilian PIRATA mooring were replaced, and one French mooring was serviced (see map below). This was by far the longest and most remote cruise on a NOAA ship since the NOAA fleet was called home due to the COVID-19 pandemic. The four PNE moorings were scheduled for replacement in May-June 2020, but that cruise was canceled because of COVID-19. As a result, by the start of the cruise in January 2021 the moorings had been in the water for 21-23 months, far beyond their expected lifetimes of 12-14 months, and in desperate need of replacement. On the return transit to Key West, an additional PIRATA mooring in the central tropical North Atlantic was deployed. The previous mooring at this site had been deployed by the Brazilians in late 2018 and had since become unmoored and lost data transmission. The combination of COVID-19, an ocean oil spill, and ship mechanical issues had prevented Brazil from replacing the buoy as originally planned.

Sixty-one CTD profiles of the water column, from the ocean surface to 1500 m depth, were conducted along the ship's track to gather temperature, salinity, dissolved oxygen, seawater pressure and density, and velocity data. Twelve Argo floats were also deployed. Additionally, a group from Virginia Union University measured vertically-integrated atmospheric aerosol loads and



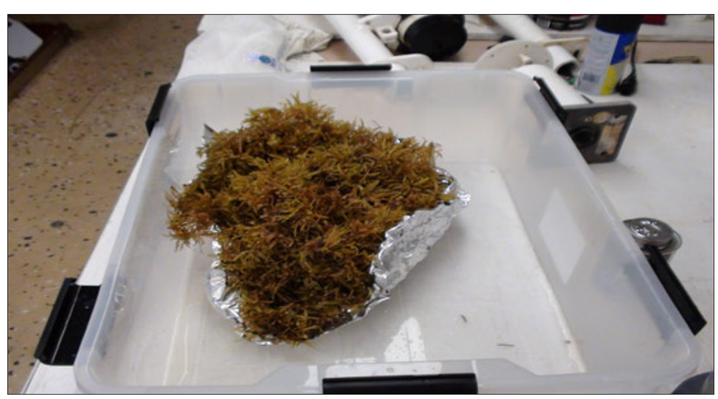
PNE cruise track with starting port (green circle) and end port (red circle). Symbols show locations of moorings that were recovered, deployed, and serviced, ocean profiles from CTD casts, nutrient samples, and Argo deployments.



The *Brown's* deck crew, PMEL's mooring technicians, and AOML volunteers deploy a PIRATA buoy at 15°N, 38°W.

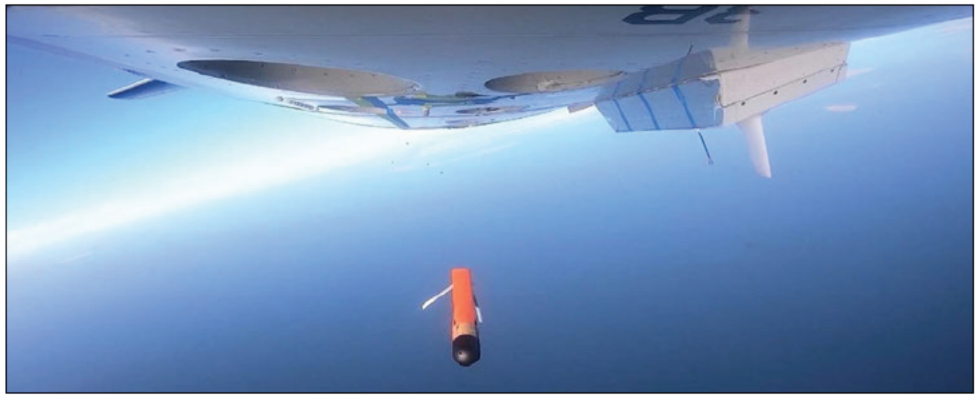
near-surface concentrations of carbon monoxide, sulfate, and ozone throughout the cruise. The data are in support of AEROSE (Aerosols and Ocean Science Expeditions), which has participated in PNE cruises since 2006 and also involves researchers from NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), Howard University, and Arizona State University. AEROSE measurements monitor African dust and smoke emission/transport and their impacts on the environment and provide crucial in-situ calibration and validation of satellite data.

A new addition to the PNE cruise this year was the Fearless Fund, a nonprofit organization supported by the US Department of Energy, in conjunction with NOAA, to produce macroalgae at an energy (or carbon dioxide removal) scale. The group joined the cruise to better understand the production system of the macroalgae Sargassum, which has been expanding farther into the tropical Atlantic since 2011. The Sargassum team worked with AOML to obtain more than 300 near-surface water samples that will be analyzed for phosphate and nitrate by AOML's Ocean Chemistry and Ecosystems Division. The goal is to improve understanding of the sources of nutrients for Sargassum production in the tropical Atlantic. The Sargassum group, in collaboration with AOML and PMEL, also performed a CO_2 sequestration test, which involved sinking Sargassum biomass to the deep sea (see image below). The Sargassum will be retrieved during next year's PNE cruise to assess its decay rate and potential for CO_2 sequestration. AOML, PMEL, AEROSE, and Fearless Fund look forward to continuing their joint efforts during the 2022 PNE cruise.



Sargassum was sealed in a container and sent to the bottom of the ocean for a CO_2 sequestration experiment.

Drones that Hunt Hurricanes? NOAA Puts Some to the Test



An Altius-600 uncrewed aircraft is launched from one of NOAA's P-3 Hurricane Hunter planes. The diminutive drone—only 40 inches in length and weighing 25 pounds—has a cruising range of up to 4 hours.

NOAA scientists launched a new uncrewed small aircraft—a research drone—from a NOAA Hurricane Hunter plane in the clear skies over Maryland during the week of January 11 to test its ability to gather weather data that could improve hurricane forecasts.

"We're hopeful this new technology, once it can be successfully tested in a hurricane environment, will improve our understanding of the boundary layer to advance NOAA's forecast models used to predict the track and intensity of tropical cyclones," said Joseph Cione, PhD, an AOML meteorologist. "Ultimately, these new observations could help emergency managers make informed decisions on evacuations before tropical cyclones make landfall."

NOAA Corps pilots routinely fly the agency's two P-3 Orion Hurricane Hunter aircraft into the eye of tropical cyclones to gather vital weather data. But they avoid the perilous lower eyewall in the boundary layer where the ocean meets the atmosphere. This violent area of high winds and towering ocean waves is of key interest to scientists, but it's too dangerous for piloted aircraft.

Instead, scientists aboard the Hurricane Hunters release sensors tethered to parachutes, known as dropsondes, that gather data as they fall to the ocean, recording wind speed and direction, temperature, moisture, and pressure as they go.

"Dropsondes give us 'snapshots' of weather conditions, while the continuous flow of data collected by uncrewed aircraft provide something closer to a movie," said Cione, who conducted the drone test missions at Patuxent River Naval Air Station. "Deploying uncrewed aircraft from NOAA Hurricane Hunters will ultimately help us better detect changes in hurricane intensity and overall structure."

NOAA worked closely with Area-I, the Georgia-based aerospace company that created the Altius-600 drone, to adapt it for sampling weather data. The drone offers new data-gathering features such as the ability to fly for up to 4 hours and at distances of up to 265 miles from its point of launch. Like dropsondes, however, they cannot be recovered once deployed.

NOAA Corps test pilots and NOAA engineers also coordinated closely with the Naval Air Station Patuxent River's Atlantic Test Range and the Navy's unmanned aircraft test squadron UX-24 to successfully execute the test flights, which are required to certify the Altius-600 for operational use in hurricane conditions.

This article is modified from an online version published at www.noaa.gov

AOML Mourns the Loss of Robert Kohler

"Constant, kind, and always willing to help." Peter Black

Robert (Bob) Kohler, the director of Computer Networks and Services (CNS) at AOML, died on Sunday, February 7, 2021, after a brief battle with colo-rectal cancer. He was 76 years old. Bob led the CNS group for more than 20 years, supervising a staff of seven IT specialists.

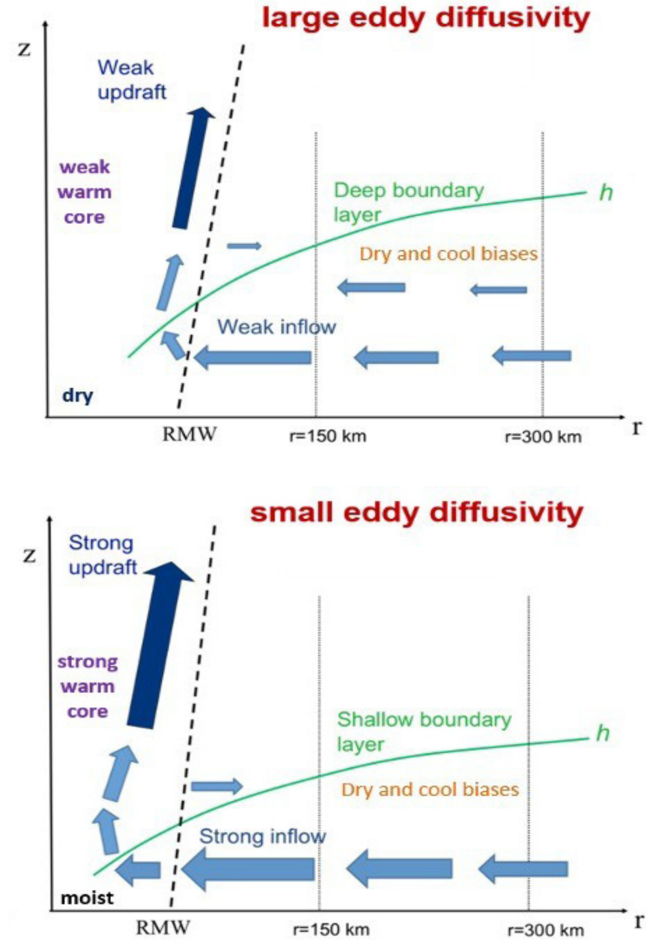
He began his federal career in 1967 with the US Coast and Geodetic Survey (USCGS), spending time at sea documenting magnetic and tectonic trends and digitizing nautical charts. In 1970 he was sent to Byrd Station in west Antarctica where he spent 13 months conducting magnetic and seismic ground surveys. Kohler Dome in Antarctica is named in his honor for the work he performed there. For his numerous contributions while with the USCGS, Bob was made a Fellow of the American Congress of Surveying and Mapping/American Association for Geodetic Surveying.

His career switched gears in 1981 when Bob joined AOML's Hurricane Research Division as a computer programmer analyst. Over the ensuing years he supported tropical cyclone research, even participating in missions aboard NOAA's Hurricane Hunter P-3 aircraft to provide software support and to plot/process data obtained in flight. He was selected to lead CNS in 1999.

Frank Marks, director of the Hurricane Research Division, recalled that "Bob had a wealth of knowledge and experience that made him an invaluable asset. He brought those same values and strengths to his expanded role in leading CNS through a number of transitions. Bob understood the scientific process and the role IT played in fostering that process."

AOML hosted a memorial service for Bob on March 10, 2021 at Tropical Park in Miami. The event brought together friends, family, and staff, virtually and in person, to commemorate Bob's life and his many years of service at AOML. Bob's federal career with the US Coast and Geodetic Survey and with NOAA spanned 54 years, making him one of AOML's longest-serving federal employees. He is survived by Nancy Marshall, his wife of 43 years.

Study Examines how Different Techniques to Model the Hurricane Boundary Layer Can Improve Forecasts



Two images that show hurricane structure differences in the region closest to the storm center due to changes in the vertical eddy diffusivity. RMW represents the radius of maximum wind speed, or the eyewall. Light blue arrows show radial flow, while dark blue arrows show updrafts and convection. The region below the green line is the boundary layer. When eddy diffusivity is small, both the strongest winds and thunderstorms tend to be located closer to the storm center.

In a recent study published in the journal *Atmosphere*,* hurricane scientists at AOML examined how turbulent mixing in the boundary layer affects the intensity and structure of hurricanes in NOAA's Hurricane Weather Research and Forecasting (HWRF) model. They found that turbulent mixing affects where thunderstorms in hurricanes occur and how fast air flows towards the center of a storm.

Knowing what is happening in the atmosphere immediately above the ocean, an area called the boundary layer, is vital for predicting hurricane intensity. While hurricanes can measure hundreds of miles across, the strongest winds usually occur in gusts smaller than 100 yards across, what is known as the turbulent scale. The swirling flow associated with this small area is called turbulent mixing, which is especially important in the boundary layer, as it can transport heat and moisture from the ocean below to the storm above.

However, turbulent-scale features are too small for HWRF and other models to capture; instead, scientists use parameterization to estimate the strength of turbulent mixing. Parameterization is a method used to represent the small-scale processes that can't be resolved by models. This study reviewed the impact of planetary boundary layer parameterization schemes that have been used in the operational version of HWRF since 2011.

"The horizontal grid spacing of a hurricane forecast model is usually larger than 1 km, but the scales of turbulent eddies can be as small as 10 m," said Jun Zhang, PhD, a Cooperative Institute hurricane scientist at AOML.

In this study, the HWRF model was run multiple times using five types of parameterization to determine which forecasts were closest to the observations obtained from NOAA's Hurricane Hunter aircraft. Scientists then looked at how and why different boundary layer parameterization schemes produced different forecasts in the HWRF model.

Turbulent mixing is controlled by a parameter called the vertical eddy diffusivity. According to Zhang, the vertical eddy diffusivity is a parameter in the forecast model that describes the strength of vertical mixing by the small-scale rotating flow in the atmosphere. "This study shows the tremendous value in using observations from the unique platform of Hurricane Hunter aircraft to improve the representation of fundamental physical processes in hurricane models," said AOML meteorologist and study coauthor Robert Rogers.

"This parameter is very important for hurricane intensity forecasts," said Zhang. When vertical eddy diffusivity is large, more turbulent mixing occurs. When it is small, less turbulent mixing occurs, and the strongest winds in the model are closer to the center of the storm.

Scientists also determined that turbulent mixing affects where thunderstorms are located in hurricanes. When vertical eddy diffusivity is small, the strongest thunderstorms in a hurricane tend to be located closer to the center of the storm and farther inside the eyewall where the fastest winds occur.

Turbulent mixing can also impact how fast air flows towards the center of a hurricane near the ocean surface, otherwise known as the radial flow, as well as the height of the boundary layer. This inflow feeds energy from the ocean into the hurricane's core. When the vertical eddy diffusivity is small, the radial inflow is strong, and the boundary layer is shallow.

These findings emphasize the importance of model physics on hurricane intensity and structure forecasts and will guide model developers to further improve hurricane forecast models. Such improvements have the potential to save lives, reduce property damage, and increase the public's confidence in NOAA's official hurricane forecasts and warnings.

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*Zhang, J.A., E.A. Kalina, M.K. Biswas, R.F. Rogers, P. Zhu, and F.D. Marks, 2020: A review and evaluation of planetary boundary layer parameterizations in Hurricane Weather Research and Forecasting model using idealized simulations and observations. *Atmosphere*, 11(10):1091, https://doi.org/10.3390/atmos11101091.

Scientists at AOML Facilitate Leap in Hurricane Modeling and Prediction Systems

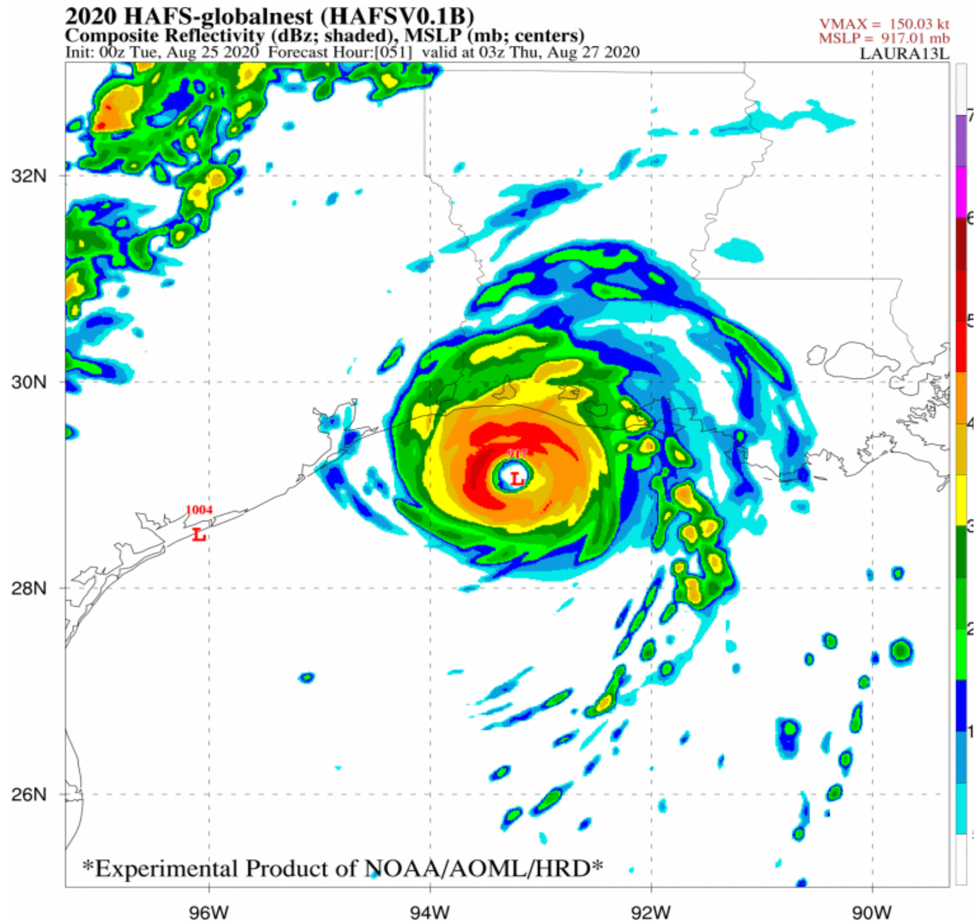
Scientists at AOML have created a new, advanced moving nest model within the Unified Forecast System, the bedrock of NOAA's weather prediction applications. AOML's Hurricane Modeling Group developed the high resolution model for the FV3 dynamical core, laying the foundation for the next generation of advancements in hurricane forecasting.

The Hurricane Analysis and Forecast System (HAFS) is NOAA's next-generation numerical model and data assimilation system, which is being developed within the framework of the Unified Forecast System. Central to the improvement of HAFS has been the goal of adding an embedded moving nest to the FV3 dynamical core, enabling scientists to track the inner core region of tropical cyclones at 1-2 km resolution.

"The creation of the moving nest model capability is a key milestone in the development of the next generation Hurricane Analysis and Forecast System," said Frank Marks, PhD, the director of hurricane research at AOML.

Scientists at AOML partnered with colleagues at NOAA's Environmental Modeling Center and NOAA's Geophysical Fluid Dynamics Laboratory during the overactive 2020 Atlantic hurricane season to test and evaluate the HAFS in real-time. Two models were configured within the framework of the 2020 Hurricane Forecast Improvement Project for testing purposes.

The first model was a version of HAFS with a high resolution static nest embedded within a global domain. The second model was a version of the Hurricane Weather Research and Forecasting (HWRF) system with multiple storm-following nests that allow hurricane forecasters to simultaneously track multiple tropical cyclones.



Hurricane Laura (2020) as depicted by the Hurricane Forecast and Analysis System (HAFS) model prior to landfall along the Louisiana coast as a powerful Category-4 hurricane. HAFS accurately predicted Laura's track, structure, and intensity.

The HWRF model has demonstrated a remarkable improvement as a result of the Hurricane Forecast Improvement Project, which aims to reduce errors in hurricane track, intensity, and storm surge forecasts. Since the project began in 2009, HWRF track errors have been reduced by about 30% and intensity forecast errors by about 25%. The HWRF model has additionally demonstrated a near 10% improvement in hurricane intensity forecast accuracy annually since 2011.

After cutting a path of destruction across the Caribbean, Hurricane Laura came ashore in Cameron, Louisiana on August 27, 2020 with 150 mph sustained winds and a 15-foot storm surge.

"We are now developing a system that will surpass the HWRF system," said lead scientist for the Hurricane Modeling Group and chief architect of the HWRF model, Sundararaman Gopalakrishnan, PhD. "We're moving from one generation to the next."

The advancements in these models will improve forecasting skill by increasing the accuracy of NOAA's extended forecasts and the extent of evacuation areas, especially on 5-7 day timescales, well before tropical cyclones make landfall. This research transition will greatly benefit emergency managers by providing information that will improve the quality of their planning efforts, ultimately saving lives and reducing property damages.

Researchers Solve an eDNA Mystery

AOML Cooperative Institute Associate Research Professor Luke Thompson and Cooperative Institute Post-Doctoral Associate Sean Anderson have been analyzing seawater at the University of Miami dock across the street from AOML for the environmental DNA left behind by fish. While many of the fish species detected were expected for the area, a few unexpected species such as rainbow trout, a native of the North Pacific Ocean, came as quite a surprise. To help solve this mystery, surveys were sent to fish biologists with expertise of the South Florida region. More than 20 survey responses from expert "a-fish-ionados" shared their knowledge, and based on this expert feedback and Luke and Sean's research, 31 of the top 40 most abundant fish sequences could be accounted for as native to South Florida waters at the genus level or lowest assigned level.

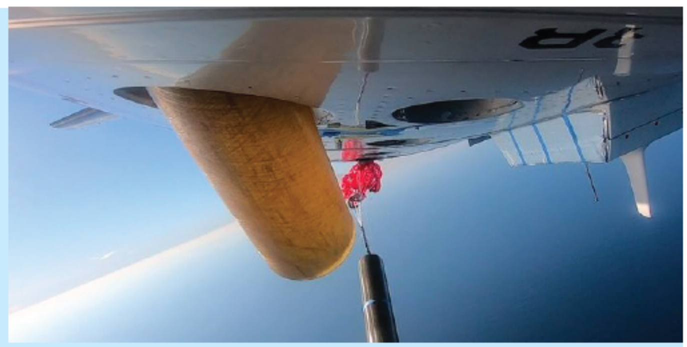
For non-native sequences, including the abundant sequence assigned as *Oncorhynchus mykiss* (rainbow trout), many respondents surmised its DNA could be from fish parts being dumped nearby, with several mentioning the Miami Seaquarium next door to the University of Miami. It was subsequently confirmed by the curator of the Seaquarium that leftover parts from three feed fishes—*Oncorhynchus mykiss*, *Clupea harengus* (herring), and members of *Osmeridae* (capelins and smelts)—were dumped nightly into the water, which were among the most abundant sequences observed, respectively. Two other non-native sequences, assigned to *Ammodytes* spp. (sand lance), may derive from common bait fish associated with fishing activities around Bear Cut on Virginia Key. Mystery solved...case closed!

Sean Anderson at the University of Miami dock.

New Hurricane Ocean Profilers Tested Ahead of Deployment during 2021 Hurricane Season

AOML partnered with NOAA's Aircraft Operations Center in January 2021 to complete testing of the Air-Launched Autonomous Micro-Observer (ALAMO) profiling float. This testing cleared the ALAMO float for deployment from NOAA's P-3 Hurricane Hunter aircraft, marking the first time the floats will be used during hurricane reconnaissance missions.

Because the ocean plays a critical role in fueling hurricanes, a better understanding is needed of how ocean conditions impact hurricane intensity. The most direct way to reduce this uncertainty is to gather targeted upper-ocean measurements before and during the passage of tropical cyclones.



An ALAMO profiling float is deployed from a NOAA P-3 Hurricane Hunter aircraft.

Once deployed, ALAMO profiling floats measure temperature, salinity, and pressure in the upper 300 m of the ocean, generating profiles every 1-2 hours for several weeks. The data are automatically processed and posted to the Global Telecommunication System for use by the operational community to improve the ocean's representation in ocean-atmosphere coupled forecast models. By deploying these uncrewed systems, AOML scientists will gain insight into how the ocean drives hurricanes, targeting storms that threaten landfall in regions with strong salinity or shallow temperature stratifications. These data can then be used in hurricane research models to reduce intensity forecast error.

AOML Brings New Technology to Fishery Surveys

Cooperative Institute Postdoctoral Associate Sean Anderson participated in a NOAA Fisheries cruise aboard the NOAA Ship *Pisces* from March to May to improve ecosystem-based fisheries management through the use of environmental DNA (eDNA) sequencing. Camera traps were placed on the seafloor in the Gulf of Mexico to capture video of passing fish, while bottles collected seawater from areas where the fish passed through, leaving behind traces of their DNA. The seawater was subsequently filtered, with DNA extracted, sequenced, and analyzed. This new technology will help increase the understanding of how eDNA detection of fishery species correlates with direct measurements of these species by camera traps. It will also help improve the understanding of fish distributions in the Gulf of Mexico and enhance understanding through the modeling of these distributions. The survey was conducted in support of the Southeast Area Monitoring and Assessment Program (SEAMAP), a state-federal-university program that collects, manages, and disseminates fishery-independent data and information in the southeastern US. SEAMAP is jointly led by AOML, NOAA's Southeast Fisheries Science Center, and the Universtiy of West Florida.

Sean Anderson processes samples for eDNA aboard the NOAA Ship *Pisces*.

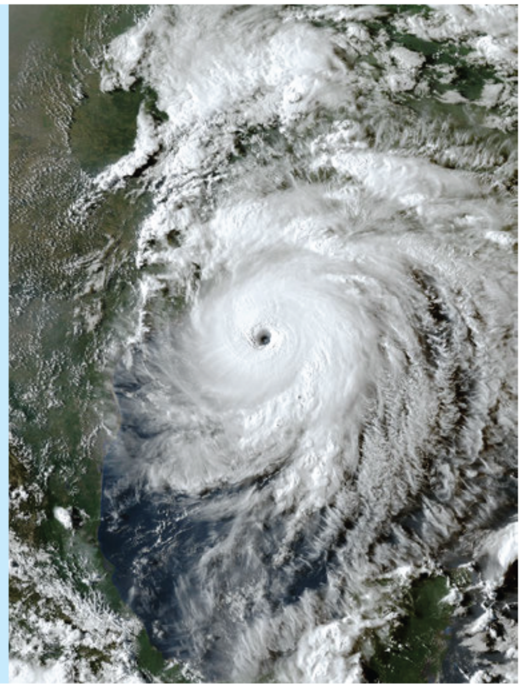
Virtual Meetings Focus on Collaboration with Partners, Next Steps

AOML leaders and principal investigators helped organize and participate in three science workshops in January and February, capitalizing on the virtual environment to identify areas for collaborative research with partners and exploring next steps.

January 26-28: AOML collaborated with NOAA's Global Ocean Monitoring and Observing Program and the US Integrated Ocean Observing System to host the *Integrating Ocean Observations to Improve Hurricane Intensity Forecasts Workshop*. The 3-day event brought together federal and academic partners to focus on upper ocean/air-sea boundary layer observing, analysis, and modeling efforts in support of hurricane intensity science and forecasting.

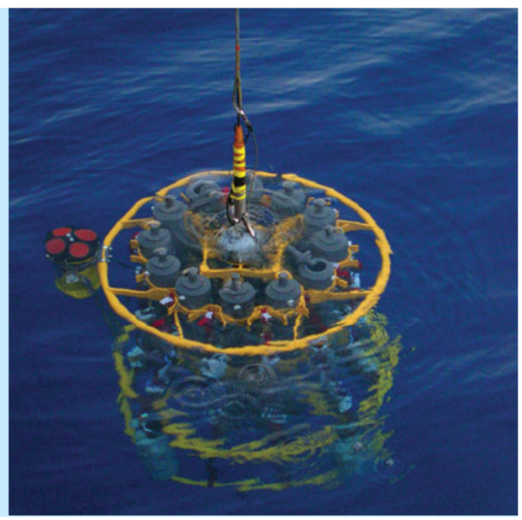
Participants were tasked with addressing how NOAA could improve the integration, coordination, and communication of its ocean observing and modeling activities as they relate to forecasting hurricane intensity. Presentations and discussions explored how to improve the state of NOAA's hurricane intensity forecasting system, as well as how to best close gaps in NOAA's observational efforts of the upper ocean and air-sea boundary layer based on current and future observing capabilities.

The workshop was well attended, with more than 100 participants daily from NOAA's National Weather Service, Office of Marine and Aviation Operations, and Office of Oceanic and Atmospheric Research. External partners, included, among others, Rutgers University, the US Navy, University of Washington, and Naval Research Laboratory.



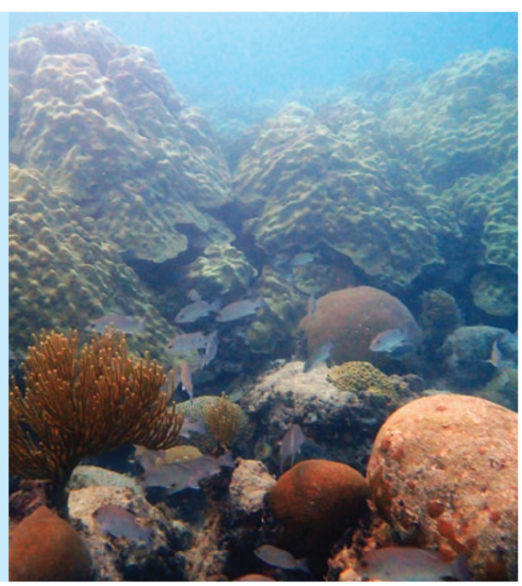
February 2: AOML scientists joined colleagues with NOAA's Center for Satellite Applications and Research (STAR) for a 1-day workshop to share research priorities, goals, and objectives. Leaders and principal investigators from AOML and STAR jointly discussed how to enhance their current collaborations and develop new opportunities for future collaboration.

The workshop featured three breakout sessions focused on hurricane research, physical oceanography, and ocean chemistry/ecosystems. Each session featured presentations by STAR and AOML scientists, followed by a discussion to identify research areas of interest and potential synergy. For example, during the ocean chemistry/ecosystems session, participants noted that ecological forecasting and ocean heat content were two areas for mutually beneficial research. A findings report is being generated with potential actions, while a "roadmap" is being developed to serve as a platform for successful interactions and collaborations in the future.



February 23-25: The National Centers for Coastal Ocean Science (NCCOS) of NOAA's National Ocean Service and AOML hosted a joint workshop to increase awareness and knowledge of NCCOS and AOML activities, as well as identify opportunities for future collaboration and next steps. Following introductory comments and background information by NCCOS Director Dr. Steve Thur and AOML Director Dr. John Cortinas, participants attended 2-hour breakout sessions.

Over the span of 3 days and nine sessions, principal investigators from both institutions gave presentations on a wide range of research topics, including coral reef research, harmful algal blooms-hypoxia-pathogens, integrated ecosystem assessment and ecosystem restoration, pollution, edna and 'omics, climate and extreme weather, ocean acidification impacts on coastal ecosystems, uncrewed systems, advanced sampling technologies, physical modeling, and ecosystem modeling/forecasting. Discussions folllowed every session to explore areas for collaborative research, current capabilities, resources, funding, and next steps. In total, more than 70 NCCOS and AOML principal investigators participated.



Spotlight On!

AOML is pleased for two of its scientists to have been recently recognized for their accomplishments: Oceanographer Evan Forde was highlighted by the Department of Commerce in honor of Black History Month, while oceanographer Renellys Perez was highlighted by NOAA's Office of Oceanic and Atmospheric Research in honor of Women's History Month. Here are their stories:

I grew up in Miami, Florida, and attended Miami-Dade County public schools. I earned a bachelor's degree in Geology (with an oceanography specialty) and a master's degree in Marine Geology and Geophysics from Columbia University in New York City. I am proud of a 46-year career as a federal employee, working hard as a career civil servant on behalf of the American people each day. To me, the phrase "good enough for government work" challenges me to do my job even better and more than anyone could reasonably expect.

I would tell youth interested in a government career that federal employment is rewarding and has many benefits. Employment in the federal government is protected by laws that uphold workers' rights and promote fairness. I have never served my country in our military, but I often remind myself that each workday I am serving my fellow citizens, and that always brings a smile to my face.

In my personal time, I strive to foster youth development and improve my community. I have served as a PTA president, a scoutmaster, youth basketball coach, Sunday school and youth church teacher, church webmaster, neighborhood Crime Watch chairman, HOA vice president, board of directors member for a Boys and Girls Club, and in numerous other roles that have strengthened my community and me as a person.

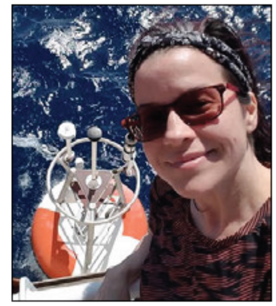
My father was my greatest mentor. When I was troubled or struggling in life, my dad would sometimes remind me of this quote from the poem "If" by Rudyard Kipling:

> *"If you can fill the unforgiving minute*
> *With sixty seconds' worth of distance run,*
> *Yours is the Earth and everything that's in it,*
> *And—which is more—you'll be a man, my son!"*

This quote always makes me want to do my very best and give all I've got to every challenge. As I reflect during Black History Month, I am more aware of black Americans' substantial contributions to our country and to mankind. This enhanced awareness not only helps to create a sense of pride in me but also inspires me to be an inspiration to others.

Evan Forde is an oceanographer with AOML's Computer Networks and Services group. His work is currently focused on several areas of scientific research, including the analysis of satellite sensor data and identification of critical atmospheric conditions related to hurricane formation and intensification. A portion of Evan's work responsibilities also involves assisting the AOML computer systems administrator with networked computing risk assessment and threat mitigation. Evan additionally creates contingency plans and training exercises to ensure the resiliency of AOML's essential computing elements.

Note: Evan's guest blog post of February 22 was part of the *Spotlight on Commerce* series highlighting the contributions of Department of Commerce African Americans during Black History Month.



What drew you to your current career? My love of math and physics, fondness for the ocean, and desire to study observable phenomena (even if you need a satellite to observe it).

What is your typical day at NOAA like, and how has the pandemic changed your typical work day? A typical day involves attending meetings, working on new research ideas, mentoring the early career scientists I work with, exchanging ideas with colleagues, answering emails, and planning for future research cruises. The pandemic has removed the face-to-face interactions but has given me opportunities to virtually participate in meetings and workshops I wouldn't normally be able to attend. Planning future research missions 6 months to a year in advance involves a lot of moving parts, and planning cruises during the pandemic adds more complexity and uncertainty.

What do you hope to accomplish in the future? What do you hope the future for women in science looks like? My hope for the future is that our NOAA workforce looks like our country, and that underrepresented groups in science and leadership no longer lack sufficient representation.

Have any opportunities opened up by the change to virtual-only work? Yes, I have participated in NOAA mentoring, virtual NOAA leadership training courses, and the Latinos@NOAA Employee Resource Group. I probably wouldn't have participated in some of these activities prior to teleworking. I sought out these opportunities to feel more connected to NOAA while teleworking. I have enjoyed [redacted] organizing conferences that are 100 percent virtual to continue doing science during this time, and participating in virtual outreach for K-12 students.

Has your idea or definition of success changed in the past year? I have a kinder definition of success that I learned from parenting during the pandemic: am I learning, am I growing, am I showing up, am I doing my best in this challenging time?

What gives you hope, either with regard to science, your field in NOAA, or in general? My colleagues were able to complete a 40-day research cruise on the NOAA Ship *Ronald H. Brown* in January-February safely and successfully thanks to shelter-in-place protocols. As more and more of us get vaccinated, I am hopeful that it will become easier to achieve those aspects of our NOAA mission that the pandemic has made challenging.

Dr. Renellys Perez is an oceanographer who co-leads AOML's contribution to the Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) Northeast Extension project and leads the Southwest Atlantic Meridional Overturning Circulation (SAM) project, both funded by NOAA's Global Ocean Monitoring and Observing Program.

Note: The complete profile for Renellys can be found online at https://research.noaa.gov/News/Scientist-Profile.

Welcome Aboard

Dr. Heidi Hirsh joined AOML's Ocean Chemistry and Ecosystems Division in January as a University of Miami-Cooperative Institute post-doctoral researcher. Heidi is working with Dr. Ian Enochs and other NOAA principal investigators in Miami and Honolulu to complete a synthesis of the National Coral Reef Monitoring Program's carbonate chemistry observations from coral reefs in the Central Pacific and Atlantic/Caribbean regions. She will use these observations to build statistical models that link offshore data with nearshore reef carbonate chemistry, facilitating better forecasts of future ocean acidification conditions on coral reefs. Heidi recently earned a PhD in Earth System Science from Stanford University.

Dr. HeeSook Kang joined AOML's Physical Oceanography Division in January as a University of Miami-Cooperative Institute senior research associate. HeeSook joins the Ocean Modeling team to contribute to an assessment of the impacts of ocean observations primarily in regard to hurricane forecast applications. She previously completed a 3-year post-doctoral appointment with the Physical Oceanography Division in 2006 where she worked to improve how data were assimilated into the HYbrid Coordinate Ocean Model (HYCOM). HeeSook holds a PhD in Physical Oceanography from the University of Miami's Rosenstiel School.

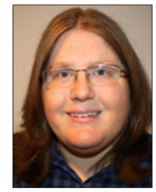
Emily Milton joined AOML's Ocean Chemistry and Ecosystems Division in February as a University of Miami-Cooperative Institute research associate. Emily will work with Kelly Montenero, Chris Kelble, and the Integrated Ecosystem Assessment team to assess the role of watershed processes on coastal water quality in south Florida by using water quality data to identify spatial and temporal hot spots and changing patterns. She will also support fieldwork in Florida Bay and participate in bimonthly research cruises for AOML's ongoing South Florida Project. Emily is a recent graduate of the University of Miami's Rosenstiel School with an MS degree in Marine Biology and Ecology.

Dr. Kandaga Pujiana joined AOML's Physical Oceanography Division in January as a University of Miami-Cooperative Institute assistant scientist. Kandaga's research at AOML will focus primarily on studying the role of the North Atlantic's large-scale ocean circulation and its influence on regional weather and climate. He holds a PhD in Ocean and Climate Physics from the Department of Earth and Environmental Sciences at Columbia University.

Dr. Filippos Tagklis joined AOML's Physical Oceanography Division in February as a University of Miami-Cooperative Institute post-doctoral researcher. Filippos will work with Drs. Sang-Ki Lee, Shenfu Dong, and other scientists at AOML to better understand the impact of physical oceanic processes on ocean acidification and ecosystems along the US east coast. He holds a PhD in Chemical and Physical Oceanography from the School of Earth and Atmospheric Sciences at Georgia Institute of Technology.

Farewell

Dr. Levi Cowan, a University of Miami-Cooperative Institute post-doctoral scientist with AOML's Hurricane Research Division, resigned in February. Levi has accepted a federal position as a meteorologist forecaster with the Joint Typhoon Warning Center in Pearl Harbor, Hawaii. During his year at AOML, Levi worked with the Modeling Group on the development and analysis of NOAA's Hurricane Analysis and Forecast System, as well as the Advanced Weather Interaction Processing System.



Elizabeth Ehrbar, a University of Miami-Cooperative Institute information technology programmer with AOML's Hurricane Research Division, resigned in January. Elizabeth has accepted a federal position as a meteorologist with the Ocean Prediction Center at the National Centers for Environmental Prediction in College Park, Maryland. During Elizabeth's 4 years at AOML, she performed data backups, upgrades of software, and wrote computer scripts.

Nancy Griffin, an information technology specialist/data manager with AOML's Hurricane Research Division, retired in March after 40 years of federal service. Nancy began her federal career at AOML in 1980. At the time, airborne Doppler radar was a new technology being introduced aboard NOAA's P-3 Hurricane Hunter aircraft. Nancy participated in the testing cycles for the first prototype instruments and wrote some of the computer code that processed, quality controlled, and graphically displayed the raw data they collected. Over the years, Nancy continued to quality control airborne Doppler radar data, refine airborne radar software, and make radar products more useful to scientists and the tropical cyclone community.

Dr. Derek Manzello, an oceanographer with AOML's Ocean Chemistry and Ecosystems Division, resigned in January. Derek has accepted a position as the Coral Reef Watch Coordinator with the Center for Satellite Applications and Research at NOAA's National Environmental, Satellite, Data Information Service (NESDIS) in College Park, Maryland. During Derek's 20 years at AOML, his research focused on coral reef ecology, particularly how climate change and ocean acidification impact the health and continuity of coral reefs across the Atlantic/Caribbean region and other locales.

Dr. Christopher Meinen, an oceanographer with AOML's Physical Oceanography Division, resigned in February to pursue other opportunities. Chris began at AOML in August 2002 as a University of Miami-Cooperative Institute assistant scientist. He became a federal oceanographer in October 2004. Over the years Chris' research focused on the meridional overturning circulation, warm water volume changes in the equatorial Pacific, the structure and variability of strong ocean currents, how ocean circulation patterns and seafloor temperatures change, and how they relate to the global climate system. Chris also mentored many early career scientists and played a key role in two international field programs to observe the meridional overturning circulation in the North and South Atlantic.

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Keynotes is published quarterly 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., D. Sheinin, B. Thomas, **L. GRAMER**, Z. Zhang, B. Liu, H.-S. Kim, and A. Mehra, 2020: A hydrodynamical atmosphere/ocean coupled modeling system for multiple tropical cyclones. *Atmosphere,* 11(8):869.

Androulidakis, Y., V. Kourafalou, **M. LE HÉNAFF,** H.-S. Kang, N. Ntaganou, and C. Hu, 2020: Gulf Stream evolution through the Straits of Florida: The role of eddies and upwelling near Cuba. *Ocean Dynamics,* 70(8):1005-1032.

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