AOML Keynotes

NOAA'S ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

July-September 2022

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

Cabo Verde Missions Explore Earliest Roots of Atlantic Hurricanes

In This Issue

AOML hurricane scientist Jason Dunion (far right) with the Gulfstream-IV Hurricane Hunter science crew at the Amílcar Cabral International Airport on Sal Island in the eastern Atlantic. Photo credit: NOAA.

Scientists at AOML deployed to the Cabo Verde islands in August to explore how tropical waves that move off the coast of West African develop into tropical storms and hurricanes. These first-ever missions thousands of miles across the Atlantic mark the farthest distance traveled by NOAA's Hurricane Hunters to help forecast models better predict the future track and intensity of developing storms.

The region produces some of the Atlantic's longest lasting, most intense hurricanes. Storms that develop here, known as Cape Verde hurricanes, make up more than half of the named tropical systems that annually form. They also account for more than 80-85% of all major hurricanes, i.e., Category-3 and above, that strike the United States.

Jason Dunion and Jon Zawislak, both University of Miami-Cooperative Institute scientists at AOML and the director/deputy director, respectively, of NOAA's 2022 Hurricane Field Program, worked jointly with colleagues from the National Aeronautics and Space Administration (NASA), Office of Naval Research (ONR), and other NOAA offices to plan the groundbreaking project.

Scientists, engineers, and flight crews deployed to Sal Island in the eastern Atlantic, a journey of more than 3600 miles, in support of NASA's Convective Processes Experiment-Cabo Verde (CPEX-CV), NOAA's Advancing the Prediction of Hurricanes Experiment (APHEX), and ONR's Tropical Cyclone Rapid Intensification (TCRI) experiment.

Zawislak served as the lead project scientist for NASA's concurrent month-long CPEX-CV mission, organizing the science plan, configuring flight crews for an assortment of experiments, and ensuring project objectives were met. (***cont. page 9***)

Hurricane Hunters Take to the Skies as Tropics Heat Up

AOML hurricane scientists Rob Rogers and Trey Alvey review tail Doppler radar data onboard NOAA's P-3 Hurricane Hunter aircraft during a mission into Tropical Storm Fiona on September 17. The observations were analyzed, quality-controlled, and transmitted in-flight to forecast models and hurricane specialists at the National Hurricane Center. Photo credit: NOAA.

AOML's hurricane scientists spent a busy summer onboard NOAA's P-3 and G-IV Hurricane Hunter aircraft flying both operational and research missions into hurricanes Earl, Fiona, and Ian. The observations gathered were ingested into NOAA's cutting-edge models to help prepare communities in the path of severe weather, as well as improve the understanding of how tropical cyclones form, intensify, and dissipate.

Operational missions were tasked by NOAA's Environmental Modeling Center to collect tail Doppler radar (TDR) data and other observations that are critical for track and intensity forecasts. Research missions were conducted in partnership with NOAA and Office of Naval Research (ONR) colleagues.

AOML scientists collect and quality control TDR observations by flying through the dense cumulonimbus clouds that circle the hurricane eye to pinpoint a storm's strongest winds, how far they extend outward, and the regions of heaviest rainfall. Dropsondes released along the flight track measure atmospheric variables on their descent toward the ocean, while observations obtained from the storm periphery are used to identify the steering currents mostly likely to influence where a tropical cyclone will travel.

Missions into Hurricane Earl began on August 28 when the storm was a tropical depression east of the Leeward Islands. Earl provided the opportunity to observe a tropical system as it developed into a hurricane and then dissipated at sea in the North Atlantic.

AOML's hurricane scientists conducted research modules in Earl that supported the early and mature stage science objectives of the Advancing the Prediction of Hurricanes Experiment (APHEX), the main component of NOAA's 2022 Hurricane Field Program. Twenty missions were completed in Earl over 12 consecutive days, marking the longest series of missions into a single tropical system ever conducted by NOAA.

A week later, missions began in Hurricane Fiona on September 17 when Fiona was a tropical storm west of Puerto Rico. Fiona steadily intensified during this first mission, and the National Hurricane Center upgraded the storm to a Category-1 hurricane based on observations from the NOAA P-3 and Air Force C-130 aircraft, as well as the San Juan WSR-88D radar.

TDR and dropsonde observations obtained over a 6-day period captured Fiona's intensification into the first major hurricane of the 2022 season as the storm approached Bermuda with peak winds of 130 mph. Supplemental atmospheric and oceanic data were also collected in the environment of Fiona in collaboration with ONR partners for research purposes.

Missions into Hurricane Ian began on September 23 as the system intensified into a tropical storm while moving through the Caribbean Sea. Subsequent missions documented Ian's growth into a hurricane while passing over the western tip of Cuba, as well as the storm's further intensification into a dangerous major hurricane on its approach toward Florida.

An important and historic first in Ian was the deployment of an Altius-600 uncrewed aircraft system from the P-3 into the eye of Ian. This airborne drone successfully collected observations from the lowest levels of Ian, a region rarely sampled due to the extreme turbulence encountered near the ocean surface.

In total, 15 missions in and around Hurricane Ian were completed before its historic and devastating landfall along Florida's west coast as a borderline Category-5 hurricane with tops winds of 155 mph.

Underwater Gliders Gather Critical Ocean Data

Over the summer, scientists at AOML worked with numerous partners to deploy and remotely pilot underwater gliders in the Caribbean Sea and tropical Atlantic Ocean. The gliders monitored ocean conditions in support of NOAA's Hurricane Field Program in areas where tropical cyclones typically travel, producing thousands of temperature and salinity profiles to depths of 1000 meters. These observations of the upper ocean's thermal structure were transmitted in real-time to the Global Telecommunication System for assimilation into NOAA's operational hurricane forecast models to improve intensity forecasts. The data are also used for research studies to better understand the ocean's role in the formation and intensification of tropical cyclones.

NOAA and Saildrone Launch Hurricane-Tracking Surface Drones

"This season, NOAA will work with numerous partners to gather oceanic and atmospheric observations using a suite of platforms to monitor the conditions that play a role in hurricane intensity changes. Storms that intensify rapidly can cause extensive damage and loss of life. Real-time observing systems are crucial to better understanding the atmospheric and oceanic processes that lead to the formation and intensification of these hurricanes."

John Cortinas, PhD
AOML Director

Saildrone 1032 was launched on August 2, 2022 in the coastal waters of St. Petersburg, Florida for a 3-month mission to track tropical cyclones in the eastern Gulf of Mexico. Photo credit: NOAA.

One of the biggest challenges to hurricane forecasting is predicting rapid intensification, when hurricane wind speeds increase at least 35 mph over a 24-hour period. To fully understand how storms intensify, scientists collect data on the exchange of energy between the ocean and atmosphere in the forms of heat and momentum. However, gathering data in this dangerous environment is best accomplished by uncrewed systems.

To meet this challenge, Saildrone Inc. partnered with AOML and NOAA's Pacific Marine Environmental Laboratory in August to deploy seven ocean drones that collected data from tropical cyclones during the 2022 Atlantic hurricane season.

Five saildrones supported by NOAA's Uncrewed Systems Operations Center and NOAA's Weather Program Office surveyed the western Atlantic Ocean and Caribbean Sea. Another two saildrones supported by NOAA's Global Ocean Monitoring and Observing Program tracked storms in the Gulf of Mexico.

Saildrones are equipped with a special "hurricane wing" that looks like a hard sail to withstand the extreme wind conditions encountered in storms as they gather data from the near-surface ocean and atmosphere in real-time. The data are used to improve the understanding and prediction of tropical cyclone intensity changes and to advance the knowledge of the ocean-atmosphere interactions that fuel them.

This year, five of the saildrones worked with underwater gliders to obtain nearly collocated measurements of the air-sea interface and upper ocean (see information box below). Over the summer, NOAA and partner scientists deployed underwater gliders equipped with sensors that measured temperature and salinity down to a half mile below the ocean surface.

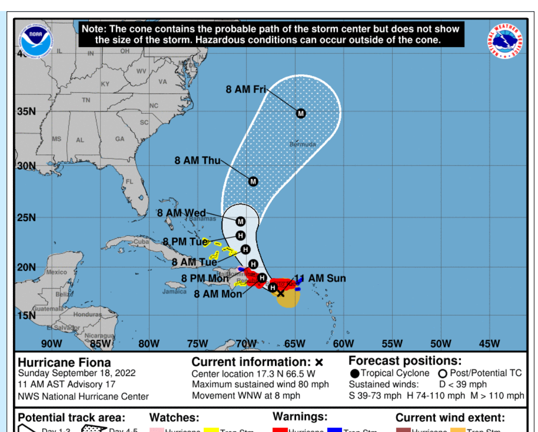
Underwater gliders provide high-volume, high-resolution data in areas where hurricanes frequently travel. Because of the strong interaction between the ocean and atmosphere during a hurricane's passage, better representation of the ocean in weather models has led to more accurate intensity forecasts.

"The air-sea interface is where energy is transferred from the warm ocean to hurricanes, but it's not the whole story," said Greg Foltz, an AOML scientist. "Conditions in the subsurface ocean and lower atmosphere affect the rate of energy transfer and the efficiency with which it can fuel a hurricane's intensification. To understand this flow and exchange of energy, coordinated measurements from multiple ocean-atmosphere observing platforms are needed."

Observations from the saildrones and underwater gliders help forecasters better understand the forces that fuel hurricane development. The data are transmitted and assimilated into forecast models, as well as ingested into the Advanced Weather Interactive Processing System II, a visualization tool, for use by NOAA's National Hurricane Center forecasters and field offices.

Saildrones and Underwater Gliders Monitor Hurricane Fiona

Saildrone SD-1031 collected data along a transect through Hurricane Fiona on September 18 as the storm was southwest of Puerto Rico, measuring peak 1-minute winds of 51 knots and gusts up to 66 knots. The saildrone was directed through the center of Fiona's eye, and its measurements of minimum atmospheric pressure aided National Hurricane Center forecasters in assessing the storm's intensity. Simultaneously, AOML underwater glider SG610 gathered profile observations of temperature and salinity from the ocean surface to depths of 800 meters a few kilometers away. These collocated observations of the air-sea interface and upper ocean provided forecast models with critical data to better predict Fiona's intensity. Saildrone SD-1040 also passed through Fiona's eye on September 18-19 northwest of Puerto Rico, and SD-1078 crossed Fiona's path on September 22 south of Bermuda, measuring maximum 1-minute winds of 68 knots with gusts to 94 knots.



National Hurricane Center projected track of Hurricane Fiona on September 18, 2022.

Uncrewed Aircraft System Completes Trailblazing Mission in Hurricane Ian

An Altius-600 uncrewed aircraft system demonstration model is displayed alongside a Hurricane Hunter P-3 aircraft at NOAA's Aircraft Operations Center in Lakeland, Florida during its second flight test cycle on May 25, 2022. Photo credit: NOAA.

For the first time, an Area-I Altius-600 uncrewed aircraft system (UAS) has been deployed into a hurricane by scientists at AOML while onboard a NOAA P-3 Orion Hurricane Hunter aircraft. Despite extreme turbulence, the 27-pound drone was successfully launched from the P-3 into Category-4 Hurricane Ian during a period of rapid intensification. It completed a 105-minute mission, acquiring critical measurements from the lowest altitudes of Ian to help researchers better understand the complex mechanisms that enable storms to intensify.

The Altius-600 is capable of operating in low- to medium-altitude maritime environments, areas of the storm too dangerous for humans to go, with a flying range of 150 miles while traveling at speeds of up to 100 mph. It features an airframe that can handle considerable damage, with its actions controlled by onboard programming and/or by aircraft-based operators.

Upon release, the uncrewed aircraft deployed its 8-foot wingspan and acquired a center fix on the eye of Ian at 4,500 feet. It then dropped to 3,000 feet within the eye to collect temperature, pressure, and moisture observations.

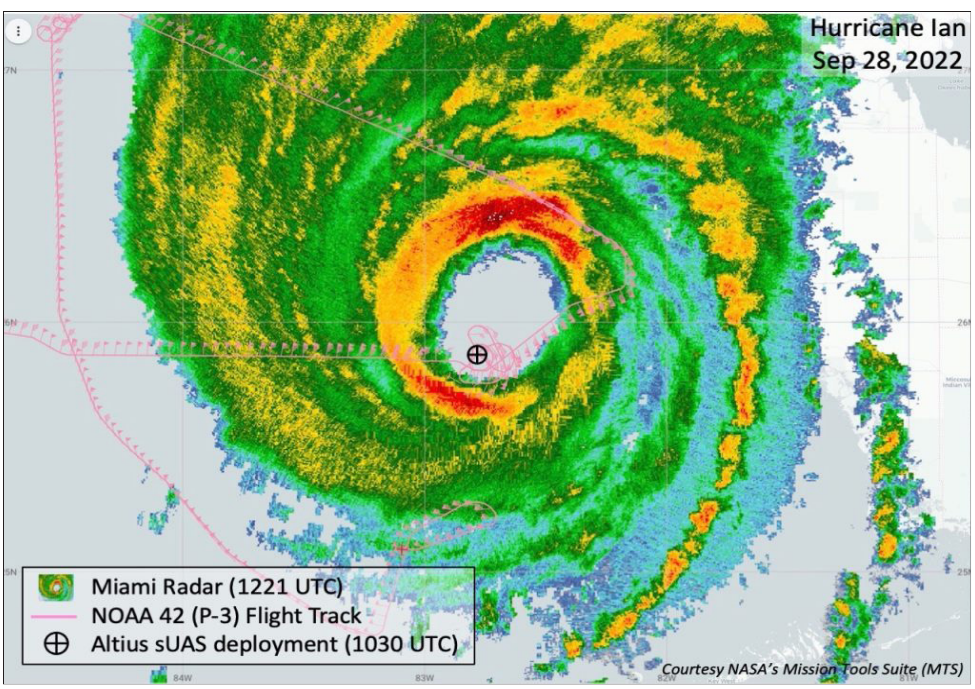
The crew then directed it into the eyewall where it completed a series of circumnavigations at different altitudes. At less than 2,300 feet above the sea surface the UAS recorded winds of more than 187 knots (216 mph) and at one point even descended to as low as 200 feet.

"If Altius survives this, it will survive anything," said Joe Cione, PhD, AOML scientist and NOAA's lead meteorologist for the new technology. "On its first try, Altius did what we hoped it would do: keep humans out of harm's way."

Scientists can only study what can be measured. In extreme environments like hurricanes, they are limited by their ability to safely deploy instruments. Fixed systems, like weather stations and buoys, collect data at ground level. Saildrones and gliders provide tracking data at and below the ocean surface, while Hurricane Hunter aircraft provide a mobile look from the upper levels of the atmosphere. Dropsondes released from aircraft gather high resolution data along a vertical path, and weather balloons provide the same, but rising from below. What drones like the Area-I Altius-600 enable is the ability to dive into the heart of a storm and measure its lower altitudes.

Scientists at the National Hurricane Center, Environmental Modeling Center, and Hurricane Research Division at AOML will use the datasets obtained by Altius-600 uncrewed aircraft to advance understanding of the extremely turbulent hurricane boundary layer environment where the ocean and atmosphere intersect. This ability, coupled with other observing systems, will help clarify how tropical systems function.

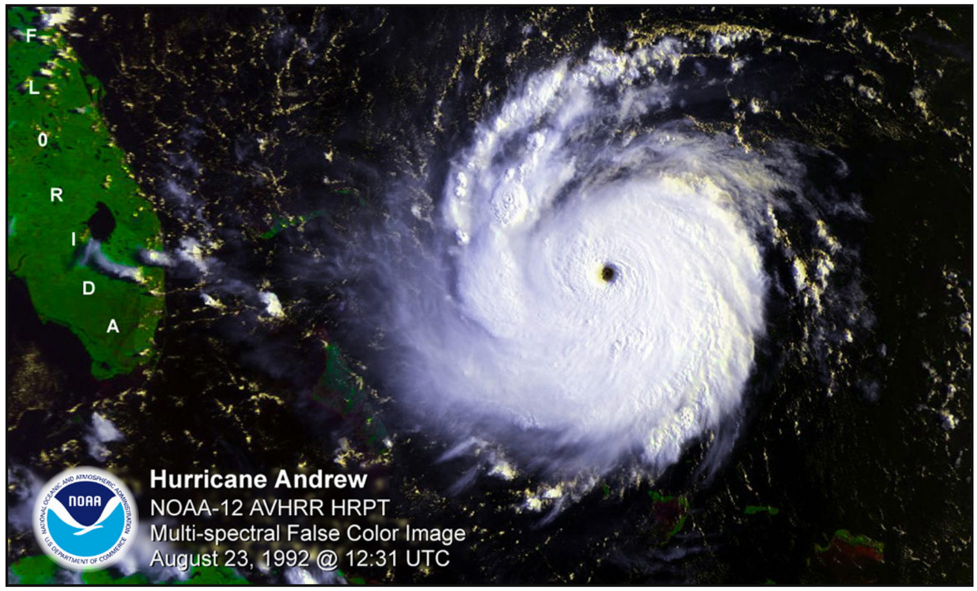
Observations obtained by the Altius-600 will also improve the accuracy of hurricane models through better understanding of a storm's track, intensity, and structure, as well as help NOAA improve the safety of its operations and more precisely target future research. Ultimately, better models provide better analyses to the National Hurricane Center responsible for creating forecasts for the public.



Radar image of Hurricane Ian on September 28 that shows the flight track of NOAA's Hurricane Hunter P-3 aircraft and deployment location of the Altius-600 within Ian's eye. Photo credit: NOAA.

Researchers Mark 30 Years of Progress in Hurricane Forecasting Since Andrew

August 24, 2022 marked the 30th anniversary of Hurricane Andrew's landfall near Homestead, Florida with sustained 165 mph winds, becoming one of the most catastrophic hurricanes in US history. The storm decimated much of southern Miami-Dade County, causing an estimated $50.5 billion in damages (in 2020 dollars). Since 1992, NOAA scientists have revolutionized the field of hurricane forecasting to save lives and property, developing new, more accurate instruments, observing platforms, and models to improve forecasts.



An upper level ridge of high pressure across the eastern US and western Atlantic enabled Andrew to rapidly intensify as the storm was driven westward toward southern Miami-Dade County. Photo credit: NOAA.

When Andrew swept ashore, flying debris destroyed most of the ground-based instruments used for measuring wind intensity, while electric-based instruments failed due to widespread power outages. Of the few instruments that survived, Andrew's powerful winds exceeded their capabilities, exposing the inadequacies of the era's technology.

Andrew was initially classified as a Category-4 hurricane with maximum winds of 145 mph. A re-analysis study conducted in 2002, however, led to Andrew's upgrade to Category-5 status, as hurricane experts determined the storm's surface winds had been 20 mph stronger than originally predicted.

Several hurricane scientists at AOML who lived in South Florida during Andrew's passage still work at the laboratory. Their direct experience of Andrew's destructive power inspired them to apply what they learned and fueled their resolve to better warn the public of the dangers storms like Andrew posed.

Frank Marks, Sc.D., the director of AOML's Hurricane Research Division, was the lead scientist aboard the last NOAA P-3 Hurricane Hunter mission into Andrew on August 22, 1992. "During our flight we found that Andrew had not only reintensified into a hurricane but was also tracking west toward Florida," he recalled. "It was a sobering realization, as it was pretty clear it was going to make landfall in south Florida close to home."

Today, AOML's hurricane scientists rely upon satellite observations and an array of land-based, sea-based, and airborne instruments that provide critical data to forecasters. GPS dropsondes and autonomous instruments like ocean gliders, saildrones, and uncrewed aircraft systems collect high-resolution measurements in the storm environment.

Stepped-frequency microwave radiometers provides estimates of the damaging winds at the surface, while tail Doppler radar pinpoints the regions of strongest wind and heaviest rainfall. High-speed broadband satellite communications transmit these observations in real-time to the National Hurricane Center to keep forecasters updated on the dynamic, changing condition of storms.

AOML hurricane scientist Stanley Goldenberg in the front yard of his home in August 1992 following Hurricane Andrew's south Florida landfall. Photo credit: NOAA.

Key improvements to forecast guidance products include the Statistical Hurricane Intensity Prediction System, Rapid Intensity Index, and Tropical Cyclone Genesis Index. Additionally, NOAA's uses high-resolution, state-of-the-art computer models such as the Hurricane Weather Research and Forecasting (HWRF) and Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic (HMON) modeling systems for hurricane track and intensity guidance.

AOML scientists are currently testing the newest advance in hurricane forecasting, the Hurricane Analysis and Forecast System (HAFS) model. Developed at AOML, HAFS will become operational in 2023. HAFS brings together oceanic and atmospheric observations that enable forecasters to simultaneously observe multiple storms to better understand how they interact.

Andrew's south Florida landfall spurred hurricane scientists to better understand the complex processes that fuel and weaken tropical cyclones and advance the science of hurricane prediction through better observations, high-resolution forecast models, and analyses. In the 30 years since Andrew, track forecasts have improved by 75%, while intensity forecasts are 50% more accurate.

Coral Scientists Rescue Coral Colonies from Collapsed Star Island Seawall

A team of coral researchers from AOML and the University of Miami rescued 43 coral colonies in August after a seawall collapsed at Star Island, near Miami Beach.

The coral rescue effort occurred at one of NOAA's regularly monitored research sites. While conducting a routine survey, scientists from AOML noticed the partially collapsed seawall, which had previously hosted dozens of coral colonies, including the endangered mountainous star coral (*Orbicella faveolata*). The corals directly impacted by the initial wall collapse were crushed, while the surrounding coral colonies were dislodged and covered in silt.

Within days of the collapse, a collaborative, highly-trained rescue team surveyed the surviving corals and recovered them from the remaining portion of the seawall. Among those rescued were endangered species and species susceptible to stony coral tissue loss disease, which has killed millions of coral colonies since appearing in the offshore waters of Miami in 2014.

"It was an unfortunate situation that the wall collapsed and resulted in the loss of so many colonies," said Michael Studivan, PhD, a University of Miami-Cooperative Institute scientist based at AOML who led the rescue effort. "Our actions to save what was left of the corals will support ongoing conservation efforts and showcase the important work that AOML is doing here in Miami."

The rescued corals were brought to the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science for assessment. They will support research and restoration programs at both AOML and the Rosenstiel School, including coral disease experiments, coral spawning, and reef restoration efforts.

Keir Macartney, NOAA-Center for Coastal and Marine Ecosystems/University of Texas post-doctoral fellow at AOML, carefully collects a coral colony from the area of the collapsed seawall. Photo credit: NOAA.

Some of the corals were relocated to AOML's coral urban reef experimental site, a coral nursery at the Port of Miami. These corals can be viewed by a live video stream run by Coral Morphologic, an AOML partner, called the Coral City Camera (see link at bottom right).

Research over the past several years by AOML scientists, including environmental monitoring surveys, biodiversity assessments, and lab-based experimentation, has suggested that corals in the wider Port of Miami area are more resilient than their counterparts at offshore reefs. These "urban corals" often live on artificial substrates such as seawalls and rip-rap that are exposed to extreme swings in temperature, pH, and water quality. It is hypothesized that corals in habitats like the Port of Miami may be better able to survive climate change and could be a source of particularly resilient corals for restoration efforts.

The research teams from both AOML and the University of Miami have permitted coral nurseries and were given special authorization to salvage corals from the site by the Florida Fish and Wildlife Conservation Commission. Both groups are experienced in rapid coral relocation efforts from having previously participated in construction mitigation and coral disease rescue operations at the Port of Miami and in the Florida Keys.

"This was a well-executed collaborative effort on behalf of AOML and the University of Miami," said Ian Enochs, PhD, research ecologist and principal investigator for AOML's Coral Program. "It highlights the critical need for researchers and regulatory partners to create rapid response protocols in the face of a changing climate, coastal development, and increased damage to coral reefs."

Funding for the coral rescue effort at Star Island was provided by NOAA Research's 'Omics Initiative.

Corals impacted by silt at the site of the Star Island seawall collapse: Left–Endangered *Orbicella faveolata* buried under 4 inches of silt; Right–*Colpophyllia natans* with partial mortality (top left) due to sediment burial. Photo credit: NOAA.

Coral City Camera live stream:
https://www.coralcitycamera.com/

AOML Mourns the Loss of George Berberian

"George was always the one to bring us together and make sure we interacted on more than just a professional level, that we got to know each other personally and enjoyed good times. He could always brighten your day with a quick joke or one of his many fabulous stories."

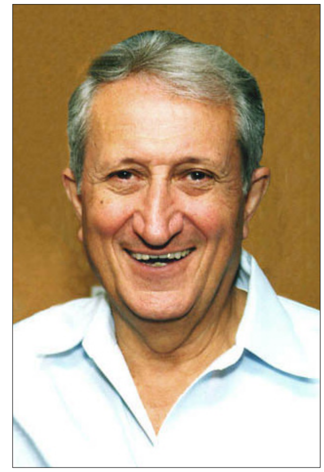
Chris Kelble, Director
Ocean Chemistry and Ecosystems Division

It is with great sadness that AOML notes the passing of George Berberian, a long-time friend and colleague with the Ocean Chemistry and Ecosystems Division, who died on August 13, 2022 at 93 years of age.

Born in Zahle, Lebanon, George immigrated to the United States in the early 1950s. He enlisted in the Army but, after 2 years of active duty, transferred to the Army Reserve to pursue his education, earning both BS (Geology) and MS (Geochemistry) degrees from American University in Washington, DC.

He began his scientific career as a junior oceanographer with the Research and Development Group of the US Coast and Geodetic Survey in 1962, assisting in the preparation of bathymetric maps of the Bering Sea and studies on the geomorphology of the Aleutian Arc. In 1965, a reorganization of the research entities housed within the Department of Commerce resulted in the formation of the Environmental Science Services Administration (ESSA), the forerunner of NOAA.

George continued as an oceanographer with the new Institute of Oceanography, one of four research institutes in ESSA, led by Dr. Harris Stewart. Following ESSA's assertion to build a state-of-the-art oceanographic research laboratory on Virginia Key, he joined more than 100 scientists, technicians, and administrative staff who moved to Miami in 1967 with Harris Stewart, the founding director of AOML.



During his 30+ year federal tenure at AOML, George helped plan and implement multi-disciplinary oceanographic programs focused on studying the circulation and chemistry of the Gulf of Mexico, Caribbean Sea, Yucatan Channel, and Cayman Sea. He traveled the world aboard research vessels during countless cruises, often as the chief scientist, and was fond of sharing stories of his time at sea. Among his leadership positions, George served for almost 20 years as the first deputy director of AOML's Ocean Chemistry Division.

Following his retirement from federal service in 1995, George continued working with the Ocean Chemistry and Ecosystems Division as a University of Miami-Cooperative Institute Research Associate, conducting and overseeing dissolved oxygen analyses of water samples both at sea and in the laboratory.

With his welcoming, enthusiastic personality, propensity for sharing jokes and stories, and ease in connecting with people from all walks of life, George made friends wherever he traveled. He was generous to a fault and loved by all who knew him.

George was the last of AOML's original staff still affiliated with the lab at the time of his death, with more than 60 years of service to NOAA and the nation. His kindness and perpetual good will made him a valued friend and colleague who will be missed by many at AOML.

In Memoriam

AOML notes the recent passing of the following former colleagues, all of whom made valuable contributions to the success of the lab's science programs.

Robert Castle, a former Information Technology Specialist with AOML's Ocean Chemistry and Ecosystems Division, passed away in Michigan in May 2022. Bob supported the Ocean Carbon Cycle group for 26 years before his retirement from federal service in 2016. Among his duties, Bob analyzed and reduced pCO_2 underway data and developed some of the initial underway pCO_2 data analysis and reduction software. Bob loved going to sea and sailed aboard an assortment of research vessels as an analyst of underway dissolved inorganic carbon measurements. These observations were gathered in support of research geared toward quantifying changes in the ocean's storage and transport of heat, freshwater, salinity, carbon, nutrients, oxygen, and trace gases to better understand their impacts on the physics, chemistry, and biology of the world's oceans.

Dr. Donald Hansen, a former long-time oceanographer, Physical Oceanography Division Director, and Acting AOML Director, passed away on January 9, 2022 in Vero Beach, Florida one week before his 91st birthday. Don was part of the original group of scientists, technicians, and administrative staff that moved to Miami, Florida with founding AOML Director Harris Stewart in 1967. Over the years, his research focused on estuarine, coastal, and deep ocean circulation, tides, air-sea interaction, and ocean observing technologies, including the first use of drifting buoys at AOML for climate studies. He was selected in 1970 to lead the division, a position he held until retiring from federal service in 1993. From 1978-1980, he also served as AOML's Acting Director following Harris Stewart's retirement.

Dr. Robert Molinari, a former long-time oceanographer, Physical Oceanography Division Director, and AOML Senior Scientist, passed away on July 30, 2022 in Boise, Idaho at 79 years of age. Bob began his career with NOAA-AOML in 1971. He was selected to lead the division in 1993 but stepped down 4 years later to become the Director of NOAA's newly formed Global Ocean Observing System Center housed at AOML. A year later, he was appointed as AOML's Senior Scientist, a position he held until his retirement from federal service in 2006. During his years at AOML, Bob served as the Chief Scientist for close to 40 cruises in the Altantic and Indian oceans, Caribbean Sea, and Gulf of Mexico. His research focused mainly on subtropical Atlantic climate studies, the large-scale circulation of the North Atlantic Ocean, and the Atlantic's western boundary currents.

Coastal Downwelling Study Selected as a Featured Paper

A study* by scientists with AOML's Hurricane Research Division was recently selected from a variety of publications as a featured paper for *EOS Science News* by the American Geophysical Union. Gramer *et al.* (2022) used a state-of-the-art hurricane modeling system developed at AOML—the Basin-Scale Hurricane Weather Research and Forecasting (HWRF-B) model—to find that coastal downwelling factors, such as moisture and increased heat, transfer into the atmosphere to create a favorable environment for hurricane intensification.

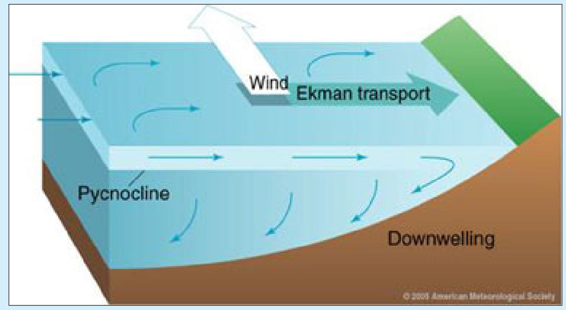


Diagram shows the process of coastal downwelling, which has been found to impact the intensity of landfalling hurricanes. Image credit: American Meteorological Society.

Using the HWRF-B model and buoy observations, the study examined the forecasts of three 2020 Atlantic hurricanes—Eta, Hannah, and Sally—that intensified as they approached land. It was found that coastal downwelling occurred when hurricane winds blew parallel to the coast, which led to rising water levels along the coast. This process brings warm surface water over the continental shelf, which further helps to intensify landfalling hurricanes. The analysis and modeling of coastal downwelling enables better understanding, prediction, and forecasting of hurricane intensification prior to landfall, with important implications for public safety. This research was conducted with support from the Hurricane Forecast Improvement Program (HFIP) and funding from the Hurricane Supplemental.

*Gramer, L.J., J.A. Zhang, G. Alaka, A. Hazelton, and S. Gopalakrishnan, 2022: Coastal downwelling intensifies landfalling hurricanes. *Geophysical Research Letters*, 49:e2021GL096630, **https://doi.org/10.1029/2021GL096630**.

AOML Scientists Contribute to the *State of the Climate in 2021* Report

The *State of the Climate in 2021* report* was released in August by the American Meteorological Society, showing that greenhouse gas concentrations, global sea levels, and ocean heat content reached record highs in 2021 despite a La Niña event in the Pacific Ocean. Compiled by NOAA's National Centers for Environmental Information, *State of the Climate in 2021* is based on the contributions of more than 500 scientists globally. It provides a detailed account of Earth's climate indicators, extreme weather events, and data collected by environmental monitoring stations and in situ instruments, all essential components for informing future research, policy decisions, and management actions.

Scientists at AOML communicated the impacts of the Earth's warming and changing environments in numerous sections of the *Global Oceans* chapter of the report, including the Meridional Overturning Circulation, ocean currents, and the role of the oceans in the carbon cycle. AOML researchers also contributed to *The Tropics* chapter, authoring two sections focused on tropical cyclones and tropical cyclone heat potential.

*Blunden, J. and T. Boyer, Eds., 2022: *State of the Climate in 2021*. *Bulletin of the American Meteorological Society*, 103(8):Si–S465, **https://doi.org/10.1175/2022BAMSStateoftheClimate.1**.

Ice Worm Publication Selected as a Spotlight Paper

A study* by scientists with AOML's Ocean Chemistry and Ecosystems Division and colleagues with the universities of Oregon and California was recently selected as a spotlight paper in the journal *Applied and Environmental Microbiology*. The focus of this special feature by Lim *et al.* (2022) is an enigmatic bristle worm, *Sirsoe methanicola,* that can be found in the depths of the Gulf of Mexico inhabiting "methane ice." Methane ice, or methane hydrates, represent vast reserves of natural gas that play an important role in global carbon cycling and climate change. Although methane ice worms were first discovered in 1997, this deep sea creature has remained elusive.

***S. methanicola.* Photo credit: R. Emlet/T. Young.**

The paper is the first to describe its microbial diversity using metagenomic analysis. In 2009, methane ice worm specimens were collected by the crewed Johnson Sea-Link II submersible during the SJ-009-GOM research cruise on the RV *Seward Johnson*. DNA was subsequently extracted from the gut and body fragments of the worms. Lim *et al.* (2022) used bioinformatics to reveal new information about this elusive species; specifically, the gut microbiome associated with the worm is dominated by the bacteria *Sulfurospirillum.* Since *Sulfurospirillum* are free-living organisms, it came as a surprise to the research team to find them associated with an animal. This analysis suggests an important role for sulfur-cycling bacteria in the life of this mysterious denizen of the deep sea. The research was conducted with support from NOAA's OAR 'Omics Initiative, the Northern Gulf Institute, National Science Foundation, and National Institute of Health.

*Lim, S.J., L. Thompson, C.M. Young, T. Gaasterland, and G. Goodwin, 2022: Dominance of *Sulfurospirillum* in metagenomes associated with the methane ice worm (*Sirsoe methanicola*). *Applied and Environmental Microbiology*, 88(15):e00290-22, **https://journals.asm.org/doi/10.1128/aem.01271-22**.

AOML Director Receives Presidential Rank Award

President Joe Biden has selected AOML Director John Cortinas, PhD, as a 2022 recipient of the Presidential Rank Award, one of the most prestigious awards for federal career civil service. It recognizes the hard work and important contributions of dedicated civil servants.

Cortinas has been a trailblazer and a visionary leader for more than 15 years of federal service through senior leadership positions in NOAA's Office of Oceanic and Atmospheric Research (OAR). Prior to becoming the AOML director in 2019, he served as the director of OAR's Office of Weather and Air Quality, as well as the director of the Cooperative Institute program.

Cortinas was recognized for fostering world-class research that has made significant improvements in NOAA's ability to provide accurate and timely forecasts and warnings for extreme weather, including hurricanes, thunderstorms, floods, heat waves, and strong winds. Moreover, as the first openly gay Senior Executive of Hispanic descent to lead both an OAR program and national laboratory, he has been an exemplary role model for NOAA's workforce and others from under-represented communities, working tirelessly to advance diversity and inclusion across the agency.

Throughout his career, Cortinas has been a passionate advocate for under-represented groups in science, technology, engineering, and math (STEM). He is a member of several scientific organizations that work to improve diversity within STEM, including the Society for the Advancement of Chicanos and Native Americans in Science, the National Organization of Gay and Lesbian Scientists and Technical Professionals, Latinos@ NOAA, the American Geophysical Union, and the American Meteorological Society (AMS), for which he is currently an elected representative of the AMS Council.

Cortinas grew up in Omaha, Nebraska, and is the oldest of five children. He holds a doctorate in Geophysical Sciences from the Georgia Institute of Technology in Atlanta and has authored and co-authored many scientific articles, as well as served on numerous national and international scientific working groups and committees. Congratulations to AOML director John Cortinas on receiving this prestigious award.

(*continued from page 1*)

Dunion led NOAA's APHEX science mission on the Gulfstream-IV (G-IV) Hurricane Hunter jet to test new targeted sampling techniques for optimizing aircraft observations. Targeted sampling improves forecasts by determining the best locations for where to gather data in the storm environment.

"The National Hurricane Center provides a 5-day forecasts for future potential storms," said Dunion. "And we can see a time coming when it's going to be a 7-day forecast. If you're looking out 7 days, you really need to be looking out farther east, out toward Cape Verde."

During three 8-hour missions in the skies above Sal Island, the G-IV science crew sampled an area of disturbed weather, a "potential storm," and a dense mass of Saharan dust, known as the Saharan Air Layer, just to its north.

Jason Dunion onboard NOAA's Gulfstream-IV Hurricane Hunter jet reviews real-time data from flying through an area of disturbed weather, a "potential storm," above the Cabo Verde islands. Photo credit: NOAA.

Dropsondes launched from the G-IV at altitudes as high as 45,000 feet measured a host of atmospheric variables, including barometric pressure, temperature, humidity, and winds as they fell toward the ocean. Forecast model ensembles were used to identify optimal dropsonde locations to improve model forecasts of the tropical wave's intensity and future track.

These observations will be used to study how Saharan dust blowing off the African coast intermingles with tropical waves and affects their development. Forecast models will also benefit from the observations: More real-time data of what's occurring in the atmosphere when storms are in their formative, earliest stage will help the models better predict their track and intensity as they travel the broad expanse of the Atlantic.

Although an ocean away, the research conducted in this rarely sampled region will help unlock the complex dynamics of how tropical waves form into tropical depressions, a key phase in the life cycle of tropical cyclones.

With the Cabo Verde missions now completed, scientists at AOML will work with their NOAA colleagues to assess the potential value of expanding future hurricane reconnaissance efforts farther east in the Atlantic, all for the benefit of improving track and intensity forecasts.

Renellys Perez Selected as Physical Oceanography Division Deputy Director

AOML is pleased to announce that Renellys Perez, PhD, has been selected as the new deputy director of the Physical Oceanography Division and officially began her new duties on August 15.

Renellys was born and raised in Miami, Florida, where her parents met after coming to the United States from Cuba. She earned BS and MS degrees from the University of Miami and then attended Oregon State University, where she earned a PhD in Oceanography in 2006.

After completing a National Research Council post-doctoral fellowship with NOAA's Pacific Marine Environmental Laboratory, Renellys began at AOML in 2008 as a University of Miami-Cooperative Institute Assistant Scientist. In 2017, she became a federal oceanographer.

Her research focuses on the variability of ocean currents and how they influence the distribution of heat and salt throughout the tropical and subtropical oceans, as well as their impacts on regional weather and climate. Renellys has also studied the processes that drive equatorial ocean currents and tropical instability waves in the Atlantic and Pacific oceans, the variability of boundary currents, and the Meridional Overturning Circulation in the South Atlantic Ocean.

She chose oceanography as a career path due to her "love of math and physics, fondness for the ocean, and desire to study observable phenomena, even if you need a satellite to observe it." The aspects she enjoys most about her position are interacting with people from across AOML, mentoring, outreach, going to sea, and building and sustaining partnerships, whether they be within AOML, across NOAA, or with external partners. Through her work on science panels and steering committees, Renellys understands the importance of developing integrated observing strategies to tackle important science and societal challenges.

Over the past 10 years, Renellys has served as a principal investigator or co-principal investigator for the PIRATA Northeast Extension project, Global Drifter Program, Tropical Atlantic Current Observations Study, and the Southwest Atlantic Meridional Overturning Circulation project. In support of this research, she has authored or coauthored more than 40 peer-reviewed journal articles. Her most recent research focuses on the Deep Temperature program to analyze deep and abyssal temperatures from bottom-moored instruments in the South and North Atlantic Ocean.

In addition to her research, Renellys has been recognized for her efforts to help build a more diverse, inclusive, and equitable science community. In 2020, she was honored with an EEO Diversity Award for Exemplary Service from NOAA's

Office of Oceanic and Atmospheric Research for her educational outreach activities and mentorship of women and minority communities.

As the new deputy director of AOML's Physical Oceanography Division, Renellys will work closely with director Rick Lumpkin in supervising staff and tending to an assortment of administrative functions. She will also continue her scientific leadership roles for the PIRATA Northeast Extension project, Tropical Atlantic Current Observations Study, and the South Atlantic meridional overturning circulation and deep temperature projects.

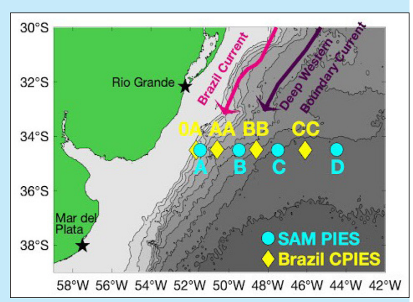
Congratulations and best wishes to Renellys on her selection as the new deputy director of AOML's Physical Oceanography Division.

SAM Cruises Resume after Three-Year Lapse

In July-August, the Southwest Atlantic Meridional Overturning Circulation project, or SAM, led by Renellys Perez and Shenfu Dong of AOML, completed its first cruise since June 2019, due mainly to safety protocols necessitated by the COVID pandemic. The Meridional Overturning Circulation (MOC) redistributes heat, salt, dissolved oxygen, nutrients, and carbon throughout the global climate system. SAM consists of an array of moorings along 34.5°S, including four pressure-equipped inverted echo sounders (PIES), that track the variability of these components of the MOC as they flow through the South Atlantic Ocean. Data from the moorings aid in monitoring the Brazil Current and Deep Western Boundary Current along the western boundary of the Atlantic basin. The moorings also collect temperature observations used to generate a time series of bottom temperatures along 34.5°S.

In spite of rough weather and technical difficulties, three mooring sites were visited during the cruise aboard the Brazilian research vessel *Alpha Crucis*. Two NOAA-AOML moorings were recovered with all of their data, and new were units deployed in their place to continue collecting critical time-series measurements. A Brazilian mooring was also recovered and redeployed. Diego Ugaz and Christian Saiz, both University of Miami-Cooperative Institute electrical engineers, represented AOML during the cruise, with ground support provided by Ulises Rivero and Pedro Pena of AOML.

Variations in the MOC have important global impacts on climate variables such as coastal sea levels, shifts in regional surface air temperature, precipitation patterns, and extreme weather, e.g., drought, heat waves, and tropical cyclones. The SAM array is funded by NOAA's Global Ocean Monitoring and Observing Program and AOML and is maintained through a collaboration between AOML and researchers in Argentina and Brazil.



Top right: **Location of the Brazil Current, Deep Western Boundary Current, and pressure-equipped echo sounder (PIES) moorings in the Atlantic.** ***Bottom right:*** **A PIES instrument (photo credit: Dr. Olga Sato, University of Sao Paulo).**

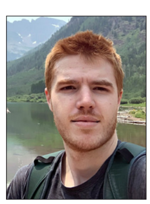
Welcome Aboard

Dr. Tiago Carrilho Bilo joined AOML's Physical Oceanography Division in October as a University of Miami-Cooperative Institute Assistant Scientist. Tiago will work with Drs. Renellys Perez, Shenfu Dong, and other scientists to study the Atlantic Meridional Overturning Circulation and the variability of boundary currents in the South Atlantic using in situ observations. He will also study changes in water mass properties, particularly deep and abyssal ocean temperatures. Tiago holds a PhD in Meteorology and Physical Oceanography from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science.

Shaun Dolk joined AOML's Physical Oceanography Division in July as the new federal manager for the Global Drifter Center's Data Assembly Center (DAC). The DAC quality controls data from drifting buoys deployed globally for marine forecasts and weather/climate research. Shaun began with the drifter group in 2007 as a University of Miami-Cooperative Institute Research Associate and, over the years, rose to the rank of Senior Research Associate. He has unofficially served as the drifter DAC manager since late 2021. Shaun holds a MPS degree in Weather, Climate, and Society from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science.

Thia Griffin-Elliott joined AOML's Office of the Director in July as a Communications and Web Specialist through Groundswell, a federal contractor. Thia joins the Communications team to maintain and keep content updated on the AOML website, generate and revise web pages, and analyze web traffic on the site. They will also support the AOML community by creating graphics and writing articles to share the lab's research with a variety of audiences. Thia holds an MS degree in Marine Science from the University of South Florida's College of Marine Science, with research focused on the inorganic carbon system and trace metals in Tampa Bay.

Dr. Jin-Sil Hong joined AOML's Physical Oceanography Division in September as a Northern Gulf Institute post-doctoral scientist. While at AOML, she will support research to examine the non-linear relationship between the frequency of drought in the southeastern US and Pacific-Atlantic decadal climate variability. Jin-Sil holds a PhD from the Department of Marine Sciences and Convergent Technology at Hanyang University in South Korea, with expertise in air-sea interactions on decadal time scales.



Dr. Nicholas MacKnight joined AOML's Ocean Chemistry and Ecosystems Division in June as a University of Miami-Cooperative Institute post-doctoral scientist. Nicholas will work with Dr. Stephanie Rosales to identify the functional contributions and adaptive restraints of bacteria that live on *Orbicella faveolata*, a disease susceptible, yet highly productive reef-building coral. This research seeks to identify disease resistant genotypes within this susceptible species. Nicholas recently obtained his PhD in Quantitative Biology from the University of Texas at Arlington.

Alison MacLeod joined AOML's Ocean Chemistry and Ecosystems Division in September as a University of Miami-Cooperative Institute Research Associate. Alison will support the Ocean Carbon Cycle group, which studies the transport and transformation of carbon in the ocean and the fate of anthropogenic carbon dioxide. Her primary duties will be to serve as a seagoing and lab-based analyst. Alison holds a BS degree in Oceanography, with minors in Geography and Data Science from the University of Washington. Her senior thesis was on impacts of pH on non-steroidal anti-inflammatory drugs (NSAID) adsorption to microplastics in the North Pacific Gyre.

Dr. Jhon Mojica joined AOML's Ocean Chemistry and Ecosystems Division in September as a University of Miami-Cooperative Institute Senior Research Associate. Jhon will support the Port Everglades Adaptive Management Moorings and Expert Information System project by managing an array of data buoys and sensors deployed in Port Everglades to better understand the drivers of water quality and monitor turbidity during dredging operations in 2023. Prior to joining AOML, Jhon held a post-doctoral position at the New York University's Center for Global Sea Level Change in Abu Dhabi, United Arab Emirates, where he studied ocean-glacier dynamics in Greenland fjords, Antarctic ice shelves, and several areas around Antarctica. He holds a PhD in Physical Oceanography from the University of Barcelona.

Edward Ryan joined AOML's Physical Oceanography Division in September as a University of Miami-Cooperative Institute Senior Research Associate. Ed will support the US Argo Data Assembly Center at AOML, which processes and quality controls all Argo data collected by US scientific and governmental institutions. His primary duties will focus on data quality control and the use of BUFR (Binary Universal Form for the Representation of meteorological data) software. He comes to AOML with 30 years of experience as a member of the research staff at the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science. Ed holds an MS degree in Physics from the University of Cincinnati.

Kayelyn Simmons joined AOML's Ocean Chemistry and Ecosystems Division in July as a federal oceanographer. Kayelyn is a former 2021 John A. Knauss Fellow who worked with NOAA's Coral Reef Conservation Program in support of the US Coral Reef Task Force. At AOML, Kayelyn will lead benthic habitat characterization studies for several efforts, including the National Coral Reef Monitoring Program and Port Everglades Dredging Expansion project. She recently earned her PhD Marine Science from North Carolina State University, with a focus on coral reef soundscapes and habitat photogrammetry within the Florida Keys National Marine Sanctuary.

Farewell

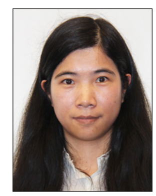
Dr. Kyle Ahern, a University of Miami-Cooperative Institute Senior Research Associate with AOML's Hurricane Research Division, resigned in September to accept a position as a post-doctoral scientist with the State University of New York at Albany. Kyle joined AOML in February 2020 to work with the Hurricane Modeling group, contributing to multiple moving nest developments for the Hurricane Analysis and Forecast System (HAFS) model, as well as contributing to research using the HAFS model.

Nathan Formel, a University of Miami-Cooperative Institute Senior Research Associate with AOML's Ocean Chemistry and Ecosystems Division, resigned in August to accept a Research Assistant position with the Woods Hole Oceanographic Institution in Woods Hole, Massachusetts. During Nate's 5 years at AOML, he studied the effects of ocean acidification and ocean warming on coral reef ecosystems, as well as worked to develop new technologies and methods for better monitoring water chemistry at coral reef sites.

John Morris, a University of Miami-Cooperative Institute Research Associate with AOML's Ocean Chemistry and Ecosystems Division, resigned in August to accept a position as a post-doctoral scientist with the University of Hawaii's NOAA affiliated Cooperative Institute for Marine and Atmospheric Research in Honolulu, Hawaii. John will conduct research on a variety of topics related to coral reef ecosystems. He recently earned his PhD in Coral Reef Ecology from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science under the advisorship of Dr. Ian Enochs of AOML.

NOAA Corps Officer LT Alyssa Thompson, the Research Operations Manager for AOML's Ocean Chemistry and Ecosystems Division (OCED), resigned from the NOAA Corps in August to pursue other professional opportunities. Alyssa joined AOML in April 2018 to oversee OCED's small boat operations and assist with diving and field sampling efforts for ecosystem research conducted in south Florida's coastal waters. She also served as AOML's acting Associate Director on several occasions, working with AOML senior leadership to manage various contracts and special projects from their planning to completion stages.

Dr. Joshua Wadler, a University of Miami-Cooperative Institute Assistant Scientist with AOML's Hurricane Research Division, resigned in August to accept a faculty position with the Applied Aviation Sciences Department at Embry-Riddle Aeronautical University. Josh first joined AOML in the summer of 2014 as a NOAA Hollings scholar intern to conduct research on the distribution of deep convection in hurricanes. He returned to AOML in September 2020 as a University of Miami-Cooperative Institute post-doctoral scientist with research focused on air-sea interaction processes in tropical cyclones and the use of small uncrewed aircraft systems.



Dr. Yuan-Yuan Xu, a University of Miami-Cooperative Institute post-doctoral scientist with AOML's Ocean Chemistry and Ecosystems Division, resigned in September to accept a position with Planetary Technologies in Halifax, Canada. During Yuan-Yuan's 3 years at AOML, she worked with the Ocean Carbon Cycle group on studies to assess changes in carbonate chemistry variables. She also explored artificial intelligence techniques applied to the biogeochemical Argo profiling float array.

Researchers Prep for Dredging Operations at Port Everglades

True color image taken at 5500 feet above Port Everglades on September 23, 2022.

In September, researchers with AOML's Ocean Chemistry and Ecosystems Division (OCED) collected in situ remote sensing reflectance measurements, multi-parameter profiles, and particulate absorption coefficient samples at Port Everglades in Fort Lauderdale. The observations were gathered during concurrent hyperspectral overflights above Port Everglades led by Andrea Vander Woude, NOAA's Great Lakes CoastWatch Node manager, and Lauren Marshall, a researcher with NOAA's Great Lakes Environmental Research Laboratory. The flights were conducted to obtain reflectance measurements of ocean color with ultra-high spectral resolution at altitudes of 5,500 and 9,500 feet that will be calibrated against the in situ observations collected by the OCED team.

These data will be used to characterize water quality conditions and bio-optical properties prior to the start of dredging operations of the Port Everglades navigation channel led by the US Army Corps of Engineers in 2023. The study complements work led by AOML's Ecosystems Assessment Group under the auspices of the Port Everglades Adaptive Management Moorings and Expert Information System program. Researchers with the group previously deployed an expert system on the ocean floor at Port Everglades that will be used to determine when coral reefs near the navigation channel are affected by sediment resuspension and accumulation. Once dredging operations to widen the channel begin, the system will issue alerts when turbidity conditions reach above-normal levels, enabling managers to adjust dredging activities to minimize impacts to coral reefs in the area.

Sediment resuspension stresses corals by decreasing the amount of sunlight that reaches the seafloor, reducing the photosynthetic performance of algae, i.e., zooxanthellae, living within the coral's tissue. Sediment particles can also transport pathogens linked to the spread of stony coral tissue loss disease that has degraded coral communities across south Florida and the Caribbean.

U.S. Department of Commerce
Ms. Gina M. Raimondo
Secretary of Commerce
www.doc.gov

National Oceanic and Atmospheric Administration
Dr. Richard W. Spinrad
Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator
www.noaa.gov

Office of Oceanic and Atmospheric Research
Dr. Steven Thur
Assistant Administrator
www.research.noaa.gov

Atlantic Oceanographic and Meteorological Laboratory

Dr. John V. Cortinas
Director

Dr. Molly O. Baringer
Deputy Director

CDR Tony Perry III
Associate Director

Dr. Frank D. Marks, Director
Hurricane Research Division

Dr. Christopher R. Kelble, Director
Ocean Chemistry and Ecosystems Division

Dr. Rick Lumpkin, Director
Physical Oceanography Division

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

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., Jr., X. ZHANG, and **S.G. GOPALAKRISHNAN**, 2022: High-definition hurricanes: Improving forecasts with storm-following nests. *Bulletin of the American Meteorological Society*, 103(3):E680-E703.

Barron, N.R., A.C. Didlake, and **P.D. REASOR**, 2022: Statistical analysis of convective updrafts in tropical cyclone rainbands observed by airborne Doppler radar. *Journal of Geophysical Research-Atmospheres,* 127(6):e2021JD035718.

Chen, C.-C., H.-Y. Hsieh, **A.B. MAYFIELD**, C.-M. Chang, J.-T. Wang, and P.-J. Meng, 2022: The key impact on water quality of coral reefs in Kenting National Park. *Journal of Marine Science and Engineering,* 10(2):270.

CHEN, X., G.H. Bryan, **A. HAZELTON, F.D. MARKS**, and P. Fitzpatrick, 2022: Evaluation and improvement of TKE-based eddy-diffusivity mass-flux (EDMF) planetary boundary layer scheme in hurricane conditions. *Weather and Forecasting*, 37(6):935-951.

Chung, E.-S., S.-J. Kim, A. Timmermann, K.-J. Ha, **S.-K. LEE**, M.F. Stuecker, K.B. Rodgers, S.-S. Lee, and L. Huang, 2022: Antarctic sea-ice expansion and Southern Ocean cooling linked to tropical variability. *Nature Climate Change,* 12(5):461-468.

Da, N.D., and **G.R. FOLTZ**, 2022: Interannual variability and multiyear trends of sea surface salinity in the Amazon-Orinoco plume region from satellite observations and an ocean reanalysis. *Journal of Geophysical Research-Oceans*, 127(5):e2021JC018366.

Garcia-Ibanez, M.I., Y. Takeshita, E.F. Guallart, N.M. Fajar, **D. PIERROT**, F.F. Pérez, W.-J. Cai, and M. Alvarez, 2022: Gaining insights into the seawater carbonate system using discrete *f*CO_2 measurements. *Marine Chemistry,* 245:104150.

GRAMER, L.J., J.A. ZHANG, G. ALAKA, A. HAZELTON, and **S. GOPALAKRISHNAN**, 2022: Coastal downwelling intensifies landfalling hurricanes. *Geophysical Research Letters,* 49(13):e2021GL096630.

HAZELTON, A., J.A. ZHANG, and **S.G. GOPALAKRISHNAN,** 2022: Comparison of the performance of the observation-based hybrid EDMF and EDMF-TKE PBL schemes in 2020 tropical cyclone forecasts from the Global-nested Hurricane Analysis and Forecast System. *Weather and Forecasting,* 37(4):457-476.

KIM, H.-S., J. Meixner, B. Thomas, B. Reichl, B. Liu, A. Mehra, and A. Wallcraft, 2022: Skill assessment of NCEP three-way coupled HWRF-HYCOM-WW3 modeling system: Hurricane Laura case study. *Weather and Forecasting,* 37(8):1309-1331.

LEE, S.-K., H. LOPEZ, G.R. FOLTZ, E.-P. Lim, **D. KIM**, S.M. Larson, **K. PUJIANA, D.L. VOLKOV, S. CHAKRAVORTY**, and **F.A. GOMEZ**, 2022: Java-Sumatra Niño/Niña and its impact on regional rainfall variability. *Journal of Climate*, 35(13):4291-4308.

Li, X., **Y.-Y. XU**, D.L. Kirchman, and W.-J. Cai, 2022: Carbonate parameter estimation and its application in revealing temporal and spatial variation in the South and Mid-Atlantic Bight, USA. *Journal of Geophysical Research-Oceans*, 127(7):e2022JC018811.

Meng, Z., L. Zhou, R. Murtugudde, Q. Yang, **K. PUJIANA**, and J. Xi, 2022: Tropical oceanic intraseasonal variabilities associated with the central Indian Ocean mode. *Climate Dynamics*, 58(3-4):1107-1126.

Millette, N., **C. KELBLE, I. SMITH, K. MONTENERO**, and E. Harvey, 2022: Spatial variability of microzooplankton grazing on phytoplankton in coastal southern Florida, USA. *PeerJ,* 10:e13291.

Truelove, N.K., **N.V. PATIN**, M. Min, K.J. Pitz, C.M. Preston, K.M. Yamahara, Y. Zhang, B.Y. Raanan, B. Kieft, B. Hobson, **L.R. THOMPSON, K.D. GOODWIN**, and F.P. Chavez, 2022: Expanding the temporal and spatial scales of environmental DNA research with autonomous sampling. *Environmental DNA*, 4(4):972-984.

THOMPSON, L.R., S.R. ANDERSON, P.A. Den Uyl, **N.V. PATIN**, G. Sanderson, and **K.D. GOODWIN**, 2022: Tourmaline: A containerized workflow for rapid and iterable amplicon sequence analysis using QIIME 2 and Snakemake. *GigaScience,* 11(1):giac06.

TUCHEN, F.P., P. Brandt, J. Hahn, R. Hummels, G. Krahmann, B. Bourles, C. Provost, M.J. McPhaden, and J.M. Toole, 2022: Two decades of full-depth current velocity observations from a moored observatory in the central equatorial Atlantic at 0°N, 23°W. *Frontiers in Marine Science*, 9:910979.

Yancey, C.E., D.J. Smith, P.A. Den Uyl, O.G. Mohamed, F. Yu, S.A. Ruberg, J.D. Chaffin, **K.D. GOODWIN**, A. Tripathi, D.H. Sherman, and G.J. Dick, 2022: Metagenomic and metatranscriptomic insights into population diversity of *Microcystis* blooms: Spatial and temporal dynamics of *mcy* genotypes, including a partial operon that can be abundant and expressed. *Applied and Environmental Microbiology,* 88(9):e02464-21.

Zhao, Z., R. Gao, **J.A. ZHANG**, Y. Zhu, C. Liu, P.W. Chan, and Q. Wan, 2022: Observations of boundary layer wind and turbulence of a landfalling tropical cyclone. *Nature Scientific Reports*, 12:11056.