AOML Keynotes

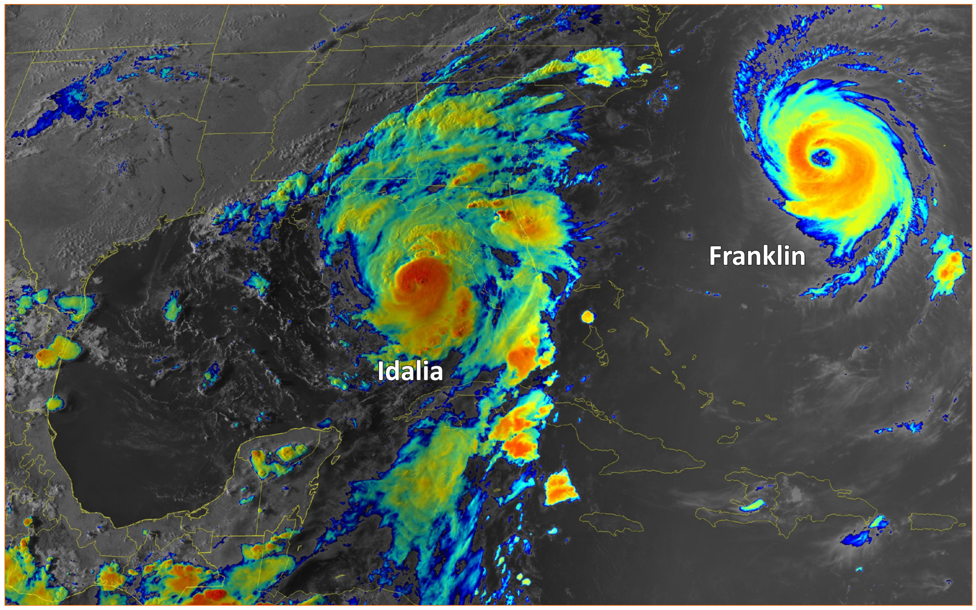
NOAA'S ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

July-September 2023

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

Multi-Faceted Effort Yields Detailed View of Hurricanes Franklin and Idalia

As Atlantic hurricanes Franklin and Idalia intensified in August, NOAA scientists collected critical data from the atmosphere, ocean surface, and ocean below. This multi-faceted effort to measure the two storms from top to bottom was undertaken to enhance forecasts and help advance the scientific understanding of tropical cyclones. While a fleet of strategically placed oceanographic instruments gathered temperature, salinity, and surface wind speed observations, NOAA's Hurricane Hunter aircraft flew repeatedly through the storms for atmospheric data.



NOAA GOES-East satellite image of Hurricane Idalia approaching the west coast of Florida and Hurricane Franklin churning in the western Atlantic on August 24, 2023.

Each element of this coordinated effort was an integral piece of a puzzle that helped NOAA's National Weather Service forecasters issue vital warnings and NOAA researchers better understand the storms, all with the goal of protecting lives and property.

From the Air

NOAA conducted 17 operational and research missions into Franklin and Idalia from August 21-31, 2023, with NOAA's P-3 aircraft flying operational missions to observe the location and intensity of both systems and tail Doppler radar missions to pinpoint the strongest winds and regions of heaviest rainfall. NOAA's G-IV jet additionally conducted one tail Doppler radar mission and numerous synoptic surveillance missions to identify the atmospheric steering currents mostly likely to influence where Franklin and Idalia would travel.

The aircraft captured the organization and development of both storms before and during the periods when they underwent rapid intensification, i.e., when hurricane winds strengthen by 35 mph or more in 24 hours or less.

The crews aboard the P-3 additionally deployed dropsondes to measure air pressure, temperature, humidity, and wind, as well as deployed airborne expendable bathythermographs to measure the ocean surface and subsurface temperature near the hurricanes. Through careful coordination, these instruments gathered data in close proximity to a saildrone, an uncrewed surface observing vehicle.

At the Sea Surface

For the third year, NOAA and Saildrone, Inc. partnered to deploy saildrones to track hurricanes in the Atlantic. Saildrones provide key information about the ocean and atmosphere, including ***cont. page 2***

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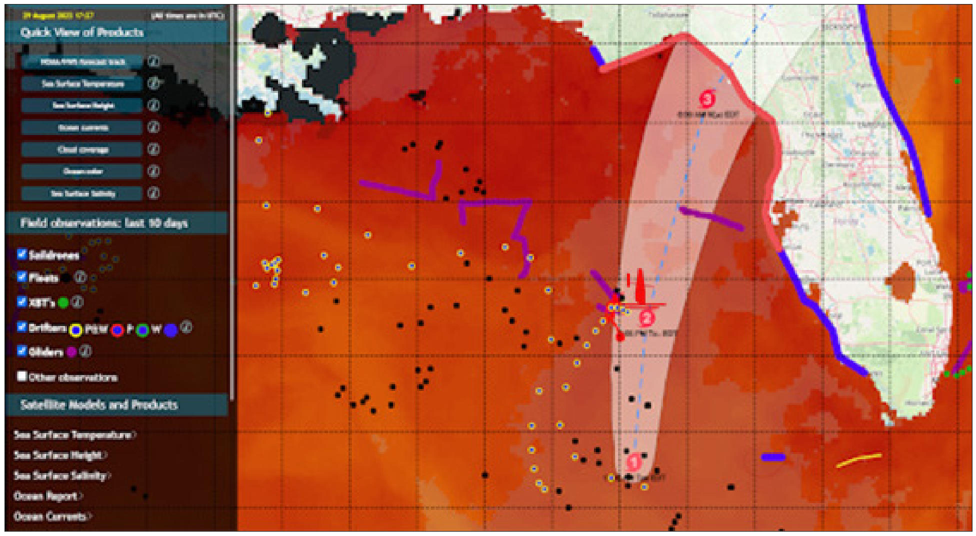
sea surface temperature, salinity, surface air temperature, humidity, pressure, wind speed and direction, and wave height.

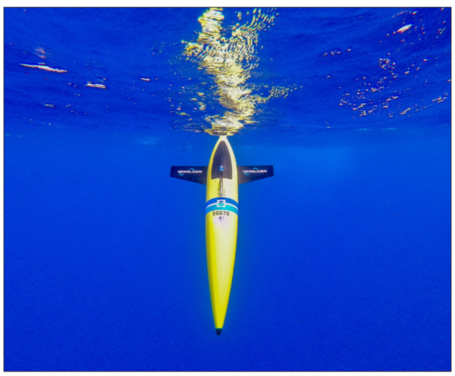
Powered by solar, wind, and wave energy, the saildrones were deployed in the early months of hurricane season in areas where tropical cyclones typically travel with the goal of collecting observations as storms passed through the region.

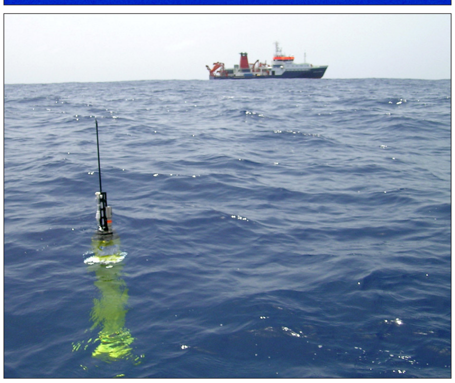
Three saildrones were impacted by the passage of Franklin, including one that spent close to 13 hours in tropical storm conditions with maximum sustained winds of 54.31 knots. A P-3 aircraft worked in coordination with the saildrones as it deployed dropsondes nearby.

Four saildrones gathered data before, during, and after Idalia's passage in both the Gulf of Mexico and the Atlantic. On August 29, Saildrone 1083 passed through the north side of Idalia's eyewall, Idalia's eye, and then Idalia's southern eyewall, all while multiple dropsondes were deployed in the vicinity of the saildrone from the P-3 aircraft. This saildrone withstood sustained tropical storm-force winds for more than 9 hours and experienced 9.6 meter (31 feet) tall waves.



Ocean observations of Hurricane Idalia on August 29, 2023 that show the location of a saildrone (red track), underwater gliders (purple tracks), floats (black dots), and drifters (black dots with yellow outlines) near Idalia, plus the forecast track of Idalia (from https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/index_phod.html).





Ocean observations were collected in Franklin and Idalia by underwater gliders (top), an Argo biogeochemical float (middle), and drifting buoys (bottom).

Below the ocean surface

While the aircraft, dropsondes, radars, and drones measured the air and sea surface, underwater gliders, profiling floats, and drifting buoys monitored the ocean below, which plays a major role in hurricane intensity. These observations supported NOAA's Extreme Events Program focused on using a variety of ocean observing technologies to examine how hurricanes respond to changes in ocean conditions and how ocean observations can improve hurricane forecast models.

Underwater gliders operated by AOML, regional partners of the Integrated Ocean Observing System (IOOS), the US Navy, academic institutions, and other collaborators collected temperature and salinity observations to depths of 1000 meters, slightly more than a half mile, in areas of the tropical Atlantic where hurricanes are known to either intensify or weaken.

One glider operated by IOOS and the University of South Florida passed under the path of Hurricane Idalia and collected collocated, simultaneous observations with a saildrone. Data were also collected by Argo floats and drifting buoys, two types of ocean observing instruments NOAA has used year-round for decades.

Argo floats are autonomous profiling instruments deployed across the global ocean. In the Atlantic Ocean basin they provide temperature, salinity, and pressure profiles as they drift with the currents and move vertically through the water column.

Several Argo floats were in the area as Franklin and Idalia passed by, including a biogeochemical Argo float that collected a profile in the path of Idalia on August 29 in the Gulf of Mexico. In addition to collecting temperature and salinity data, these specialized Argo floats also collect oxygen, nitrate, pH, chlorophyll-a, irradiance, and particles that will help unlock new information about the natural biogeochemical processes that occur in the wake of a major storm.

Several satellite-tracked drifting buoys distributed across the Atlantic basin were also impacted by Franklin and Idalia. These buoys provided researchers with in-situ observations of mixed layer currents, temperature, atmospheric pressure, winds, waves, and salinity.

A Scripps Institute wave drifter (part of the Global Drifter Program) was overrun by Category 1 Idalia on August 29 as the storm approached Florida. It measured a barometric pressure that dropped to a low of 986.3 hPa with significant wave heights peaking at 7.36 meters (25 feet).

Hurricanes Franklin and Idalia were the first and second major hurricanes, respectively, of the 2023 Atlantic season, both with sustained winds above 110 mph. The extensive, multi-partner effort to measure them by a multitude of observing instruments exemplified the commitment of NOAA's scientists to advance the understanding of tropical cyclone development, as well as their efforts to enhance forecasting and gain greater insight into the environmental conditions at play from the atmosphere to the deep ocean.

Atlantic Meridional Overturning Circulation Increases Flooding Risk Along US Southeastern Coast

Sea level rise is one of the most challenging consequences of global warming. A new collaborative study led by scientists at AOML and the University of Miami's Cooperative Institute for Marine and Atmospheric Studies has found that Atlantic Meridional Overturning Circulation (AMOC) induced changes in basin-wide ocean heat content influence the frequency of flooding along the southeast coast of the United States.

The meridional overturning circulation is a system of ocean currents that moves heat, salt, freshwater, and other properties around the Earth and throughout the global climate system. There is a surplus of heat in the tropics relative to the poles due to incoming solar radiation. The ocean, specifically the AMOC, plays a key role in transporting this heat to the subpolar North Atlantic, thus regulating global and regional climate, weather, and sea levels.

As polar ice sheets continue to melt and ocean warming intensifies, sea levels are projected to rise by over half a meter by the end of the 21st century. Due to oceanic and atmospheric conditions, sea level changes vary by location, with some regions rising much faster than the global average. The US east coast has been identified as a hotspot for accelerated sea level rise in the North Atlantic.

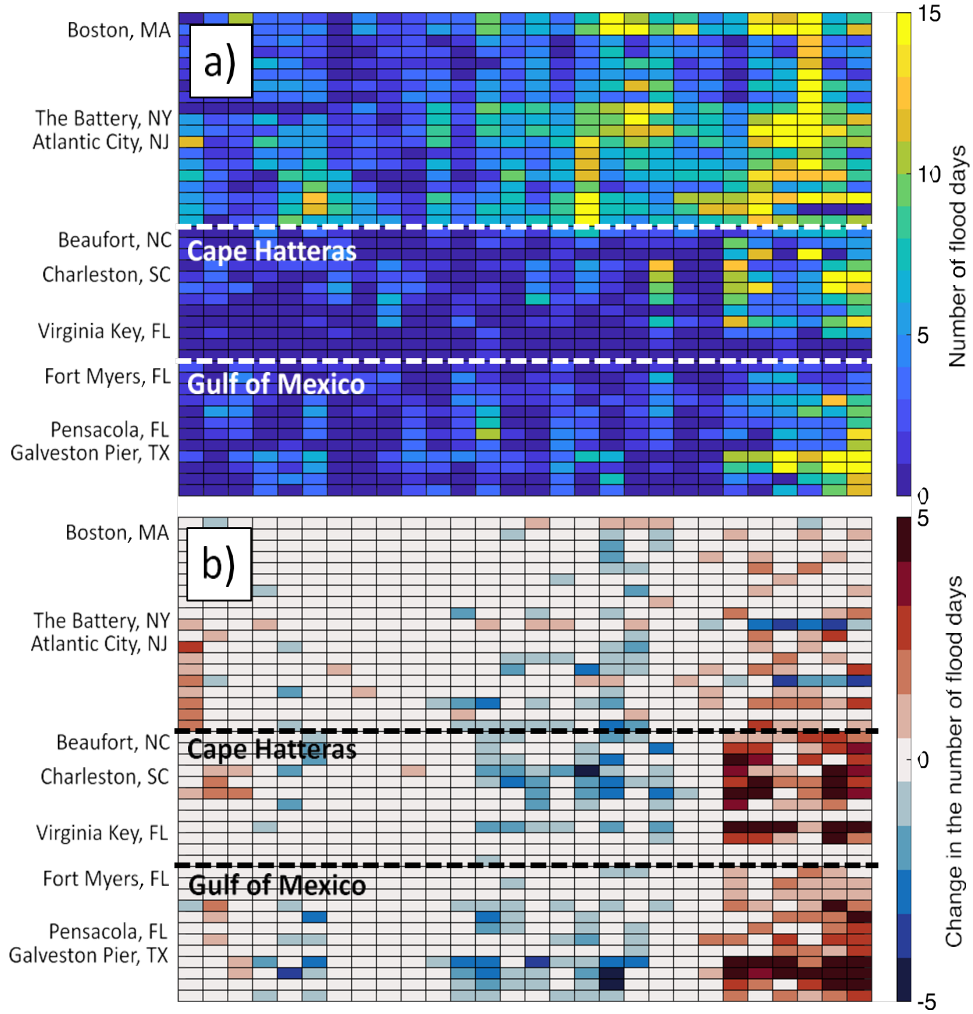
Climate models suggest a potential slowdown in the strength of the AMOC towards the end of the 21st century due to anthropogenic, i.e., man-made, forcing. This slowdown is projected to accelerate the rise of coastal sea levels along the western boundary of the North Atlantic, which should dramatically increase the risk of flooding.

This study explored an alternative mechanism, according to which changes in the AMOC lead to the redistribution of heat in the ocean and cause large-scale warming and cooling, with associated sea level increases and decreases, respectively. Specifically, when the subtropical North Atlantic warms and its sea level increases, the subpolar North Atlantic and the tropics cool and their sea levels decrease, and vice versa. This natural variability pattern is known as the North Atlantic sea surface height tripole.

In 2010-2015, an AMOC-induced heat redistribution led to a substantial warming in the subtropical North Atlantic that accelerated a rise in sea levels along the South Atlantic Bight and Gulf of Mexico coasts. This sea level rise accounted for 30-50% of local flood days in 2015-2020.

The results of this study demonstrated the importance of accounting for natural, large-scale sea level variability to improve coastal sea level projections and to better assess the risk of coastal flooding. Because its mechanisms are not yet fully understood and because it is difficult to predict, this natural variability is often neglected in coastal flood modeling and projections.

The study also highlights the value in obtaining continued, long-term measurements at ~26.5°N by the Rapid Climate Change (RAPID), Meridional Overturning Circulation Heat-flux Array (MOCHA), and Western Boundary Time Series (WBTS) projects. Continued observations obtained by the Argo program and satellite altimetry are also valuable for predicting coastal sea levels and making flood-rise projections.



a) The number of flood days per year between 1993 and 2020 at each tide gauge used in the study, as indicated on the vertical axis. A flood day is defined as a day when the water level exceeds the Minor flood threshold for 1 h or more. b) The difference between the actual number of flood days and the number of flood days after subtracting the tripole-related sea level from tide gauge records. The positive/negative values indicate years and tide gauges, when and where the North Atlantic sea surface height tripole was increasing/decreasing the frequency of floods. The horizontal dashed lines show the approximate locations of Cape Hatteras and the boundary between the US Atlantic and Gulf coasts.

*Volkov, D.L., K. Zhang, W.E. Johns, J.K. Willis, W. Hobbs, M. Goes, H. Zhang, and D. Menemenlis, 2023: Atlantic meridional overturning circulation increases flood risk along the United States southeast coast. *Nature Communications*, 14:5095, https://doi.org/10.1038/s41467-023-40848-z.

Landmark Study Indicates Weakening of Ocean Carbon Sink

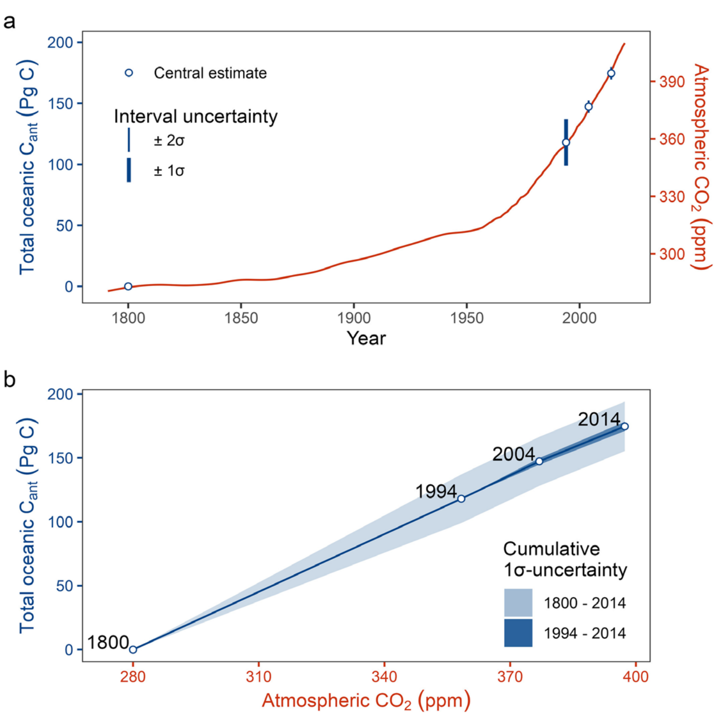
A landmark study* published by an international team of scientists has shown that the ocean's role as a carbon sink and its ability to store anthropogenic, or human-caused, carbon may be weakening. The study captured a two-decade snapshot of global interior ocean measurements to quantify the change in the ocean's storage of anthropogenic carbon and what it suggests about the future under a changing climate.

"We will not achieve the desired outcome of decreasing emissions if we don't account for the natural sinks," explained Rik Wanninkhof, PhD, an author on the paper and leader of AOML's Ocean Carbon Cycle group. "As we work towards achieving net zero emissions, we are expecting natural sinks to behave the way they have in the past… and if they don't, we'll have to decrease our emissions even more."

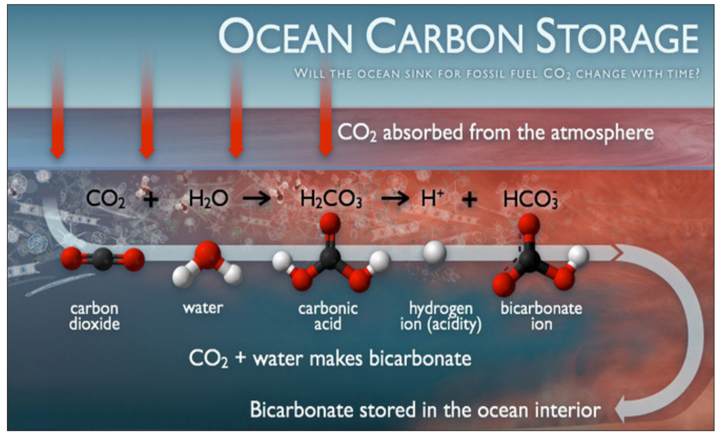
The global ocean's accumulation of anthropogenic carbon has increased proportionately with human emissions since the start of the industrial period (~1800). From 1994 to 2004, the global ocean storage of anthropogenic carbon increased by an estimated 29 billion metric tons. From 2004 to 2014, however, the global ocean storage of carbon increased by 27 billion metric tons.

Identifying the rates at which the ocean accumulated anthropogenic carbon allowed the science team to calculate what is known as the "global sensitivity" of ocean carbon uptake to the growth in atmospheric carbon. Over the 20-year period, the study found a 15% decrease in global sensitivity as atmospheric carbon emissions increased, indicating a weakening of the ocean carbon sink for anthropogenic carbon.

The authors suggest the reason for this weakening may be two-fold, attributing roughly half to a decrease in the ocean's buffering capacity. Following a fundamental principle of chemistry, the ocean reaches a point at which it has accumulated a substantial amount of carbon and begins to take up less additional carbon. The recent reduction in the "global sensitivity" could be a first indication that the ocean will accumulate anthropogenic carbon at a reduced rate in the future, leading to more carbon in the atmosphere and exacerbating climate change.



The accumulation of anthropogenic carbon in the ocean interior increased from 1800 to 2014 (a) over time and (b) as atmospheric carbon dioxide increased (figure from Müller *et al.*, 2023).



The ocean acts as a natural sink within the carbon cycle, absorbing carbon from the atmosphere and transporting it by currents to the global interior ocean. With relatively little mixing compared to surface waters, the carbon is stored for centuries in the deep ocean. Image credit: NOAA-PMEL.

The second half of the weakening is attributed to changes in the global ocean's circulation, leading to a decreased transport of carbon from surface waters to the global interior ocean where it can be stored on the timescale of centuries. Specifically, a decrease in the sensitivity of the North Atlantic to act as a carbon sink was observed over two decades and is possibly due to the observed weakening of the Atlantic Meridional Overturning Circulation (AMOC), although uncertainty remains as to whether this weakening is due to natural fluctuation.

Wanninkhof, along with Brendan Carter, PhD, and Richard Feely, PhD, both with NOAA's Pacific Marine Environmental Laboratory, analyzed global ocean carbon data from the international Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP) that were integral to the study. GO-SHIP conducts oceanographic surveys every 10 years along repeated transects to collect dissolved inorganic carbon data and other parameters around the globe. The data enable scientists to estimate the change in the ocean's uptake of carbon from the atmosphere on a decadal scale. From there, a variety of parameters are measured to "tease out" the ocean's storage of anthropogenic carbon from the natural carbon cycle and biological influences, essentially quantifying a single, critical number derived from an international collaboration of scientists from a dozen nations and decades of ocean measurements.

The study raises concerns, with some of the first potential evidence of a diminishing ocean carbon sink as climate change persists. However, it also demonstrates that understanding the extent to which the ocean is able to absorb anthropogenic carbon is crucial to counteracting the effects of climate change as scientists aim to reduce emissions.

*Müller, J.D., N. Gruber, B. Carter, R. Feely, M. Ishii, N. Lange, S.K. Lauvset, A. Murata, A. Olsen, F.F. Pérez, C. Sabine, T. Tanhua, R. Wanninkhof, and D. Zhu, 2023: Decadal trends in the oceanic storage of anthropogenic carbon from 1994 to 2014. *AGU Advances*, 4:e2023AV000875, https://doi.org/10.1029/2023AV000875.

Atlantic Niño Fuels the Most Intense and Destructive Tropical Cyclones

Scientists at AOML have found that Atlantic Niño, the Atlantic counterpart of the Pacific El Niño, increases the formation of tropical cyclones off the west coast of Africa, also known as Cape Verde hurricanes. The study published in *Nature Communications** is the first to investigate the link between Atlantic Niño and La Niña, as well as seasonal Atlantic tropical cyclone activity and its associated physical mechanisms.

Cape Verde hurricanes develop into tropical storms within roughly 600 miles of the Cape Verde Islands and become hurricanes before reaching the Caribbean. The region produces some of the Atlantic's longest lasting, most intense, and destructive storms due to plenty of warm open ocean over which to travel and strengthen before encountering land or other factors that might prompt their weakening.

Tropical cyclones that develop here make up more than half of the named tropical systems that annually form. These storms account for more than 80-85% of all major hurricanes that strike the United States and Caribbean islands (category-3 and above).

Atlantic hurricane activity is known to be largely regulated by the El Niño–Southern Oscillation, a periodic fluctuation in sea surface temperatures that occurs every 2-7 years and air pressure across the equatorial Pacific Ocean, and the Atlantic Meridional Mode, the dominant pattern of coupled ocean-atmosphere variability in the tropical Atlantic. However, these climate patterns develop predominantly in the Northern Hemisphere winter or spring and are weaker during the Atlantic hurricane season from June to November.

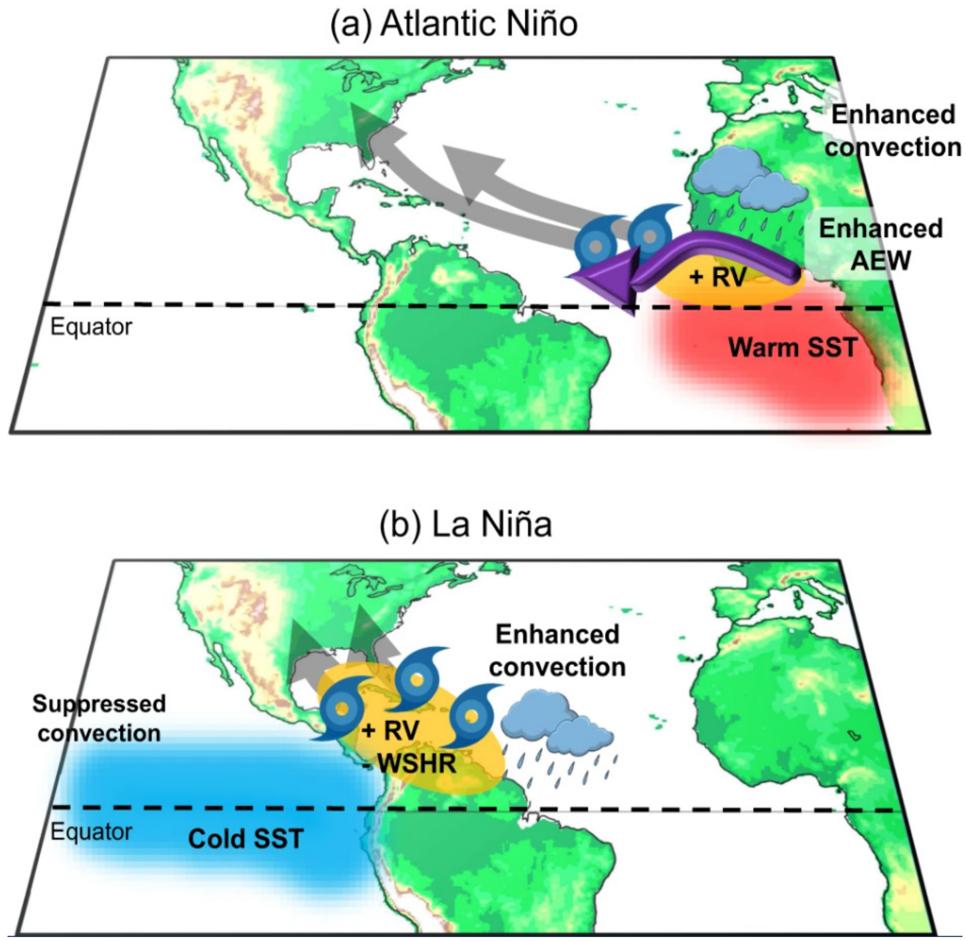
The leading pattern of sea surface temperature variability in the tropical Atlantic during the Atlantic hurricane season is the Atlantic Niño/Niña, a periodic fluctuation of sea surface temperatures across the equatorial Atlantic, similar to El Niño/La Niña in the Pacific.

However, the link between Atlantic Niño/Niña and Atlantic hurricane activity had not been previously examined. Scientists at AOML worked with partners from the University of Miami's Cooperative Institute, Northern Gulf Institute, and NOAA's Climate Prediction Center to use observations and reanalysis data that showed the Atlantic Niño strengthens the rainband over the tropical Atlantic. This enhances African easterly wave activity and low-level cyclonic vorticity (rotation) across the deep tropical eastern North Atlantic.

African easterly waves are fluctuating winds in the lower atmosphere that originate and travel westward from West Africa. These winds are seen from April until November and are responsible for about 85% of intense hurricanes and about 60% of smaller storms. Such conditions increase the likelihood of tropical cyclones developing near the Cape Verde islands, elevating the risk of major hurricanes impacting islands throughout the Caribbean and the United States.

NOAA and other agencies issue seasonal outlooks to provide the public with a guide to the expected overall activity during the upcoming hurricane season. These outlooks are largely based on the foundational relationships between observed oceanic and atmospheric states, particularly those involving the El Niño–Southern Oscillation and Atlantic Meridional Mode and tropical cyclone activity.

The Atlantic Niño/Niña, which has received little attention until now, warrants further exploration. It is potentially an additional predictor of seasonal Atlantic hurricane activity that can be used to improve seasonal hurricane outlooks, especially when other predictors are for near-normal conditions, as was the case during the 1992, 2003, and 2008 hurricane seasons.



A summary schematic illustrates the impact of (a) Atlantic Niño and (b) La Niña on Atlantic tropical cyclone activity. Blue and red shades indicate cold and warm sea surface temperature anomalies, respectively. The purple arrow in (a) indicates African easterly waves. Orange shades in (a) represent positive low-level relative vorticity anomalies, and both positive low-level relative vorticity anomalies and negative vertical wind shear anomalies in (b). The thick gray arrows in (a) represent tropical cyclone tracks.

*Kim, D., S.-K. Lee, H. Lopez, G.R. Foltz, C. Wen, R. West, and J. Dunion, 2023: Increase in Cape Verde hurricanes during Atlantic Niño. *Nature Communications*, 14:3704, https://doi.org/10.1038/s41467-023-39467-5.

Study Explores Relationship between Vortex Tilt and Intensification

In many tropical cyclones, the center of circulation in the lower and middle levels of the atmosphere is not in the same location, referred to as "tilt." Using a database of wind analyses from Doppler radars on NOAA's Hurricane Hunter aircraft, a new study* shows that the distance between the circulation centers can be a helpful predictor of future intensity changes, especially in weak systems such as tropical depressions and tropical storms.

Previous research has shown that relatively weak tropical cyclones tend to have circulations that are vertically tilted, meaning the center of circulation is not in the same place in the lower and middle levels of the atmosphere; however, relatively strong tropical cyclones, such as those of hurricane intensity, have more aligned circulations. This suggests that acquiring a nearly aligned circulation is a key step for tropical cyclones to become intense.

Despite this knowledge, whether vertical alignment precedes an increase in the system's intensity or whether alignment is the result of that increase has not been clear. The majority of previous studies exploring the relationship between intensity change and tilt used computer models and suggested that an aligned circulation was important for rapid intensification. Nevertheless, due to the lack of studies on weak tropical cyclones with data from real storms, the relationship in nature has not been established.

This study aimed to address this gap by exploring a recently developed database, the Tropical Cyclone Radar Archive of Doppler Analyses with Recentering, also know as TC-RADAR. More than 1,100 radar wind analyses were examined of tropical cyclones collected by Hurricane Hunter aircraft during NOAA's annual Hurricane Field Program.

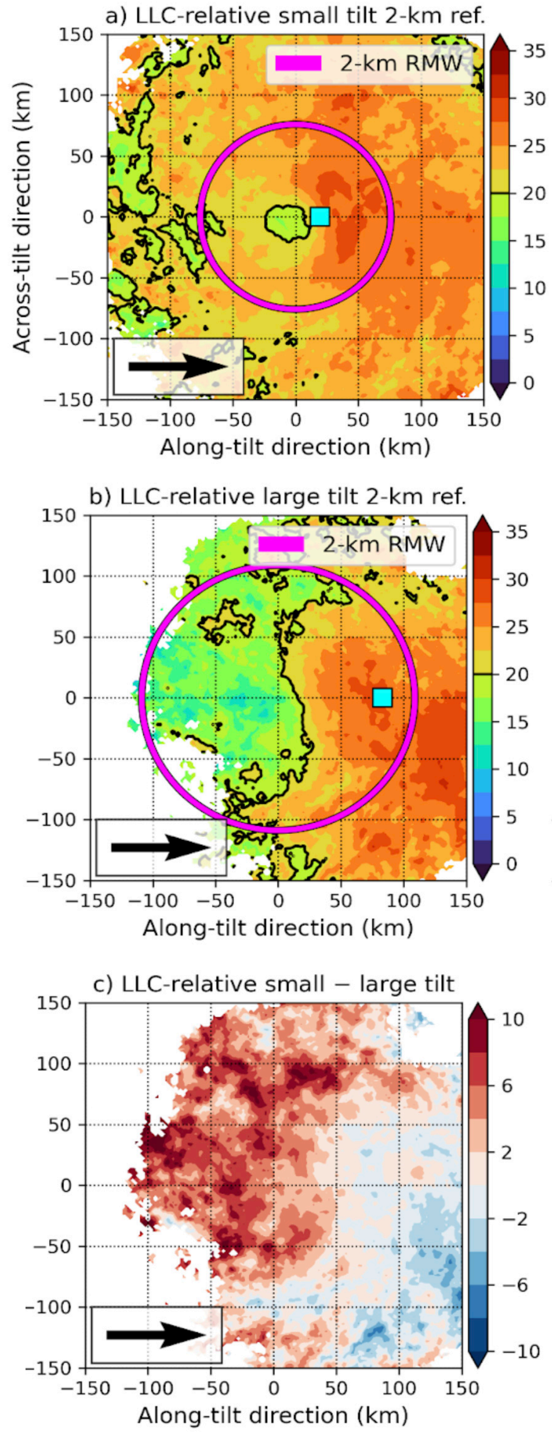
Because the relationship between alignment and intensification might be different for weaker systems than stronger systems that have already intensified, weak tropical cyclones were placed into one of two groups, "small tilt" or "large tilt," based on the degree of tilt in the lower and middle circulations. The thunderstorm activity, environmental conditions, and intensity change rates of tropical cyclones in these two groups were then compared (see images at right), allowing for a better understanding of how tilt is related to future intensity change.

In weak tropical cyclones, intensity change was closely related to the degree of tilt in the circulations. Weak, small-tilt systems intensified twice as fast as large-tilt systems. However, this relationship did not hold for strong tropical cyclones.

How quickly weak tropical cyclones intensified was dependent on both the tilt of the tropical cyclone circulation and favorability of the tropical cyclone's environment. The storms that intensified most rapidly were consistently in the small-tilt group and were typically in environments favorable for intensification. Thus, aircraft observations of the tropical cyclone tilt can provide helpful information for intensity forecasts.

This study is the first to assess the relationship between intensity change and tropical cyclone circulation tilt in weak systems using a multi-case observational dataset. It demonstrates that the circulation's degree of tilt is strongly related to the pattern of thunderstorm activity, with the strongest thunderstorms located near the circulation center in the middle portion of the atmosphere.

Small-tilt tropical cyclones were additionally found to have a greater coverage of thunderstorms closer to the center of the storm in the lower atmosphere (top image) than large-tilt systems (middle image), a favorable pattern for intensification.

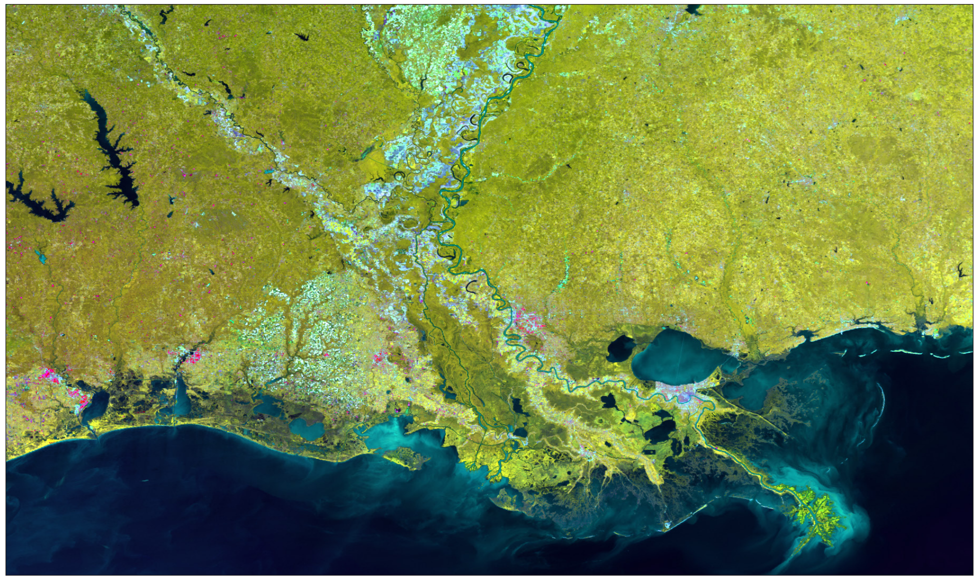


Top: **Storm-centered average radar reflectivity (a measure related to the rainfall rate; heavy rainfall is indicated by large values; units are dBZ) at a height of 2 km for all small-tilt tropical cyclones. This is constructed by placing the low-level center (LLC) of each tropical cyclone snapshot in the center of the panel and rotating each so that the mid-level center is due east of the center at 2 km (black arrow). The black contour highlights relatively large reflectivity values (>20 dBZ). The cyan square indicates the average location of the mid-level center in each set. The magenta ring shows the average location of the strongest wind around the center.** ***Middle:*** **As in the top image, but for large-tilt tropical cyclones.** ***Bottom:*** **As in the top image, but for the difference between small-tilt minus large-tilt tropical cyclones.**

*Fischer, M.S., R.F. Rogers, P.D. Reasor, and J.P. Dunion: An observational analysis of the relationship between tropical cyclone vortex tilt, precipitation structure, and intensity change. *Monthly Weather Review*, https://doi.org/10.1175/MWR-D-23-0089.1

New River Chemistry and Discharge Dataset Published for US Rivers

A new river chemistry and discharge dataset was recently published* for 140 US rivers along the west coast, Gulf of Mexico, and east coast based on historical records from the US Geological Survey (USGS) and US Army Corps of Engineers. The dataset, the work of scientists at AOML, the Northern Gulf Institute, and NOAA's Geophysical Fluid Dynamics Laboratory, will be useful for regional ocean biogeochemical modeling efforts and carbon chemistry studies.



Satellite image of the Mississippi River Delta on October 8, 2016 showing plumes of sediment and phytoplankton along the Gulf of Mexico coast. Image credit: NOAA-NESDIS.

In recent years, there has been an increased focus to better understand and quantify the influence of river inputs on US coastal ecosystems. This is reflected by the growing number of ocean biogeochemical modeling studies that address river-induced ocean patterns. The latter includes the analysis of coastal carbonate system variables impacted by riverine fluxes of carbon, alkalinity, and nutrients.

Called RC4USCoast, the dataset provides a monthly time series, as well as a long-term averaged monthly climatology, for 21 chemical variables, including alkalinity, pH, dissolved inorganic carbon concentration, and nutrients. It can be downloaded through NOAA's National Centers for Environmental Information.

"This new dataset integrates and standardizes historical USGS information from nearshore monitoring river sites," according to Fabian Gomez, PhD, a Northern Gulf Institute researcher and lead author for the study. "It makes a full set of river chemistry variables needed as inputs readily available for ocean biogeochemical models, including novel estimates of dissolved inorganic carbon. It is also useful for assessing the skill of hydrological and nutrient load models."

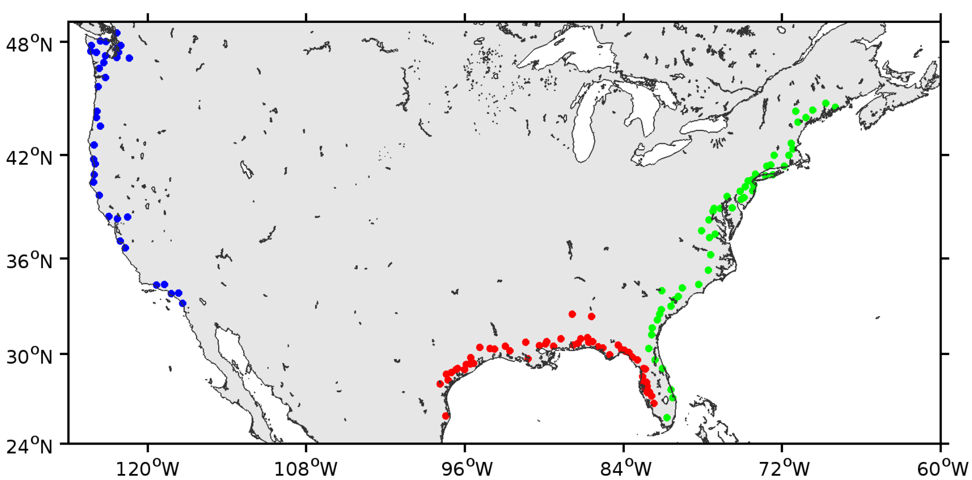
Ocean biogeochemistry models are widely used to simulate, forecast, and study marine ecosystems, ocean carbon chemistry, ocean acidification, ocean productivity, and fisheries. However, to properly simulate coastal ecosystem responses to river runoff, these models need more realistic inputs of river-water properties such as nutrients, alkalinity, and dissolved inorganic carbon concentrations.

Understanding river discharge impacts is also important because they play a role in hurricane intensification and forecasting. For example, in a recent study by scientists at AOML, it was found that the Mississippi River plume played a key role in the intensification of Hurricane Michael, a powerful category-5 hurricane that caused catastrophic damage along the Florida Panhandle as it plowed ashore in 2018.

The intense density gradient between the fresh river water on the surface layer of the Mississippi plume and the saltier ocean waters below inhibited the mixing of these two water masses. As a result, the surface layer maintained its high sea surface temperatures, enabling Michael to intensify.

This new data product for ocean-biogeochemical model applications will be used in NOAA's next-generation operational ocean modeling and decision support system, which aims to reduce impacts, increase resilience, and help marine resources and resource users adapt to changing ocean conditions.

The effort to produce the river chemistry and discharge dataset was supported by NOAA's Climate, Ecosystems, and Fisheries Initiative (CEFI), as well as NOAA's Ocean Acidification Program and Climate Program Office (CPO).



Map of the United States showing the location of US Geological Survey stations used to derive river chemistry patterns. Blue, red, and green dots correspond to rivers discharging along the west coast, Gulf of Mexico, and east coast, respectively.

*Gomez, F.A., S.-K. Lee, C.A. Stock, A.C. Ross, L. Resplandy, S.A. Siedlecki, F. Tagklis, and J.E. Salisbury, 2023: RC4USCoast: A river chemistry dataset for regional ocean model applications in the US East Coast, Gulf of Mexico, and US West Coast. *Earth System Science Data*, 15(5):2223-2234, https://doi.org/10.5194/essd-15-2223-2023.

AOML Staff Honored with Andrew Awards

AOML's Diversity, Inclusion & You (DIY) group hosted an awards ceremony on September 29 to present Andrew Awards to staff members for their exceptional professionalism and dedication to NOAA's mission, as well as for going above and beyond their regular duties during extraordinary circumstances. This year the AOML community celebrated those who supported their coworkers over the past few years, including but not limited to, the COVID-19 pandemic.

Andrew awards are given in honor of the AOML team of volunteers that selflessly helped their coworkers in the devastating aftermath of Hurricane Andrew (1992), the most catastrophic tropical cyclone to impact south Florida. DIY team members Nicole Besemer and Maribeth Gidley recognized the achievements of the following employees.

Ruth Almonte—For tireless dedication and commitment in following through on countless personnel actions, as well as administrative and budget requests.

Albert Boyd—For outstanding service and dedication to the Coral Group, AOML, and NOAA.

AOML Reintegration Team—For developing creative ways for AOML to continue producing world-class science and administrative services during the COVID-19 pandemic.

Poinsettia Byrd—For dedication and tireless work to make the AOML facility a safe, efficient, and functional place to work.

Rachel Cohn and Ian Smith—For exceptional dedication in making fieldwork possible and efficient in light of the COVID pandemic.

Izella Murry—For cheerfulness, professionalism, and efficiency in bringing normalcy to AOML during her time as a receptionist, especially when entering the building regularly during the COVID pandemic lockdown.

Jay Harris, James Haynes, Tom Heeb, Christian Labbe, Alejandra Lorenzo, John McKeever, Mike Sam, and Russell St. Fleur—For transitioning 150+ employees to mandatory remote telework in less than 2 weeks at the beginning of the COVID-19 pandemic.

Emily Osborne—For promoting a positive work culture in the Ocean Chemistry and Ecosystems Division by creating and leading the "Woman of OCED" group.

Albert Boyd with Nicole Besemer.

Emily Osborne—For creating a safe work environment for all, prioritizing the safety and well-being of researchers in the lab and field.

Ana Palacio—For dedication in supporting AOML's early career community by creating the Early Career Affinity Group.

Emy Rodriguez—For assistance with travel logistics during the Hurricane Field Program and for working extra hours to move people and equipment.

Stephanie Rosales and Alyssa Thompson—For efforts to enhance the University of Miami's health system in conducting COVID-19 tests through the loan of AOML's KingFisher instrument.

Poinsettia Byrd, James Barone, Cameron Lambert, Esperanza Lopez, Tony Perry, and Lucienne Pierre-Louis—For working diligently and efficiently to make AOML a safer and better maintained facility during the COVID-19 pandemic and during times of other health and safety issues within the building.

Elizabeth Perez—For going the extra mile to process contracts, meet tight deadlines, and tend to last-minute requests.

Leticia Barbero, Charles M. Featherstone, James A. Hooper, N. Patrick Mears, Ian E. Smith, and Emy Rodriguez—For turning the canceled GO-SHIP A13.5 cruise near the start of the COVID-19 pandemic into a new mission that maximized autonomous instrument deployments and surface water data collection.

Poinsettia Byrd with Nicole Besemer and Maribeth Gidley.

Nicole Besemer and Maribeth Gidley with Leticia Barbero (center).

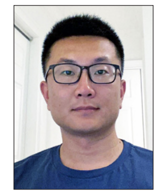
Welcome Aboard

Nicole Freeman joined AOML's Ocean Chemistry and Ecosystems Division in August as a University of Miami-Cooperative Institute for Marine and Atmospheric Studies Research Associate. Nicole will work primarily as the new 'Omics Lab Manager but will also assist with general safety matters within the division. She recently earned a BS degree in Biology from the University of Virginia with a minor in Spanish.

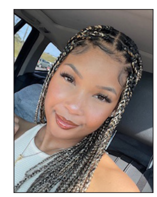
Dr. Kwun Yip "Samuel" Fung joined AOML's Hurricane Research Division in September as a University of Miami-Cooperative Institute for Marine and Atmospheric Studies post-doctoral scientist. Samuel will work with Drs. Jun Zhang and Xuejin Zhang at AOML and Professor Ping Zhu at Florida International University on the development of a three-dimensional subgrid-scale turbulent mixing scheme that will be implemented in NOAA's Hurricane Analysis and Forecasting System model. This research is in support of a Joint Technology Transfer Initiative project. Samuel recently received a PhD from the Department of Earth and Planetary Sciences at the University of Texas at Austin.

Christopher Garcia joined AOML's Physical Oceanography Division in July as University of Miami-Cooperative Institute for Marine and Atmospheric Studies Research Associate. Chris becomes part of the Engineering team to help design, test, and deploy new ocean-observing instruments for field projects, as well as maintain and repair existing instruments. He will also be a seagoing participant on oceanographic research ships and merchant vessels to assist in collecting scientific data. Chris holds a BS degree in Computer Engineering from Florida International University.

Samantha "Sammy" Harding joined AOML's Ocean Chemistry and Ecosystems Division in September as a Mississippi State University-Northern Gulf Institute Laboratory Technician. Sammy will process global environmental DNA data collected from a variety of field efforts, including the Bio-Global Ocean Ship-based Hydrographic Investigations Program (Bio-GO-SHIP), Gulf of Mexico Ecosystems and Carbon (GOMECC), and Marine Biodiversity Observation Network (MBON) projects. She holds a BS degree in Marine Biology from the University of North Carolina-Wilmington with a minor in Spanish.

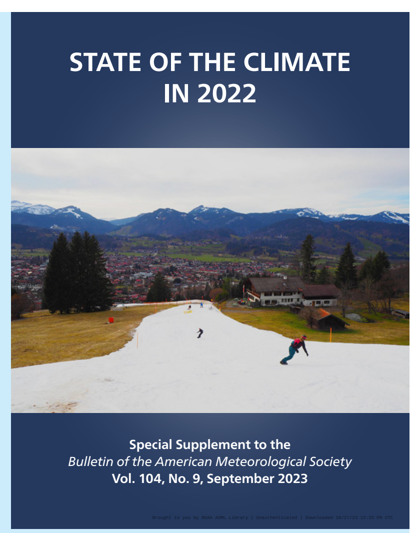


Dr. Lei Huang joined AOML's Physical Oceanography Division in September as a University of Miami-Cooperative Institute for Marine and Atmospheric Studies post-doctoral scientist. Lei will work with Drs. Denis Volkov and Shenfu Dong on the accurate attribution of sea level variability along the US eastern seaboard using a suite of satellite and in situ observations, numerical ocean models, and oceanic and atmospheric reanalyses. He recently received a PhD from the College of Earth, Ocean, and Environment at the University of Delaware.



Alexis Mayhew joined the Administrative Group of AOML's Office of the Director in September as a new Administrative Assistant contract employee. Alexis will tend to an assortment of duties in support of the Admin group, including but not limited to, assisting in the onboarding and offboarding of employees, records management, and timekeeping. She will also perform the duties of AOML's front-desk receptionist, serving as the initial point of contact for guests and colleagues at AOML.

Annual Report Documents Earth's Changing Climate



The *State of the Climate in 2022* report was released by the American Meteorological Society on September 6, showing that greenhouse gas concentrations, global sea levels, and ocean heat content reached record highs in 2022. The report is an international annual review of Earth's climate, led by scientists from NOAA's National Centers for Environmental Information and published in the *Bulletin of the American Meteorological Society*.

Based on the contributions of more than 570 scientists from around the globe, the report provides a comprehensive update on Earth's climate indicators, notable weather events, and other data collected by environmental monitoring stations and instruments on land, water, ice, and in space.

A number of researchers at AOML contributed to the report by communicating the impacts of the Earth's warming and changing environment in Chapter 3, "*Global Oceans*." The chapter documents the "triple-dip" La Niña in the equatorial Pacific Ocean that began in mid-2020, took a short break in 2021, and continued throughout 2022. The three consecutive years of La Niña conditions—an unusual "triple-dip"—had widespread effects on the ocean and climate in 2022. Although La Niña tends to decrease annual sea surface temperatures on the global scale, 2022 was still among the six warmest years on record and the warmest La Niña year, surpassing the previous record set in 2021.

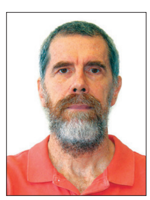
AOML researchers also contributed to the Tropical Cyclone Heat Potential (TCHP) section of Chapter 4, "*The Tropics.*" This section presented the state of the TCHP during 2022, with a focus on the seven regions where tropical cyclones occur. TCHP is an indicator of the available heat stored in the upper ocean that potentially induces tropical cyclone intensification. The section provides a discussion of the TCHP state in 2022 compared to 2021 and to the long-term average. It also discusses the possible effects of this parameter on tropical cyclone activity observed globally during the 2022 hurricane season.

Farewell

NOAA Corps Officer LT Timothy Holland departed AOML in September for his next duty station in Newport, Rhode Island. Tim will serve as the Operations Officer on the NOAA Ship *Okeanos Explorer,* which focuses on mapping uncharted areas of the ocean. During his 1.5 years at AOML, Tim served as the Operations Manager for the Ocean Chemistry and Ecosystems Division to assist with field sampling efforts as a diver support specialist and vessel operations coordinator. He also provided support for AOML's Office of the Director.

Dalynne Julmiste, AOML's Administrative Officer, resigned in August to accept a position with the Operations and Management Division of the National Marine Fisheries Service's Greater Atlantic Regional Fisheries Office. During Dalynne's 9 years at AOML, she worked alongside the AOML Director, Deputy Director, and divisional leadership team to support AOML's mission. In this role, Dalynne managed a variety of essential operations, including budget planning and execution, as well as general oversight, direction, and recommendations for AOML's budget and finances, grants, contracts, and human capital.

Izella Murry, an Administrative Assistant through the Integrated Systems Solutions contract with AOML's Office of the Director, resigned in August. Izella has accepted a Program Analyst position with the Program Office of NOAA's Integrated Ocean Observing System where she will oversee the administration of cooperative grants. During Izella's 3 years at AOML, she supported the Admin Team and tended to a variety of financial, clerical, procurement, and personnel-related duties, as well as served as the front-desk receptionist.



Kevin Sullivan, a University of Miami-Cooperative Institute Senior Research Associate with AOML's Ocean Chemistry and Ecosystems Division, retired in May after 23 years at AOML. Throughout Kevin's time at AOML, he supported the Ocean Carbon Cycle group, participating in numerous field studies and research cruises. He also designed, built, deployed, and repaired instruments used for trace gas analyses. Kevin additionally managed, processed, and quality controlled surface water carbon dioxide measurements collected in support of NOAA's Ships of Opportunity Program.

Dr. Benjamin Young, a University of Miami-Cooperative Institute post-doctoral scientist with AOML's Ocean Chemistry and Ecosystems Division, resigned in September to accept a post-doctoral research position at the University of Colorado Boulder. During his year at AOML, Ben supported the Coral Program by conducting research to identify transmission vectors and treatments for stony coral tissue loss disease, as well as apply 'omics technologies to better understand disease resistance in coral populations.

Congratulations

Michael Fischer, a University of Miami-Cooperative Institute Associate Scientist with AOML's Hurricane Research Division, is the recipient of a 2024 Editor's Award from the American Meteorological Society. Michael was recognized for his high quality and very thorough reviews of research papers submitted to the *Journal of the Atmospheric Sciences* that have been helpful in making critical editorial decisions. He will receive the award in January 2024 during the 104th AMS Annual Meeting in Baltimore, Maryland.

Dr. Hosmay Lopez, an oceanographer with AOML's Physical Oceanography Division, received a 2022 Federal Employee of the Year Award (scientific category) from the South Florida Federal Executive Board in July. Hosmay was recognized for his groundbreaking contributions to the understanding of how El Niño-Southern Oscillation (ENSO) events will evolve with global warming, with significant implications for how South Florida residents will experience climate change over the next several decades.

NOAA Makes it into the Guiness World Records

It's one, no two, for the record books! The 2024 edition of the *Guinness World Records* recognizes NOAA and industry partners with two world records: (1) the highest wind speed ever recorded by an uncrewed surface vehicle; and (2) endurance by an uncrewed aircraft system inside a tropical cyclone. Both records were achieved during AOML's 2022 Hurricane Field Program.

Catching the wind

Guinness World Records recognized NOAA and Saildrone Inc. for using a specially-designed saildrone to gather the highest wind speed ever recorded by an uncrewed surface vehicle, which occurred during Hurricane Sam—a category 4 hurricane—on September 30, 2021. On that day, the 23-foot long Saildrone Explorer SD 1045 registered a record-setting wind speed of 126.4 miles per hour. While collecting this and other weather data, SD 1045 transmitted a 28-second video that showed what it's like to be tossed inside 50-foot tall waves and 126 mph winds.

Stamina and stealth in the eye of a hurricane

Guinness World Records also recognized the Altius-600 uncrewed aircraft system, developed by Anduril, for setting a record for the longest endurance flight inside a tropical cyclone by an uncrewed aircraft. The Altius-600 was deployed from NOAA's P-3 Hurricane Hunter aircraft into Hurricane Ian on September 28, 2022. Once the drone was deployed, it spread its 8-foot long wings to fly for a record 102 minutes inside the eye of category 5 Hurricane Ian. The Altius-600 recorded wind speeds of 216 mph, communicated with NOAA's P-3 Hurricane Hunter aircraft from distances up to 135 miles, and collected key hurricane data. That data were transmitted in near-real-time to scientists, forecasters, and NOAA's operational centers.

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

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