AOML Keynotes

NOAA'S ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

April-June 2022

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

New Hurricane Research Supports NOAA's 2022 Forecasts

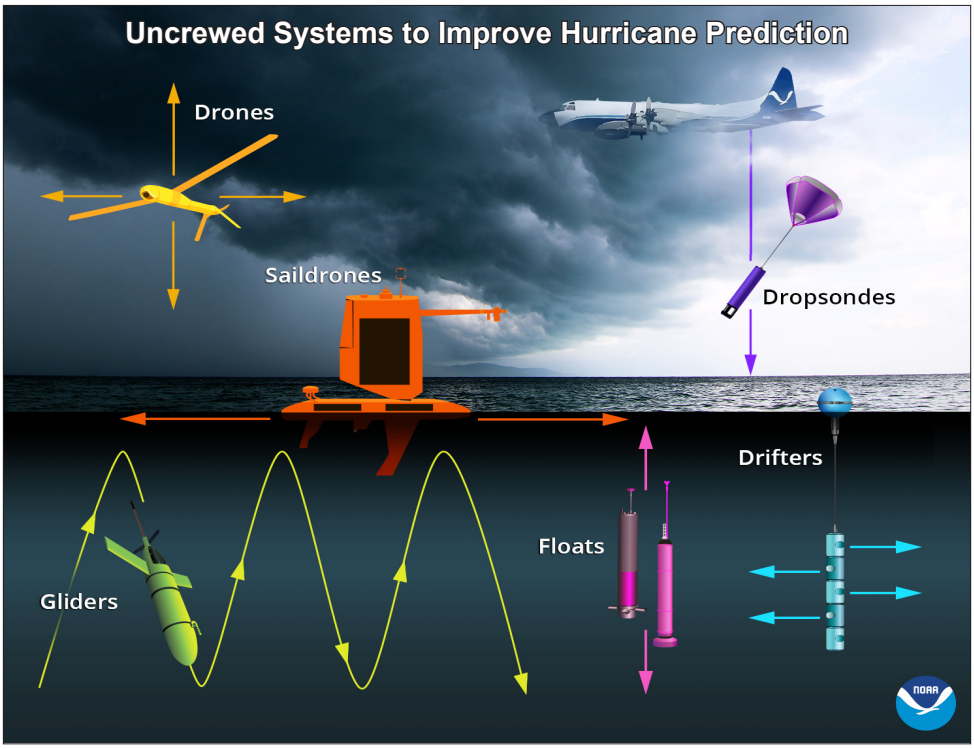
This summer during the 2022 Atlantic hurricane season scientists at AOML will once again be on the frontlines helping NOAA prepare the public for severe weather. They will also conduct new research on the complex processes of how tropical cyclones form, develop, and dissipate.

AOML's operational missions tasked by NOAA's Environmental Modeling Center and National Hurricane Center will keep forecasters abreast of the ever-changing, dynamic conditions as storms develop and intensify. Flying aboard NOAA's P-3 and G-IV Hurricane Hunter aircraft, AOML scientists will sample the periphery around storms and the towering cumulonimbus clouds that circle the hurricane eye.

A top priority will be to improve predictions of rapid intensification, events that are difficult to forecast due to the number of interacting factors. When maximum sustained winds quickly ramp up, so does the destructive capacity of a storm. To tackle this forecasting challenge, AOML scientists will coordinate with multiple partners to launch a host of instruments that sample the ocean and atmosphere in real-time.

Surface drifters, underwater gliders, and profiling floats will gather observations from the sea surface to depths of half a mile. Small uncrewed aerial systems launched from the P-3s will be tested to sample the atmosphere at altitudes just hundreds of feet above the ocean. Five saildrone uncrewed surface vehicles will be launched in partnership with NOAA's Pacific Marine Environmental Laboratory and Saildrone, Inc. to sample the upper ocean and air-sea interface.

Data from the drifters, gliders, and floats will be transmitted via satellite into NOAA's operational Hurricane Weather Research and Forecasting System and its cutting-edge research forecast model, the Hurricane Analysis and Forecast System.



AOML will coordinate with multiple partners this summer to launch an assortment of autonomous instruments to sample the ocean and atmosphere in real-time.

The frontlines of research this summer will take AOML scientists thousands of miles across the Atlantic to study the earliest beginnings of how tropical cyclones form. In partnership with National Aeronautics and Space Administration (NASA), NOAA will deploy the G-IV jet to the Cabo Verde islands, the "nursery grounds" for some of the Atlantic's largest, fiercest storms.

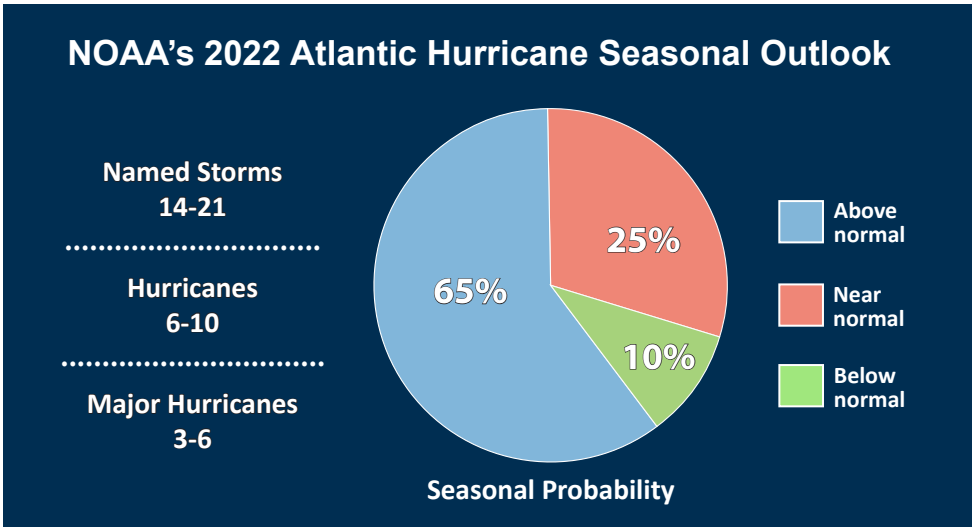
According to Jason Dunion, the 2022 Hurricane Field Program director, "instead of waiting for storms to come to us, this year we'll go to them." This first-ever deployment for NOAA Hurricane Hunters will enable AOML scientists to study how thunderstorms that drift off the west African coast develop into tropical waves, the "seedlings" for many tropical cyclones.

The groundbreaking research supports the Advancing the Prediction of Hurricanes Experiment, or APHEX, the main component of AOML's Hurricane Field Program. Research to address additional science questions will be conducted in collaboration with the Office of Naval Research and NASA.

AOML's operational and research efforts conducted throughout the 2022 Atlantic hurricane season will push the boundaries of NOAA's forecasting capabilities. The data they gather will not only protect life and property, but also advance the understanding of how and why some storms form and rapidly intensify.

NOAA Predicts Above-Normal 2022 Atlantic Hurricane Season

The ongoing La Niña in the Pacific and above-average Atlantic sea surface temperatures set the stage for a busy season ahead.



On May 24, forecasters at NOAA's Climate Prediction Center released their outlook for another above-average Atlantic hurricane season. The outlook is produced in collaboration with hurricane experts from the National Hurricane Center and AOML's Hurricane Research Division. If the outlook is correct, 2022 would increase the record to seven consecutive years with above-average Atlantic hurricane activity.

NOAA's outlook for the 2022 season, which began June 1 and ends November 30, predicts a 65% chance of an above-normal season, a 25% chance of a near-normal season, and only a 10% chance of a below-normal season.

The outlook calls for a likely range of 14 to 21 named storms (39 mph winds or higher), of which 6 to 10 could become hurricanes (74 mph winds or higher), including 3 to 6 major hurricanes (category 3, 4 or 5; with 111 mph winds or higher). NOAA provides these ranges with a 70% confidence. The outlook also calls for the Accumulated Cyclone Energy, a measure of the overall activity for a season, to be between 115-200% of the median.

The increased activity anticipated this hurricane season is attributed to several climate factors, including the ongoing La Niña that is likely to persist throughout the hurricane season, warmer-than-average sea surface temperatures in the Atlantic Ocean and Caribbean Sea, and weaker tropical Atlantic trade winds. Additionally, an enhanced west African monsoon supports stronger African easterly waves, which seed many of the strongest and longest lived hurricanes during most seasons.

"As we reflect on another potentially busy hurricane season, past storms such as Superstorm Sandy, which devastated the New York metro area ten years ago, remind us that the impact of one storm can be felt for years," said Rick Spinrad, PhD, NOAA Administrator. "Since Sandy, NOAA's forecasting accuracy has continued to improve, allowing us to better predict the impacts of major hurricanes on lives and livelihoods."

For the 2022 hurricane season, NOAA has enhanced the following products and services:

Saildrones: To improve the understanding and prediction of how hurricanes intensify, AOML and NOAA's Pacific Marine Environmental Lab will operate seven Saildrone uncrewed surface vehicles during the peak of the 2022 hurricane season and coordinate them for the first time with uncrewed ocean gliders, small aircraft drone systems, and NOAA Hurricane Hunter aircraft to measure the ocean, atmosphere, and areas where they meet.

Improved modeling: The Hurricane Weather Research and Forecasting model and Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic model, which have both shown significant skill improvements in terms of storm track and intensity forecasts, have been successfully transitioned to the newest version of the Weather and Climate Operational Supercomputing System, allowing for uninterrupted operational forecasts.

Excessive Rainfall Outlook (ERO): The ERO has been experimentally extended from 3-5 days of lead time, giving more notice of rainfall-related flash flooding risks from tropical storms and hurricanes. The ERO forecasts and maps the probability of intense rainfall that could lead to flash flooding within 25 miles of a given point.

Peak storm surge forecast graphic: In June, NOAA enhanced an experimental graphic that depicts the Peak Storm Surge Forecast for when storm surge watches or warnings are in effect. Upgrades to the graphic include an updated disclaimer and color coding that illustrates the peak storm surge inundation forecast at the coast. This tool is currently only available for the Atlantic basin.

"Hurricane Ida spanned nine states, demonstrating that anyone can be in the direct path of a hurricane and in danger from the remnants of a storm system," said Federal Emergency Management Agency Administrator Deanne Criswell. "It's important for everyone to understand their risk and take proactive steps to get ready now."

NOAA's outlook provides the public with a general guide to the overall activity for the upcoming hurricane season. It is not a landfall forecast, nor does it imply levels of activity for any particular region. NOAA will update the Atlantic seasonal outlook in early August, the beginning of the historical peak months, i.e., August-September-October, of the season.

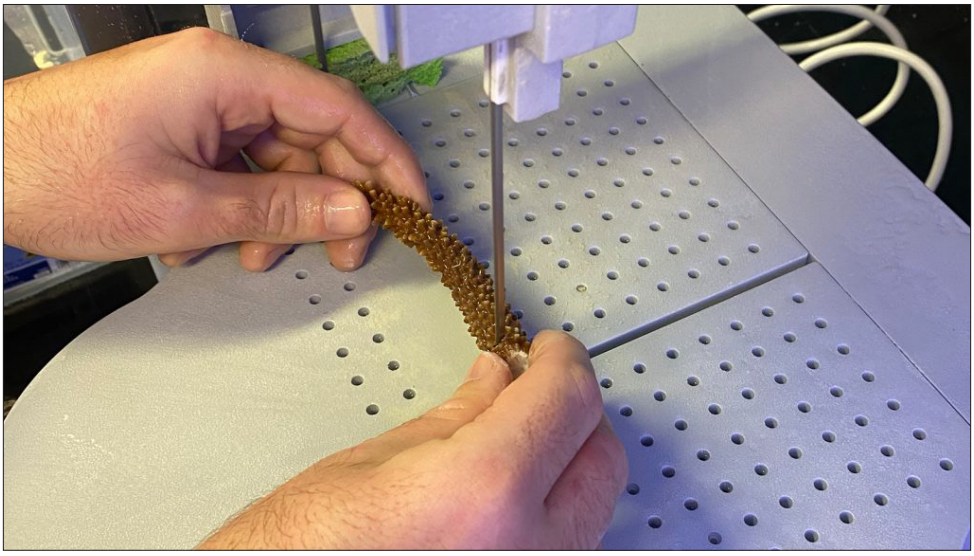
This article is modified from a May 24, 2022 web story on www.noaa.gov

2022 Atlantic Storm Names

Alex	Danielle	Gaston	Julia	Martin	Paula	Tobias
Bonnie	Earl	Hermine	Karl	Nicole	Richard	Virginie
Colin	Fiona	Ian	Lisa	Owen	Shary	Walter

Building Endurance to Beat the Heat: New Study Preps Corals for Warming Waters

Staghorn coral collected from nursery-raised source colonies in South Florida were subjected to a thermal stress hardening technique to test its ability to help corals withstand warmer ocean temperatures and the increased potential for bleaching events.



Staghorn coral from six nursery-raised source colonies in South Florida were fragmented into 128 pieces and subjected to a stress-hardening technique in the Experimental Reef Laboratory on the grounds of the University of Miami's Rosenstiel School.

In a recent study published in the journal *Coral Reefs**, scientists with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies and AOML found that staghorn coral (*Acropora cervicornis*) fragments exposed to an oscillating temperature treatment were better able to respond to heat stress caused by warming oceans.

With the rise in ocean temperatures and more frequent bleaching events, research is being conducted on techniques to improve the survivorship of nursery-raised corals outplanted on degraded reefs. Previous studies have shown that corals growing in environments with natural temperature variability experience less bleaching when exposed to increased temperatures.

Coral bleaching occurs when the colorful algae that live within the coral's tissue are expelled in response to stressors like increased water temperatures, leaving the coral looking white or bleached in appearance. Bleached corals are debilitated and vulnerable to disease, although they sometimes recover.

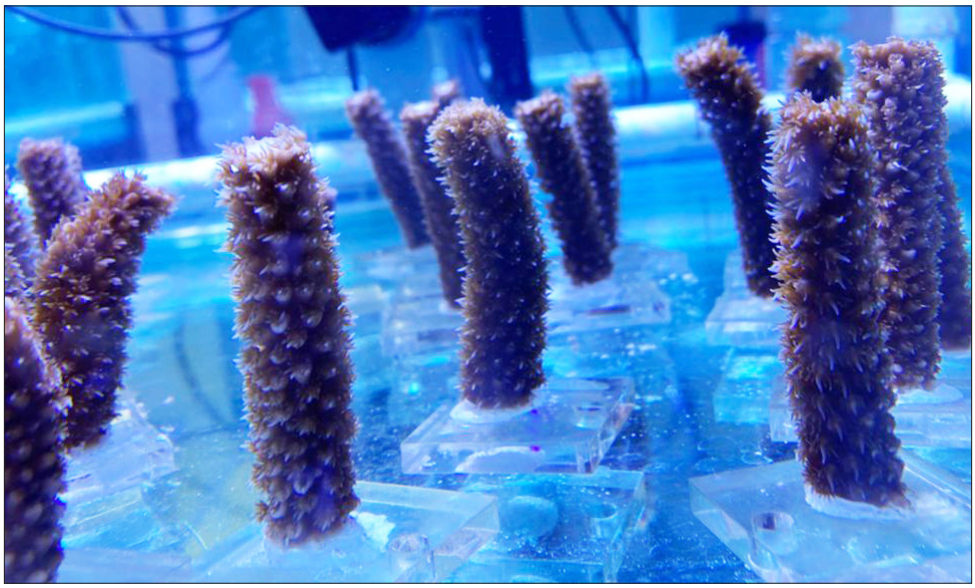
"We want to increase the efficiency and efficacy of these (restoration) efforts, and ultimately ensure that corals that are placed back out on a reef have the greatest chance of enduring the stressful conditions they will face in the future," said Ian Enochs, a coauthor on the study and lead scientist with the Coral Reef Monitoring Program at AOML.

An experiment was conducted that used a stress-hardening technique to mechanize the acclimation of coral fragments to stressful temperature conditions. Caribbean staghorn coral fragments were exposed for 3 months to either a variable temperature regime, i.e., stressful temperatures that fluctuated twice daily from 28–31°C, or a static temperature that remained at 28°C. After 3 months, all coral fragments were then exposed to a static temperature of 32°C for 2 weeks.

Scientists found that the variable temperature-treated coral group had a healthier physiological response and was better able to endure thermal stress, succumbing to bleaching more slowly than the non-variable treated group.

"This 'training' regime is similar to that of an athlete preparing for a race," said the study's lead author Allyson DeMerlis, a PhD student at AOML and the University of Miami's Rosenstiel School. "We were able to demonstrate that this temperature treatment can boost the corals' stamina to heat stress."

Moving forward, this research will guide efforts to improve the success of restoration efforts for staghorn coral, currently listed as "threatened" under the Endangered Species Act. The research also supports coral reef resiliency at a time when global warming remains a top threat to marine ecosystems. NOAA's Coral Reef Conservation Program funded the study.



Staghorn coral fragments were exposed to either twice-daily fluctuating high temperatures from 28-31°C or a static high temperature of 28°C for 3 months. The corals were then exposed to a temperature of 32°C for 2 weeks to observe their response to thermal stress.

*DeMerlis, A., A. Kirkland, M.L. Kaufman, A.B. Mayfield, N. Formel, G. Kolodziej, D.P. Manzello, D. Lirman, N. Traylor-Knowles, and I.C. Enochs, 2022: Pre-exposure to a variable temperature treatment improves the response of *Acropora cervicornis* to acute thermal stress. *Coral Reefs*, 41(2):435-445, https://doi.org/10.1007/s00338-022-02232-z.

Study Links Red Tides and Dead Zones off West Coast of Florida

Red tides caused by the algae Karenia brevis have become a near annual occurrence along the west coast of Florida, causing widespread ecological and economic harm. A new study analyzed 16 years of oceanographic data from across the West Florida Shelf to examine the frequency of hypoxia, or areas of low oxygen, and its correlation with harmful algal blooms.

Red tides are becoming a near annual occurrence along the west coast of Florida caused by large blooms of the algae *Karenia brevis*. Photo credit: P. Schmidt, *Charlotte Sun.*

A new study in the journal *Harmful Algae** has found that when red tides begin in early summer and continue into the fall, low oxygen areas—called hypoxia or dead zones—are more likely to co-occur with harmful blooms. This research by scientists at the University of Miami's Rosenstiel School, NOAA's Southeast Fisheries Science Center, and AOML is the first to systematically link hypoxia to red tides on the west coast of Florida. It offers new information to better understand the conditions that are favorable for multi-stressor events, as both hypoxia and harmful algal blooms are expected to increase as the Earth continues to warm.

Red tides are a near annual occurrence off the west coast of Florida, caused by blooms of the algae *Karenia brevis* and fueled in part by excess nutrients in the ocean. These algae blooms turn the ocean surface red and produce toxins that are harmful to marine mammals, sharks, seabirds, and humans. The toxins cause a range of issues from respiratory irritation, to localized fish kills, to large-scale massive mortalities of marine life.

"These events are so disruptive that they are being incorporated in population assessments of some grouper species for use in fishery management decisions," said Brendan Turley, a University of Miami-Cooperative Institute assistant scientist with NOAA's Southeast Fisheries Science Center and lead author of the study. "During the 2005 red tide that also had hypoxia, it was estimated that about 30% of the red grouper population was killed. There are also concerns that the conditions favorable for combined red tide and hypoxia events will increase with climate change projections into the future."

The study, conducted as part of NOAA's Gulf of Mexico Integrated Ecosystem Assessment Program, examined 16 years of oceanographic data that included temperature, salinity, and dissolved oxygen measurements from the ocean surface to the seafloor across the West Florida Shelf to determine the frequency of hypoxia and its association with known red tides.

The researchers found that hypoxia was present in five of the 16 years examined, three of which occurred concurrently with extreme red tides in 2005, 2014, and 2018. An effort is currently underway with commercial fishermen in southwest Florida that incorporates data collected annually during various NOAA surveys conducted in the region to monitor for red tide blooms and the formation of hypoxia.

This study was carried out, in part, under the auspices of NOAA and the University of Miami's Cooperative Institute for Marine and Atmospheric Studies.

Dead fish litter a beach in Sarasota, Florida. Massive blooms of the algae *Karenia brevis* turn the ocean surface red and produce toxins that cause a range of issues from respiratory irritation, to localized fish kills, to large-scale mortalities of marine life. Photo credit: NOAA-NCCOS.

*Turley, B.D., M. Karnauskas, M.D. Campbell, D.S. Hanisko, and C.R. Kelble, 2022: Relationships between blooms of *Karenia brevis* and hypoxia across the West Florida Shelf. *Harmful Algae*, 114:102223, https://doi.org/10.1016/j.hal.2022.102223.

This article is adapted from an article originally published by the University of Miami

Machine Learning Analysis of 'Omics Data Reveals how the Ocean's Tiniest Creatures Respond to Changes in the Marine Environment

Although too tiny to be seen by the naked eye, microscopic organisms have a big impact on our planet, supporting fisheries, degrading pollutants, and helping regulate the Earth's climate. A new study published in *Nature Communications** employed cutting-edge research techniques, collectively referred to as 'omics, to reveal how the ocean's tiniest creatures respond to changes in the marine environment. This work addresses a number of objectives in NOAA's 'Omics Strategic Plan, which calls for the characterization of food webs that sustain fisheries and vulnerable species.

Researchers from the Scripps Institute of Oceanography, J. Craig Venter Institute, and AOML used 'omics to reveal how microscopic bacteria, plants, and animals, i.e., the marine microbiome, responded to changes in nutrient supply in the Southern California Current region. This work is part of the NOAA-California Cooperative Oceanic Fisheries Investigations (CalCOFI) Ocean Genomics (NCOG) project, which began in 2014 with seed money jointly provided by NOAA's Office of Oceanic and Atmospheric Research and the National Marine Fisheries Service.

The work leveraged quarterly surveys from the CalCOFI program, which has been collecting data for over 70 years in the highly productive and economically valuable California Current regional ecosystem.

Example of a typical sampling set up: Bottles are stored in a crate on the bench besides two peristaltic pumps, while Milli-Q water (i.e., purified water), liquid nitrogen, and extra supplies are stored underneath the bench.

Water for eDNA analysis is collected by Niskin bottles during a CalCOFI cruise. Photo credit: Luke Thompson, AOML.

"It's interesting that 70 years ago, CalCOFI couldn't have even imagined that you could sample two liters of seawater and get comprehensive data on the marine microbial community," said Chase James, a graduate student at Scripps and the lead author of the study. Complicated patterns in space and time were observed for the various members of the microbiome.

Kelly Goodwin, an AOML microbiologist and study coauthor, said "this data set is complex. Nearly 1,000 samples were collected over 7 years, across multiple sites, and generated over 50,000 distinct genetic sequences belonging to prokaryotic and microeukaryotic organisms. Chase James used an interesting machine learning technique to reduce the complexity of the data set, called self-organizing maps or SOMs."

This approach, along with identifying the microbes in detail by using 'omics, revealed that the diversity and structure of the microbial community was best predicted by nutricline depth rather than temperature. Temperature is a globally important driver of microbial community structure according to several well-known studies conducted in the open ocean. Perhaps the different pattern observed here is because this study focused on the nearshore environment in a zone characterized by periodic upwelling.

"A major future goal of this study is to achieve the initial goals that CalCOFI set out to accomplish, which is to understand the processes that drive the success and failure of our regional fisheries," said James. "This cutting-edge research may be used to answer 70-year-old questions."

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*James, C.C., A.D. Barton, L. Zeigler Allen, R.H. Lampe, A. Rabines, A. Schulberg, H. Zheng, R. Goericke, K.D. Goodwin, and A.E. Allen, 2022: Influence of nutrient supply on plankton microbiome biodiversity and distribution in a coastal upwelling region. *Nature Communications,* 13:2448, https://doi.org/10.1038/s41467-022-30139-4.

Rainfall under Tropical Cyclones Reduces Sea Surface Cooling

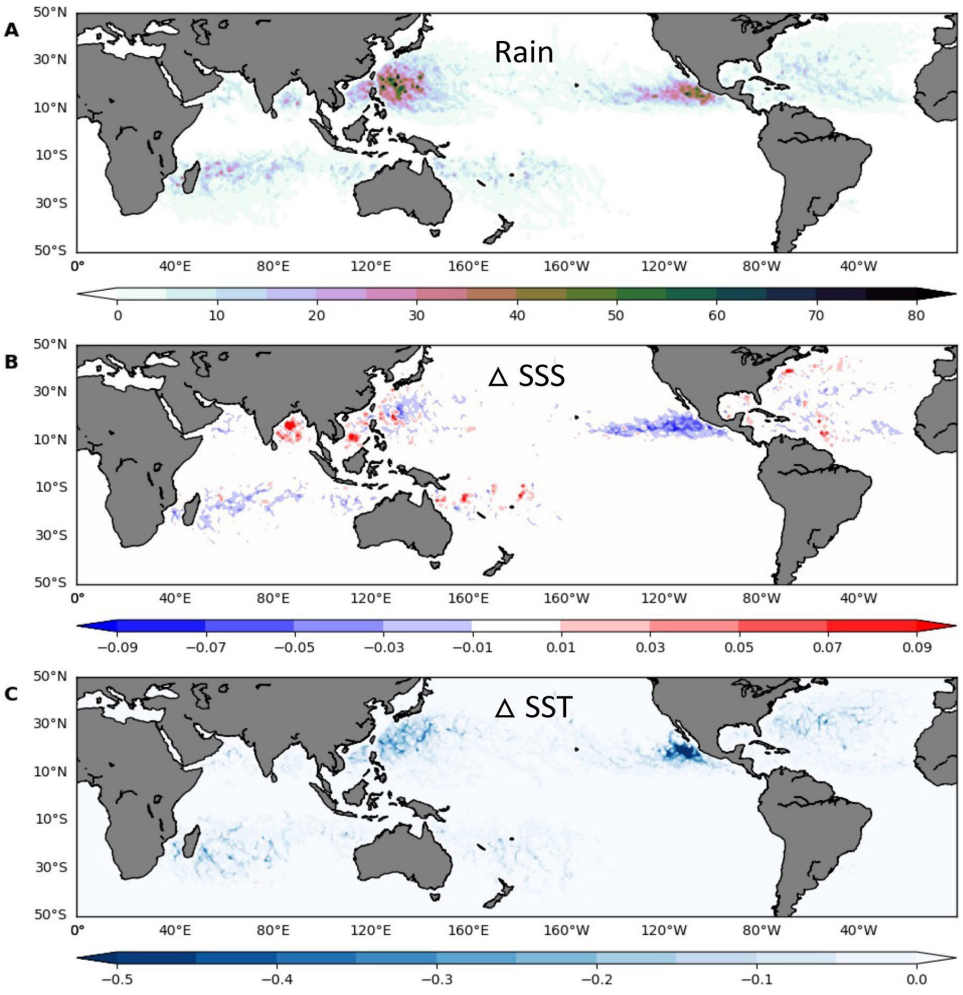
Tropical cyclones intensify by extracting heat energy from the ocean surface, making the sea surface temperature under storms crucial for storm development. A recent study* by researchers at the Pacific Northwest National Laboratory and AOML found that large amounts of rain under tropical cyclones can reduce the sea surface cooling induced by them.

When the strong winds of a tropical cyclone move over the ocean, mixing and upwelling bring colder, deeper water to the surface layer, resulting in a cooling of the sea surface temperature. This is the ocean's primary response to a hurricane, and it acts as a negative feedback on the storm's intensity, because the cooler the ocean is, the harder it is for the liquid water to become vapor to fuel the storm's clouds.

Using a variety of observations, high-resolution climate model simulations, and numerical experiments with an ocean mixed layer model, scientists demonstrated that rainfall under weak tropical cyclones can significantly reduce the magnitude of cold wakes induced by them. Less sea surface cooling allows tropical cyclones to better maintain their strength and even intensify.

While the strong winds associated with tropical cyclones tend to enhance mixing in the upper ocean, the freshwater input from rain can limit mixing. When tropical cyclones produce high amounts of rain, the added freshwater can form stratified layers that limit mixing between the warm water at the surface and the cold water that lies below. This weakened mixing reduces the sea surface temperature cooling caused by the storm.

"This is the first observational study to quantify the impact of rainfall on the ocean cooling tropical cyclones produce. The results emphasize the need to properly simulate tropical cyclone rainfall in forecast models to generate realistic ocean cooling and its negative feedback on tropical cyclone intensity," said Greg Foltz, an AOML oceanographer and coauthor on the study.



Climatological global distributions of (a) tropical cyclone rainfall, (b) the upper ocean salinity response, and (c) sea surface temperature response to tropical cyclones for the period 2004-2015 (from Balagaru *et al.*, 2022).

The mechanism identified in this study may play an important role in understanding tropical cyclone intensification as the planet warms. Tropical cyclone rain rates are projected to rise under global warming, with an amplification of the water cycle.

The study reveals that changes in the upper ocean's stratification and oceanic mixing processes are primarily responsible for the reduction of tropical cyclone-induced sea surface temperature cooling due to rainfall. Since sea surface temperature cooling plays a critical role in tropical cyclone intensification, results from the study can help improve the understanding of tropical cyclone-ocean interactions.

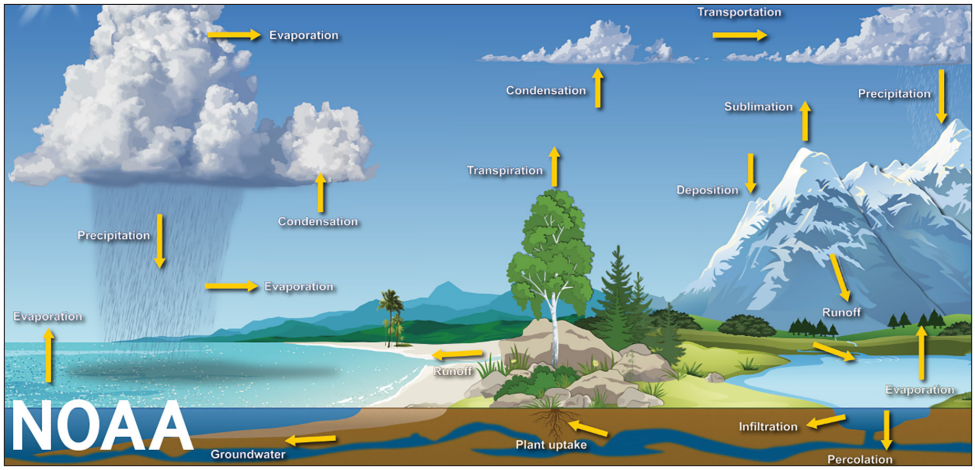


Diagram of the water cycle. Image Credit: Dennis Cain/National Weather Service.

*Balaguru, K., G.R. Foltz, L.R. Leung, and S.M. Hagos, 2022: Impact of rainfall on tropical cyclone-induced sea surface cooling. *Geophysical Research Letters,* 49(10):e2022GL098187, https://doi.org/10.1029/ 2022GL098187.

AOML Premieres State-of-the-Art Data Center

AOML premiered its new state-of-the-art data center in May, culminating an almost 5-year effort led by AOML's information technology team to provide cutting-edge computing services for the lab's scientific and administrative staff.

The impetus for the new center was Hurricane Irma, which passed over south Florida in September 2017. Following Irma, the AOML facility experienced numerous roof leaks that caused extensive water damage. The most severely impacted area was AOML's computer room, where the lab's computer servers and other critical computing resources were located.

Irma's torrential rain and 90+ mph wind gusts caused the roof above the computer room center to collapse, flooding it with water and roof debris. Although the team salvaged equipment and recovered data, damage to the room was catastrophic.

After consulting a variety of experts, the team developed and then executed a plan of action to design and build a streamlined data center in a secure location within the AOML facility. Central to the new design was the creation of a uniform, common core technology architecture that incorporated the IT requirements of AOML's three research divisions.

The multi-year effort occurred in the background, with no impact on AOML's daily computer services in support of the lab's scientific and administrative operations. Along the way, numerous technical challenges were encountered and overcome, as well as physical challenges, including construction delays and strict adherence to safety protocols necessitated by the pandemic. Construction for the data center began in March 2021.

The new data center at AOML delivers cutting-edge computing power while while keeping cooling costs in check. The center's nine cabinet system holds greater than 300 computing assets, as opposed to the old data center's total of slightly more than 100 essential computing assets. The networked computing system at AOML is comprised of 400-500 desktop and laptop computers.

The new data center is smaller than its predecessor, but comes with the built-in ability to expand as advances in technology warrant future growth. It is also more energy efficient, with ventilation and air conditioning systems that make it less reliant on external power sources. Enhanced backup capabilities ensure its continued operation, while advanced cooling capabilities keep equipment at an optimum temperature at a fraction of the cost.

AOML's new data center provides cutting-edge information technology and computing services that are energy efficient, economical, and flexible, while also reducing the lab's carbon footprint.

Oceanographer Libby Johns Retires

Dr. Elizabeth (Libby) Johns, an oceanographer with AOML's Physical Oceanography Division (PhOD), retired in June following a 36-year federal career. Libby pursued an advanced degree in marine science after graduating from Mount Holyoke College in 1976 as an English major. She earned a PhD in Oceanography from the University of Rhode Island in 1984, where her research focused on Gulf Stream dynamics. The following year Libby moved to south Florida for a post-doctoral position at the University of Miami, before being hired as a physical oceanographer by AOML in 1986.

Libby initially worked with Dr. Bob Molinari in studying western boundary currents in the North Atlantic. She later became involved with interdisciplinary efforts to study and observe the south Florida coastal ocean and the impacts of Everglades restoration on Florida Bay, Biscayne Bay, the Florida Keys reef tract, and southwest Florida shelf. In addition to this work, Libby also built partnerships with colleagues at NOAA's Southeast Fisheries Science Center, collaborating with John Lamkin's Early Life History group to study the impacts of ocean currents on the larval recruitment of economically important fish species in multiple regions across the Gulf of Mexico and Caribbean Sea. More recently, she investigated the mechanisms and transport pathways responsible for the Sargassum inundation throughout the Intra-American Sea.

Over her career, Libby worked closely with an assortment of principal investigators on various projects, led PhOD's internal review process, and enjoyed mentoring interns and the next generation of scientists. Her kindness and willingness to work with others improved both AOML's internal and external collaborations. Congratulations to Libby on the successful conclusion of her federal career and for her service to AOML, NOAA, and the nation. Best wishes for a long and happy retirement with quality time to spend with family and friends.

AOML Welcomes 2022 Summer Interns

"Despite being virtual, I have received so much invaluable support from the AOML staff, researchers, and other interns. Learning bioinformatics tools has been very challenging, but having the support from AOML has helped me overcome many obstacles and allowed me to grow as a student, scientist, and researcher."

Connie Machuca
NOAA/NERTO 2022 AOML Intern

In May, AOML began welcoming its 2022 summer interns—a motivated group of high school, undergraduate, and graduate students—who will complete 4-10 week internships at the lab. Each intern is paired with one or two mentors, all career scientists, who will challenge them to learn new skills, improve their knowledge, and gain practical work and laboratory experience in a research environment.

This year marks the largest number of in-person summer interns hosted at AOML since 2020 when mandatory telework and other safety precautions to protect employee health were initiated due to the COVID-19 pandemic.

Additionally, AOML is also hosting the largest number of undergraduate and graduate students ever working at the lab through NOAA, including William M. Lapenta, NOAA-Experiential Research and Training Opportunities (NERTO), Center for Coastal and Marine Ecosystems (CCME), and Educational Partnership Program-Minority Serving Institutions (EPP-MSI) interns.

Under the guidance of their mentors, AOML's summer interns will gather data in the field, conduct research, write code, and complete an assortment of technical assignments in support of the lab's three research divisions. They will also learn about NOAA, its mission, and the various opportunities available for students interested in pursuing careers in the marine and atmospheric sciences.

More information about the specific tasks and research AOML's 2022 summer interns will perform and/or support is available on the AOML web site at

www.aoml.noaa.gov/news/2022-interns/

A few of AOML's summer interns in front of the AOML street sign that faces the Rickenbacker Causeway.

2022 Summer Interns	AOML Mentors
Jacqueline Bloome Alonzo and Tracy Mourning Senior High School	Ulises Rivero Physical Oceanography Division
Charles Dolce–NOAA/William Lapenta Intern Texas A&M University	Renellys Perez/Greg Foltz Physical Oceanography Division
Rebecca Foody–NOAA/William Lapenta Intern Cornell University	Shenfu Dong Physical Oceanography Division
Edward Gniffke–NOAA/CCME Intern University of Texas Rio Grande Valey	Ian Enochs Ocean Chemistry and Ecosystems Division
Victoria Grisson–NOAA/William Lapenta Intern University of Texas Austin	Chris Sinigalliano/Maribeth Gidley Ocean Chemistry and Ecosystems Division
Salvador Horna Maritime and Science Technology Academy	Claudia Schmid Physical Oceanography Division
Amanda Keane University of Miami-Rosenstiel School	Michael Fischer Hurricane Research Division
Sydney Lam University of Florida	Stephanie Rosales/Luke Thompson Ocean Chemistry and Ecosystems Division
Diana Lima–Miami-Dade College Intern Florida International University	Sim Aberson Hurricane Research Division
Gabriella Lirio Florida State University	Emily Osborne Ocean Chemistry and Ecosystems Division
Nicole Luchau–NOAA/William Lapenta Intern New York University	Sean Anderson/Luke Thompson Ocean Chemistry and Ecosystems Division
Connie Machuca–NOAA/NERTO Intern California State University Monterey Bay	Kelly Goodwin/Nastassia Patin Ocean Chemistry and Ecosystems Division
Lakean McGregor–NOAA/NERTO Intern Bethune Cookman University	Chris Kelble Ocean Chemistry and Ecosystems Division
Darimar Ortiz-Davila–NOAA/NERTO Intern University of Puerto Rico	Rick Lumpkin Physical Oceanography Division
Bruno Rojas–NOAA/William Lapenta Intern Penn State University	Sim Aberson Hurricane Research Division
Sabrina Rule Maritime and Science Technology Academy	Ulises Rivero Physical Oceanography Division
Francis Seranno University of Miami-Rosenstiel School	Sean Anderson/Luke Thompson Ocean Chemistry and Ecosystems Division
Alexia Soriano Maritime and Science Technology Academy	Enrique Montes Ocean Chemistry and Ecosystems Division
Courtney White–NOAA/EPP-MSI Intern Nova Southeastern University	Jia-Zhong Zhang Ocean Chemistry and Ecosystems Division
Lara Zadeh Maritime and Science Technology Academy	Enrique Montes Ocean Chemistry and Ecosystems Division

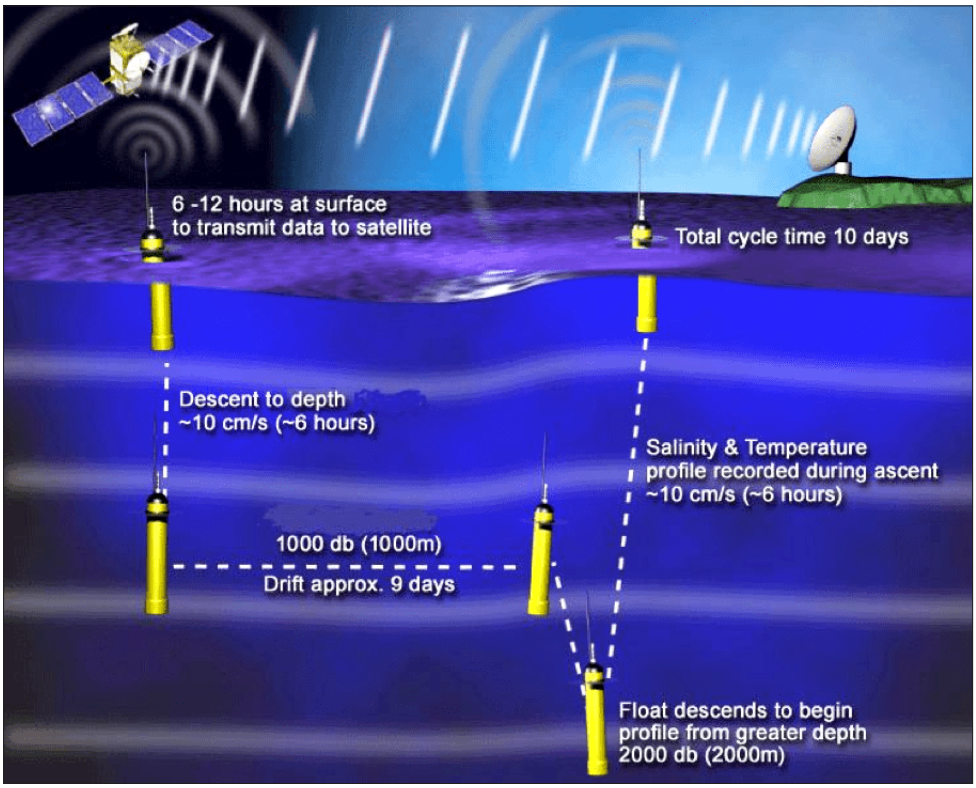
International Argo Program Receives IEEE Award

The international Argo Program, which includes AOML, was recently awarded the Institute for Electrical and Electronics Engineers (IEEE) Corporate Innovation Award "for innovation in large-scale autonomous observations in oceanography with global impacts in marine and climate science and technology."

The Argo program began in 1998 when a team of international scientists proposed the idea for a global array of autonomous floats to obtain temperature and salinity measurements of the upper 2,000 meters (1.2 miles) of the global ocean. The array of floats, called Argo, would go on to be endorsed as a pilot program of the Global Ocean Observing System and be used to fill in the large data gaps in ocean observations. Since then, the Argo Program has collected, processed, and distributed more than two million vertical profiles of temperature and salinity from the upper ocean.

Argo is an international collaborative program with participation from over 30 countries. US Argo partners include the Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, University of Washington, and NOAA's Pacific Marine Environmental Laboratory, Global Ocean Monitoring and Observing Program, and AOML, which also includes researchers from the University of Miami's Cooperative Institute for Marine and Atmospheric Studies (CIMAS).

AOML serves as the US Argo Data Acquisition Center (DAC) for the program. The role of the DAC is to collect and quality control all of the Argo data collected by US scientific and government institutions before their transmission to two international data acquisition and distribution centers that distribute Argo data to the world.



A schematic illustration that shows the cycle of the standard 10-day "park and profile" mission for a typical Argo profiling float. Image Credit: NOAA.

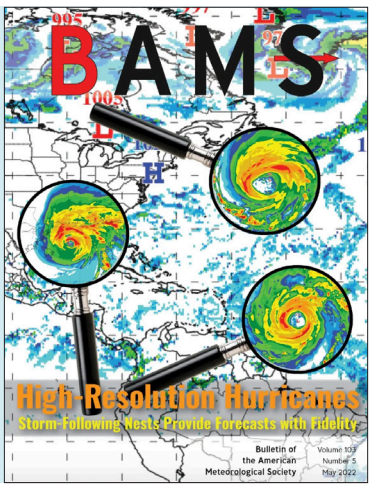
Members of the US Argo Data Assembly Team at AOML include Claudia Schmid, Emily Osborne, Molly Baringer, Jodi Brewster (CIMAS), Cedrick Estelhomme (CIMAS), Jay Harris, Jaya Nair (CIMAS), Brandon Navarro (CIMAS), Yuan-Yuan Xu (CIMAS), and Bo Yang (CIMAS), along with new members Jessica Leonard (CIMAS), Paul Johnson (CIMAS), Jen McWhorter, and Aurpita Saha (CIMAS). The award recognizes all international and US partners, along with everyone else who contributes to Argo.

The IEEE is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. The award was accepted by Argo team members during the 2022 IEEE Vision, Innovation, and Challenges Summit and Honors Ceremony on May 6, 2022 in San Diego, California.

Hurricane Storm-Following Nests Paper Featured on the Cover of BAMS

A recent peer-reviewed paper by Drs. Ghassan Alaka, Xuejin Zhang, and Sundararaman Gopalakrishnan, all with AOML's Hurricane Research Division, was the featured cover for the May 2022 issue of the American Meteorological Society's *Bulletin of the American Meteorological Society* (*BAMS*). "High-definition hurricanes: Improving forecasts with storm-following nests" by Alaka et al. (2022) provides the first research to quantify the value added to tropical cyclone intensity forecasts by storm-following nests. The paper demonstrates that storm-following nests applied to multiple tropical cyclones in the same forecast cycle can improve intensity predictions by as much as 30%. It marks AOML's first *BAMS* cover in more than a decade.

Alaka, G.J., 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, https://doi.org/10.1175/BAMS-D-20-0134.1.



AOML Scientists Support NOAA's Biennial Education and Science Forum

AOML scientists—John Cortinas, Heather Holbach, Chris Kelble, and Emily Osborne—joined hundreds of undergraduate and graduate science students from across the nation for NOAA's 10th Biennial EPP/MSI (Educational Partnership Program/Minority-Serving Institutions) Education and Science Forum on April 6-8, hosted this year at Florida A&M University in Tallahassee, Florida. The EPP/MSI Program represents NOAA's largest investment in post-secondary education and future workforce development, with thousands of students having transitioned through the program over the past 20 years. The forum provides students funded through NOAA's Cooperative Science Centers with the chance to network and present their research. It also promotes diversity and career opportunities for STEM graduates in the public, private, and academic sectors. AOML scientists interacted with the students, judged science presentations, and spoke about their research and career paths, as well as career opportunities available through NOAA. John Cortinas additionally presented a student challenge activity.

John Cortinas, Chris Kelble, and Emily Osborne at NOAA's 10th Biennial Education and Science Forum.

Earth Day at the Frost Museum Focuses on Climate Impacts

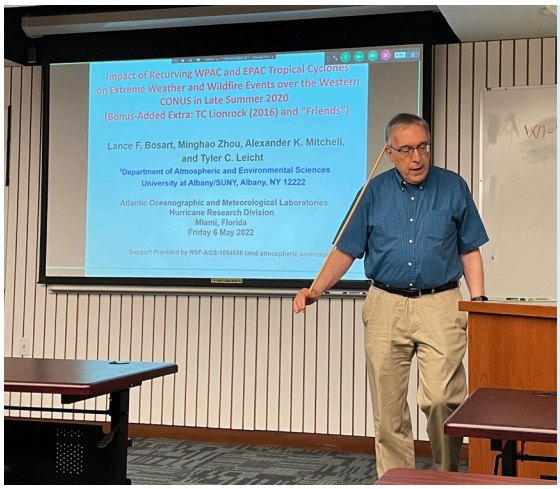
Stephanie Rosales, Katie Eaton, and Alexandra Fine of AOML's Ocean Chemistry and Ecosystems Division participated in the Frost Museum of Science's Earth Day activities on April 30. With a focus on hands-on climate activities, the event was the perfect venue to demonstrate how excess carbon dioxide in the atmosphere negatively impacts marine ecosystems like coral reefs through the process of ocean acidification. Children were invited to test the pH of water, then use straws to blow bubbles into the water and retest the pH. Observing the water's pH become more acidic from their exhaled carbon dioxide led to discussions of how excess atmospheric carbon dioxide makes seawater more acidic and how this impacts marine life, which led to discussions of how to lessen their carbon footprint.

Katie Eaton and Alexandra Fine help a young Frost patron determine the pH of water by matching the color on a pH test strip to the color on a pH chart.

Carbon Data Gathered at High Latitudes

Denis Pierrot of AOML's ocean carbon group installed an autonomous underway instrument in April aboard the *Le Commandant Charcot*, a high-end ecotourism cruise ship, to gather surface carbon dioxide measurements, i.e., pCO_2. Since then, the ship has been measuring pCO_2 at high latitudes, starting from Cherbourg, France to Reykjavik, Iceland and now sailing around Iceland and Greenland. Over the summer the *Le Commandant Charcot* will include a few excursions to the geographic North Pole, followed by a cruise through the Northwest Passage to Nome, Alaska. In addition to CO_2 observations, a FerryBox system installed aboard the ship enables it to continuously measure oxygen, chlorophyll, chromophoric dissolved organic matter, turbidity, and pH. The *Le Commandant Charcot* is operated by the French shipping company Compagnie de Ponant and has funds to support a few scientists aboard its voyages for opportunistic projects. It joins the network of volunteer merchant, cargo, and research vessels that support NOAA's Ship of Opportunity Program to gather oceanographic data from all the world's oceans. The CO_2 observations are transmitted in near real-time for processing at AOML, while meteorological data collected by the ship are transmitted in real-time to French weather services for use in forecasts and weather and climate studies. The *Le Commandant Charcot's* observations from chronically under-sampled high latitudes will help scientists better understand the global carbon cycle and its effects on Earth's changing climate. The effort to equip the *Le Commandant Charcot* with ocean-observing instruments was conducted in collaboration with Professor Nicolas Cassar of Duke University and sponsored in part by NOAA's Global Ocean Monitoring and Observing Program.

Google Earth map shows where the cruise ship *Le Commandant Charcot* is gathering measurements at high latitudes.



AOML Hosts First In-Person Seminar Since March 2020

After more than 2 years of strict adherence to safety protocols due to the COVID-19 pandemic, AOML was pleased to host its first in-person seminar on May 6, 2022. While visiting AOML to meet with hurricane research colleagues, Dr. Lance Bosart, a professor with the Department of Atmospheric and Environmental Sciences at the University of Albany/State University of New York, presented "*Impact of recurving western and eastern Pacific tropical cyclones on extreme weather and wildfire events over the western continental US in late summer 2020.*" Dr. Bosart made his presentation at AOML a week after NOAA announced its COVID-19 Reintegration Plan on April 25. A month later, however, Miami-Dade County transitioned to a high COVID-19 community level, necessitating a return to situational telework and restrictions on in-person events at the lab.

Dr. Lance Bosart presents the first in-person seminar at AOML in more than 2 years.

Eye of the Storm Focuses on Hurricane Preparedness and Education

On Saturday, May 14, AOML staff participated in a day of learning at the Museum of Discovery and Science in Fort Lauderdale. "*Eye of the Storm: Hurricane Science, Mitigation, and Preparedness*" is an annual happening co-hosted by the Florida Division of Emergency Management and Florida International University. Through exhibits, activities, and live demonstrations, the event provides information on how to prepare for hurricane season and severe weather. It also helps the public better understand how hurricanes form and develop, as well as the dangers they pose. AOML staff answered questions about NOAA's hurricane hunter missions, the assortment of instruments hurricane hunters use to gather data while flying through storms, and how NOAA uses the data for forecasts.

Neal Dorst, Katherine Sellwood, and Stan Goldenberg at the Museum of Discovery and Science in Fort Lauderdale on May 14.

***Top*: Luke Thompson provides a demonstration of the Opentrons OT-2 liquid handling robot.**

***Bottom:* Renellys Perez (center) provides a demonstration to show how temperature and salinity impact the density of water.**

Black in Marine Science Undergraduate Students Visit AOML

AOML hosted eight undergraduate students with the *Black in Marine Science* organization on May 18 as part of their week-long immersion into the south Florida marine science community. *Black in Marine Science* provides aspiring young scientists with access to learning experiences to enhance their knowledge, while also striving to increase diversity in science.

The students visited the lab to learn how scientists at AOML study and observe the marine environment. AOML director John Cortinas welcomed the group and provided an overview of the lab's deep ocean, coastal ecosystems, and atmospheric research. They were then given a tour that featured 22 members of the AOML community who showcased a variety of career paths and research areas to undergraduate students interested in marine science.

A visit to the Instrumentation Lab introduced the group to the science, instruments, and technology AOML uses to monitor the ocean's physical, chemical, and biological properties. A tour of the Microbiology and 'Omics labs explored molecular techniques to identify and measure sources of degradation to coastal ecosystems and their impact on marine ecosystem health and resilience. 'Omics technology was highlighted for its ability to genetically assess marine biodiversity, detect invasive species, and monitor biological changes in the ocean through the DNA of marine organisms found in water samples.

Scientists with AOML's Coral Program spoke of their research to support the persistence of coral reefs through monitoring and restoration activities, as well as studies to identify and strengthen resilient coral species. The students also learned about the equipment, instruments, technology, and small boats AOML uses for coastal ecosystem field sampling efforts. Demonstrations along the tour provided additional learning experiences.

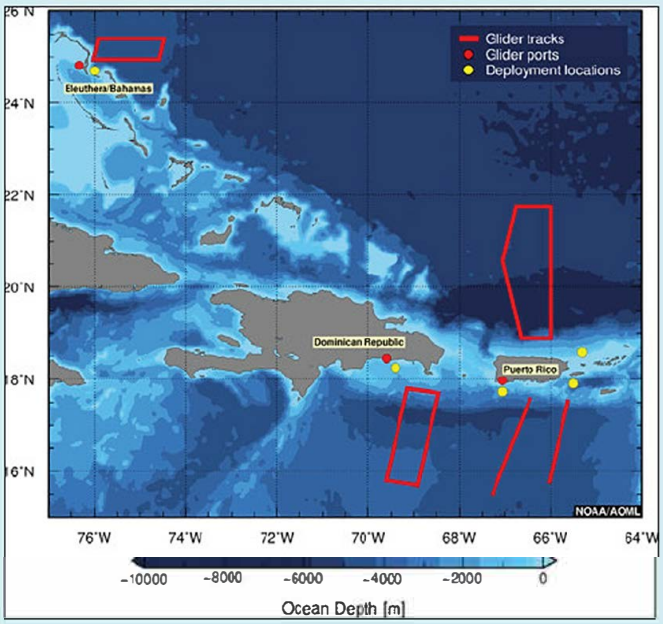
New Video Series Explores Environmental DNA

AOML released a three-part educational video series in May entitled "*Exploring environmental DNA*." The series was created by Megan Deehan, a marine conservation graduate student at the University of Miami's Rosenstiel School, as part off her year-long communications internship at AOML.

Environmental DNA or eDNA is filtered from samples of seawater. It provides scientists with information about the organisms—from microbes to mammals—that have passed through a particular region based on the genetic material, i.e., DNA, they shed and leave behind. eDNA enables scientists to more efficiently and less invasively monitor the biodiversity of different kinds of life within marine ecosystems and is valuable for managing endangered and/or invasive species, as well as for assessing the overall health of marine ecosystems.

The video series was developed in collaboration with scientists at AOML and the University of Miami's Cooperative Institute for Marine and Atmospheric Studies. Learn about eDNA through AOML's "*Exploring environmental DNA*" video series. Join Megan for part 1 of the series, "*What is eDNA?*," part 2 for an overview of the "*Subsurface Automated Sampler for Environmental DNA,*" and part 3 for a hands-on demonstration for how to extract DNA using household materials. Click the link below to access the three videos:

https://www.aoml.noaa.gov/news/exploring-environmental-dna/



Underwater Gliders deployed for Hurricane Season

Five underwater gliders will collect ocean observations this summer during the 2022 Atlantic hurricane season, the ninth year AOML and its partners have operated gliders for hurricane research and forecasts. In June, three gliders were deployed in the coastal waters off Puerto Rico—two in the Caribbean Sea and one in the tropical Atlantic. Two additional gliders, one operating east of the Bahamas and the other in the Caribbean Sea south of the Dominican Republic, will be deployed in July. All five gliders will operate for 4-5 months, obtaining 1,000-2,000 temperature and salinity profiles to depths of 1,000 meters in areas where hurricanes travel and may potentially intensify or weaken. The two gliders in the Caribbean Sea off Puerto Rico will additionally collect quasi-collocated simultaneous observations with two saildrone uncrewed surface vehicles as part of a joint NOAA-Pacific Marine Environmental Laboratory-AOML project. For more information about AOML's 2022 glider operations, visit https://www.aoml.noaa.gov/hurricane-glider-project/.

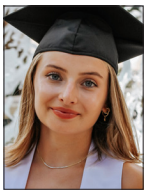
Map shows where five underwater gliders will gather observations during the 2022 Atlantic hurricane season.

Welcome Aboard

James (Jim) Barone joined the Office of the Director in May as a Facility Operations Specialist. Jim starts at AOML as an accomplished professional with experience gained from military service and government employment. Additionally, he maintains several certifications in plumbing, carpentry, masonry, and electrical, as well as a degree in psychology. Jim began his career as an enlisted member of the US Army where he served in a variety of roles, including as an Engineering Technician and Facilities Operations Manager. Before joining AOML, he was employed at the US Coast Guard station on the MacArthur Causeway leading to Miami Beach. In his new role at AOML, Jim will oversee all aspects of the maintenance and upkeep of the AOML facility.

Nicole Besemer joined AOML's Ocean Chemistry and Ecosystems Division in April as the Federal National Coral Reef Monitoring Program's (NCRMP) Caribbean Climate Operations Coordinator. Nicole began working at AOML in 2019 as a University of Miami-Cooperative Institute Senior Research Associate. In her new position, Nicole will monitor coral reefs throughout the Florida Keys, Puerto Rico, the US Virgin Islands, and Flower Garden Banks. She and the NCRMP team will focus primarily on characterizing ocean acidification and ocean warming, as well as the impacts of these stressors on the physiology and ecology of coral reef ecosystems. Nicole holds an MPS degree from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science.

NOAA Corps Officer LT Tim Holland joined AOML's Ocean Chemistry and Ecosystems Division in June as AOML's new Operations Manager. Tim will assist field sampling efforts as a dive support specialist and vessel operations coordinator. He previously served as a Deck Watch Officer aboard the NOAA Ship *Oscar Elton Sette* out of Hawaii and comes to AOML from NOAA's Global Monitoring Laboratory (GML) in Boulder, Colorado. At GML, Tim served as the station chief at two remote field sites—American Samoa and the South Pole—where in situ and remote atmospheric and solar measurements are collected. He holds a MS degree in Space Studies from the University of North Dakota..



Olivia Howson joined AOML's Ocean Chemistry and Ecosystems Division (OCED) in June as a University of Miami-Cooperative Institute Communications Intern. Olivia will work closely with OCED staff over the next year to promote their research and accomplishments by writing science articles for the AOML website, preparing web pages, supporting outreach events, making posts for social media, and other activities. She will also work closely with AOML's Communications Team. Olivia holds a BA degree in Marine Affairs and Policy from the University of Miami with minors in Public Relations and Spanish. She is currently working toward a Master of Professional Science degree in Marine Conservation at the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science.

Dr. Benjamin Johnston joined AOML's Hurricane Research Division in April as a University Corporation for Atmospheric Research (UCAR) project scientist. Ben will support NOAA's Quantitative Observing System and Assessment Program led by Dr. Lidia Cucurull by quantifying and optimizing the benefits of radio occultation observations from current and proposed satellite missions to improve hurricane predictions. Prior to joining AOML, Ben was a UCAR post-doctoral researcher with the Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) Program. He holds a PhD in Coastal and Marine System Science from Texas A&M University-Corpus Christi.

Dr. Jennifer (Jen) McWhorter joined AOML's Ocean Chemistry and Ecosystems Division in April as a term-limited federal researcher with the biogeochemical Argo team. Jen will work primarily with data from the biogeochemical Argo array in the Gulf of Mexico to explore oceanic influences on the Flower Garden Banks National Marine Sanctuary. She recently earned a PhD jointly from the Universities of Queensland and Exeter, with research focused on improving climate projections using a semi-dynamic downscaling method over the Great Barrier Reef.

Philippe Riobe joined the Office of the Director in April as the new director of AOML's Computer Services and Networks group. Phil is an information technology professional with deep expertise in innovative technologies, having led teams for over 20 years. He has spent most of his recent career working for a global Fortune 300 company, where he was responsible for evaluating and introducing new technologies to the organization. Phil holds a MS degree in Business Administration from the University of Miami, and graduated with honors from Barry University with a BS degree in Systems Engineering. He also holds many industry standard certifications and recently obtained the Certified Information Systems Security Professional (CISSP) certification from the International Information System Security Certification Consortium.

Holly Stahl joined AOML's Office of the Director in June as a University of Miami-Cooperative Institute communications intern. Holly will spend the next year working with AOML's Communications Team to promote the lab's research activities and accomplishments by writing science articles for the AOML website, maintaining and growing the lab's social media platforms, supporting outreach activities, and other duties. She will also work with the Hurricane Research Division to highlight Hurricane Field Program activities during the 2022 Atlantic hurricane season. Holly holds a BS degree in Geography-Climatic Studies from The Ohio State University with minors in Environmental Science and Media Production and Analysis. She is currently working toward a Master of Professional Science degree in Climate and Society at the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science.

Farewell

Emily Ashe, a University of Miami-Cooperative Institute communications intern with AOML's Office of the Director, completed her year-long internship in May. During Emily's time at AOML, she promoted the lab's accomplishments and research activities in a variety of ways, including writing content, maintaining and growing the lab's social media platforms, creating web pages, developing AOML's new Google site, and other related duties. Emily was also a valued member of the communications team at AOML. She recently graduated from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science with an MPS degree in Coastal Zone Management and accepted a Communications Specialist position with NOAA Research.

Lisa Bucci, a meteorologist with AOML's Hurricane Research Division, resigned in May to begin a Hurricane Specialist position with NOAA's National Hurricane Center. Lisa began at AOML as a contractor in 2010 to help develop the lab's hurricane regional Observing System Simulation Experiment (OSSE) capabilities. She transitioned to become a University of Miami-Cooperative Institute Senior Research Associate in 2012, and then a federal NOAA Pathways Intern in 2019 while working to complete her doctoral degree. Lisa successfully earned a PhD in Atmospheric Sciences in 2020 from the University of Miami's Rosenstiel School. During her time at AOML, Lisa participated in the Hurricane Field Program by flying into numerous storms, operating many of the onboard instruments, and ultimately serving as the Hurricane Field Program director in 2020. Lisa authored and co-authored papers on her OSSE work, including one that earned her and her co-authors the American Meteorological Society's Banner I. Miller award in 2016.

Megan Deehan, a University of Miami-Cooperative Institute communications intern with AOML's Ocean Chemistry and Ecosystems Division (OCED), completed her year-long internship in May. During Megan's time at AOML, she worked closely with OCED staff to highlight their research activities and accomplishments by writing news features for the AOML website, preparing web pages, creating educational videos, and a host of other duties. In addition to her work with OCED, Megan was a valued member of the communications team at AOML. She recently graduated from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science with an MPS degree in Marine Conservation.

Dr. Bo Yang, a University of Miami-Cooperative Institute senior research associate with AOML's Physical Oceanography Division, resigned in May to accept an assistant scientist position with the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science. Bo began his time at AOML in September 2020 to expand the capacity of the US Argo Data Assembly Center to process biogeochemical data from Argo floats in real-time. He also conducted research focused on using data from autonomous sensor platforms, mostly biogeochemical Argo floats, satellite remote sensing, and model simulations to study the biological production of carbon in the ocean, as well as the seawater carbon system and its connection to ocean acidification.

Congratulations

Dr. Xiaomin Chen, a Mississippi State University-Northern Gulf Institute (NGI) research scientist with AOML's Hurricane Research Division, is the 2022 recipient of the NGI Research Award, a biennial honor begun in 2020 to recognize outstanding research accomplishments by NGI staff. Xiaomin's focus is on tropical-cyclone boundary-layer parameterizations and mechanisms of rapid intensification. His research has been instrumental in developing more accurate weather forecasts for intensifying tropical cyclones.

Dr. Jason Dunion, a University of Miami-Cooperative Institute assistant scientist with AOML's Hurricane Research Division, is the recipient of the 2022 Richard H. Hagemeyer Award from NOAA's National Weather Service. Jason received the award in recognition of his leadership and substantial, long-term contributions to the US Hurricane Program. He is a 22-year veteran of AOML whose research on the remote sensing of hurricanes has led to the development of several new satellite products for monitoring tropical cyclones, Saharan dust storms, and the diurnal cycle of hurricanes. Jason received the award in March during the 2022 Tropical Cyclone Operations and Research Forum/76th Interdepartmental Hurricane Conference in Lakeland, Florida.

Dr. Jean Lim, a post-doctoral scientist with AOML's Ocean Chemistry and Ecosystems Division, is the recipient of a 2022 Women of Color STEM award. Jean was recognized by the Career Communications Group, Inc., as a Technology Rising Star for her demonstrated excellence in applying machine learning, software development, and bioinformatics to improve environmental DNA analyses and ecosystem-based fisheries management in the Gulf of Mexico. She will receive the award during the 2022 Women of Color STEM DTX Conference in October.

Dr. Gustavo Goni, an oceanographer with AOML's Physical Oceanography Division, was named in April as the new chairperson of the Sargassum Scientific Committee of the French Agence Nationale de la Recherche. The committee is tasked with evaluating the progress made in Sargassum research, including monitoring and forecasting efforts, and is jointly supported by agencies in France, the Netherlands, Brazil, and Mexico.

William (Bill) Ramstrom, a University of Miami-Cooperative Institute senior software engineer with AOML's Hurricane Research Division, was named as NOAA's Research Team Member of the Month for March 2022. Bill created and coded the first ever moving "nest" for NOAA's Unified Forecast System, a modeling system used for weather and climate operations. Bill's work supports the use of high resolution data critical for creating accurate hurricane forecast models, allowing researchers to track storm activity inside the core of a hurricane where the winds are the strongest and most destructive.

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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)*

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