AOML Keynotes

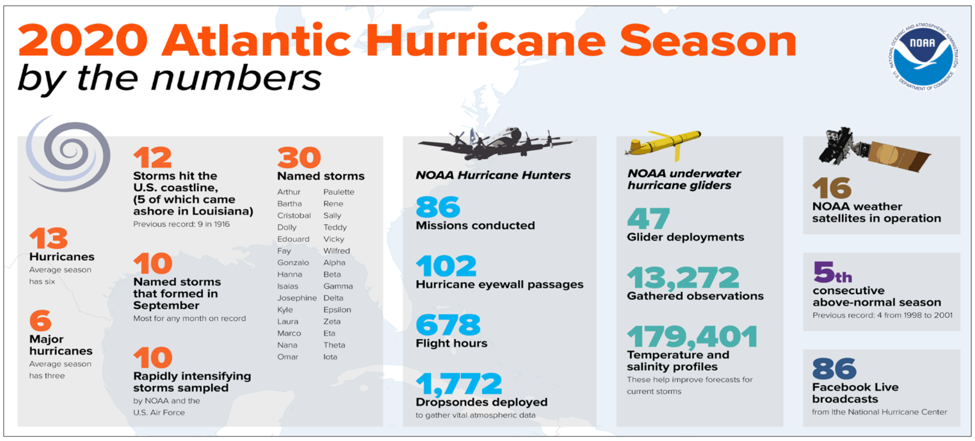
NOAA'S ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY October-December 2020

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

NOAA Meets Challenges Posed by Record-breaking Atlantic Hurricane Season

"AOML's exceptional work in aircraft mission support, gliders and uncrewed systems is a testament to the intelligence, adaptability, and dedication to duty of the entire team. Your efforts undoubtedly enhanced the accuracy of forecasts, allowing for government agencies, first responders and the public to take proactive measures and thereby lessen the risk of property damage and loss of lives."

Craig McLean
OAR Assistant Administrator



The 2020 Atlantic hurricane season presented unique challenges to NOAA's efforts to warn the public of severe weather. Atmospheric and oceanic conditions that favor storm development led to an extraordinary number of storms, while health and safety protocols due to the global pandemic curtailed the onboard participation of scientists to one person in the collection of data vital to track and intensity forecasts.

To meet these challenges, scientists at AOML collaborated with colleagues at NOAA's Aircraft Operations Center to implement a new software for virtually participating in NOAA's P-3 and G-IV Hurricane Hunter missions. The technology was used to remotely analyze, quality control, and coordinate the collection of critical storm data that are the foundation of the advisories and forecasts issued by NOAA's National Hurricane Center.

Once tested and applied, the software was successfully used during a record 58 P-3 missions into 12 storms, as well as 29 G-IV missions into eight storms. It was also used as NOAA's Hurricane Hunter aircraft collected observations in a record eight rapidly intensifying storms.

The software provided a risk mitigation strategy that ensured the safety of all participants while providing high-quality data to prepare the public for potential weather hazards such as extreme winds, storm surge, heavy rainfall, and tornadoes.

AOML was also a key contributor in NOAA's hurricane glider project, setting a new record for glider days with 47 missions, 3,600 days at sea, and greater than 179,000 temperature and salinity profiles. Many of the 2020 hurricanes traveled within range of the gliders, facilitating the capture of ocean temperature and salinity conditions below the storm while NOAA's Hurricane Hunter aircraft captured atmospheric data above.

Additionally, AOML coordinated the deployment of 36 surface ocean drifters ahead of hurricanes Isaias, Teddy, and Delta, in collaboration with numerous partners. The drifters measured surface and subsurface temperatures, winds, air pressure, ocean currents, and directional wave spectra. These combined glider and drifter observations contributed to more fully representing the ocean and atmosphere in forecast models.

The extremely active 2020 Atlantic hurricane season produced 30 named storms (39 mph winds or greater), 13 hurricanes (74 mph winds or greater), and six major hurricanes (111 mph winds or greater). The season will be remembered as the most active Atlantic hurricane season on record, surpassing the 2005 season which previously held the distinction with 28 named storms.

2020 Atlantic Named Storms

~~Arthur~~	~~Hanna~~	~~Omar~~	~~Alpha~~	~~Iota~~	Rho
~~Bertha~~	~~Isaias~~	~~Paulette~~	~~Beta~~	Kappa	Sigma
~~Cristobal~~	~~Josephine~~	~~Rene~~	~~Gamma~~	Lambda	Tau
~~Dolly~~	~~Kyle~~	~~Sally~~	~~Delta~~	Mu	Upsilon
~~Edouard~~	~~Laura~~	~~Teddy~~	~~Epsilon~~	Nu	Phi
~~Fay~~	~~Marco~~	~~Vicky~~	~~Zeta~~	Xi	Chi
~~Gonzalo~~	~~Nana~~	~~Wilfred~~	~~Eta~~	Omicron	Psi
			~~Theta~~	Pi	Omega

Greater Amounts of Cloud Ice in Tropical Cyclones Linked to Intensification

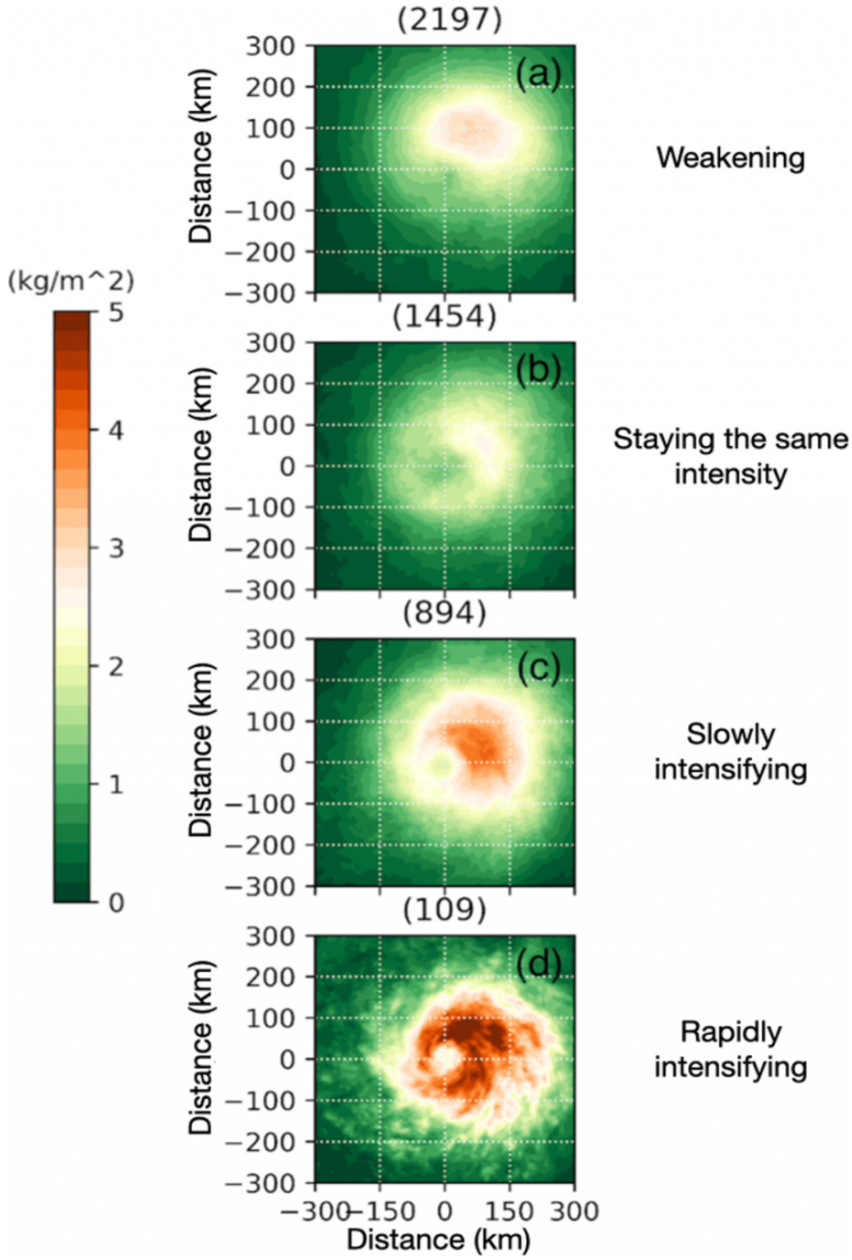
A new study published in *Geophysical Research Letters** looks at the relationship between how fast a tropical cyclone intensifies and the amount of ice in the clouds that make up the storm. Hurricane scientists found that tropical cyclones with greater amounts of cloud ice are likely to intensify faster than those with less cloud ice (see composite plots at right).

"The amount of ice in tropical cyclone clouds can be used to help predict the intensification rate of these storms," said Ghassan Alaka, PhD, a hurricane specialist at AOML. "When forecasters see a signal that indicates higher amounts of cloud ice, the results of this study provide evidence that the cyclone has a higher chance of rapidly intensifying."

It is difficult to accurately forecast a tropical cyclone's intensity. According to Alaka, the biggest problem is forecasting when intensity increases dramatically in a short period of time, known as rapid intensification.

"Rapid intensification can elude even the most sophisticated models we have available, so we are constantly searching for indicators that can help us nail down when it will occur," Alaka said.

Cloud ice can help determine the strength and organization of thunderstorms in a tropical cyclone, which can be related to the maximum wind speed near the surface. Thunderstorm activity is stronger and more organized when more cloud ice is present. Cloud ice can measure how much moisture is being transported from the surface to higher altitudes in these storms. As moisture and air are evacuated upwards into the storm, it is replaced by more air and moisture that is transported horizontally near the surface. This can lead to an increase in the maximum wind speed.



Composites of cloud ice amount for four intensification rates in HWRF forecasts. Higher amounts of cloud ice surrounding the center of a storm (0,0 in each panel) are associated with greater rapid intensification rates. The number of model snapshots in each composite is provided in parentheses above each panel.

Two types of cloud ice data were used in the study—observations from NASA's CloudSat satellite and forecasts from an experimental version of NOAA's high-resolution Hurricane Weather Research and Forecasting (HWRF) model.

CloudSat is an experimental satellite that observes clouds and precipitation from space. It uses a special downward-looking radar to measure the amount of energy that is reflected by a cloud that, when combined with temperature data, estimates how much ice is in the cloud.

NOAA's HWRF model predicts the amount of ice in clouds as part of its forecast system. Both CloudSat measurements and HWRF simulations provided high-resolution data sets of ice water content, which helped scientists better understand the relationship between cloud ice and intensification.

Hurricane scientists found that rapidly intensifying tropical cyclones have larger ice water content compared to tropical cyclones with slower intensification rates, even after accounting for the effect of initial tropical cyclone intensity.

"CloudSat and HWRF provided two independent evaluations of cloud ice," said Alaka. "The fact that the results from these two data sets were so similar provides confidence that cloud ice from both satellite measurements and high-resolution model simulations can be used to accurately predict the intensification rate of tropical cyclones."

The results from the study can be used to improve NOAA's hurricane forecast models and better the nation's ability to prepare for and respond to these natural disasters.

---

*Wu, S.-N., B.J. Soden, and G.J. Alaka, 2020: Ice water content as a precursor to tropical cyclone rapid intensification. *Geophysical Research Letters,* 47(21):e2020GL089669 (https://doi.org/10.1029/2020GL089669).

NOAA's Hurricane Gliders Return Home after a Busy Summer

NOAA's hurricane underwater gliders were recovered in November after 4 months at sea. Deployed in July, they gathered temperature and salinity data in the coastal waters of Puerto Rico, the Dominican Republic, US Virgin Islands, Gulf of Mexico, and US eastern seaboard to improve the accuracy of hurricane forecast models.

Accurately representing the ocean in forecast models is an emerging priority due to the turbulent interaction that occurs between the ocean and atmosphere during the passage of tropical cyclones. Gliders provide invaluable information about the ocean's subsurface thermal and saline structure. This information has been shown to improve the ocean's representation in NOAA's forecast model, leading to a reduction in intensity forecast errors.

The gliders are battery powered, remotely piloted, and operate under hurricane conditions. As they move through the ocean down to a half mile below the surface, they measure salinity, temperature, and other physical, chemical, and environmental parameters. Upon returning to the surface, their data are transmitted to satellites for immediate assimilation into NOAA's operational forecast model. Gliders provide high-volume, high-resolution, real-time data in areas where tropical systems frequently travel and intensify but where ocean observations are not routinely collected.

Scientists at AOML have deployed underwater gliders in the Atlantic basin every hurricane season since 2014. This summer they deployed 15 gliders that significantly increased the volume of observations.

NOAA and partner gliders collected more than 163,000 profiles of temperature, salinity, dissolved oxygen, and other parameters. The NOAA gliders also gathered data during Hurricane Isaias, Tropical Storm Josephine, and Hurricane Laura.

To prepare for the 2020 hurricane season, scientists at AOML trained new glider pilots and technicians from partner institutions in Puerto Rico and the Dominican Republic. Additionally, NOAA and the US Integrated Ocean Observing System (IOOS) jointly hosted a virtual workshop in April 2020 for planning glider deployments in the tropical North Atlantic Ocean, Caribbean Sea, South and Mid-Atlantic Ocean, and Gulf of Mexico.

AOML deploys underwater gliders to enhance understanding of air-sea interaction processes that occur during hurricane events. Credit: NOAA AOML.

AOML and partner scientists after retrieving and securing several hurricane gliders. Credit: NOAA AOML.

This training was crucial for enabling NOAA and its partners to continue glider operations during the 2020 Atlantic hurricane season, in spite of uncertainties due to the global pandemic and subsequent restrictions in travel.

AOML conducted the 2020 hurricane glider project in partnership with colleagues at IOOS, the US Navy, Caribbean Coastal Ocean Observing System (CARICOOS), the University of Puerto Rico, Cooperative Institute for Marine and Atmospheric Studies, the Dominican Republic Maritime Authority, and Southeast Coastal Ocean Observing Regional Association (SECOORA).

All of AOML's glider data were made available in real-time on the IOOS Glider Data Assembly Center web site and AOML hurricane glider web page. Additionally, glider, in-situ, and satellite observations were posted in real-time on the NOAA-AOML Hurricane OceanViewer (see links below).

Hurricane gliders safely retrieved and on deck after having spent much of the 2020 Atlantic hurricane season at sea. Credit: NOAA AOML.

IOOS Glider Data Assembly Center:
https://ioos.noaa.gov/project/underwater-gliders/

AOML Hurricane Glider web page:
https://www.aoml.noaa.gov/phod/goos/gliders/index.php

NOAA-AOML Hurricane OceanViewer:
https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/index_hrd.html

Scientists Test Saildrone Designed to Withstand Hurricane-Force Winds

On November 8, 2020, a newly designed and fully autonomous "extreme weather" saildrone was launched from Saildrone, Inc. headquarters in Alameda, California. The saildrone will spend the winter in the eastern North Pacific and Gulf of Alaska collecting upper-ocean and near-surface atmospheric observations during strong winter storms and rough seas.

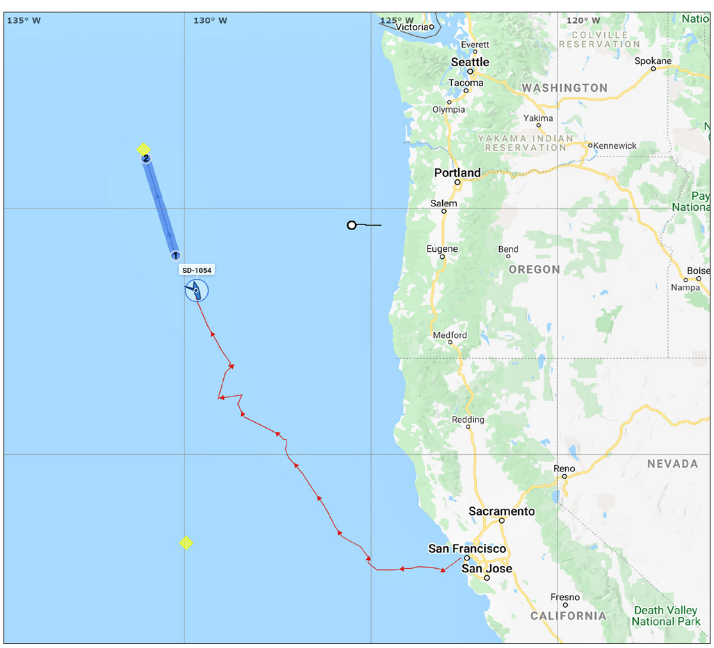
The main objective of this joint project between AOML and researchers at NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle, Washington is to perform a rigorous test of this new generation of saildrone in the harsh conditions of the North Pacific winter, with winds that can approach Category-1 Atlantic hurricane strength, while transmitting data in real-time to forecast centers such as NOAA's Environmental Modeling Center (EMC). If all goes well, multiple extreme weather saildrones may be deployed in the western Atlantic Ocean and Caribbean Sea during subsequent hurricane seasons to provide critical air-sea measurements that will aid hurricane forecasts.

Saildrones are propelled entirely by the wind and ocean currents and are equipped with solar panels to power their scientific instruments, which for this mission include sensors for near-surface winds, air temperature, humidity, barometric pressure, sea surface temperature and salinity, wave height and direction, and ocean velocity profiles. The standard saildrone is about 7 meters long with a 5-meter tall rigid sail. The new generation of saildrone for extreme weather has a shorter 3-meter sail to provide greater stability in strong winds and rough seas.

Although the main objective of the mission is to test the survivability and operability of the saildrone, other important tasks include comparing saildrone data with measurements from open-ocean moored buoys and coordinating the data from saildrones with ocean glider data to obtain collocated ocean-atmosphere measurements off the coasts of Oregon and Washington. However, the gliders are part of a separate project.

Hurricanes are some of the costliest and most dangerous natural hazards on Earth. To effectively plan and prepare for these extreme events, accurate forecasts of tropical cyclone track and intensity are required. Track forecasts have improved dramatically since 1970, yet similar progress has lagged for hurricane intensity prediction. The role of the ocean in intensity changes has been an area of study within NOAA and academic institutions. With advances in satellite observations, ocean observing platforms, air deployed instrumentation, and numerical modeling, scientists continue to assess how ocean and atmospheric processes contribute to hurricane intensification and weakening.

Saildrone 1054 will be tested by AOML and PMEL researchers for its ability to withstand extreme weather in the harsh winter conditions of the North Pacific Ocean and Gulf of Alaska.



Path of the saildrone through November 30 (red line) and planned track (dark blue shading) to the first buoy for data comparison (yellow diamond). White circle off the coast of Oregon shows the location of an ocean glider.

AOML has been a key contributor of uncrewed glider operations since 2014 and is now initiating its participation with saildrone autonomous surface vehicles in collaboration with colleagues at PMEL, EMC, the Integrated Ocean Observing System (IOOS), and Cooperative Institute for Marine and Atmospheric Studies. The ultimate objectives of the extreme weather saildrone are to acquire continuous measurements near the air-sea interface ahead of and inside of hurricanes, provide collocated measurements with ocean gliders, and transmit the data in real-time to aid hurricane intensity prediction, with the overarching goal of improved understanding of ocean-atmosphere interaction during strong wind events and reduced errors in hurricane intensity forecasts.

These saildrone measurements will fill a critical gap in the ocean-hurricane observing effort, as there are no other autonomous observing platforms capable of continuous, high-resolution air-sea measurements through hurricanes. The measurements will be part of a much broader AOML hurricane observational effort that includes the deployment of dropsondes and other expendable ocean instruments from reconnaissance aircraft, as part of the AOML's Hurricane Field Program, as well as small uncrewed aerial systems and hurricane ocean gliders.

The longer-term plan is to routinely deploy several saildrones in the western Atlantic Ocean, Caribbean Sea, and Gulf of Mexico every hurricane season to augment existing observational efforts. For this, continued partnerships across NOAA line offices (National Weather Service, National Ocean Service, Global Ocean Monitoring and Observing Program), IOOS and its Regional Associations, and outside of NOAA will be extremely valuable.

The saildrone project is supported by federal and university scientists at AOML (Greg Foltz, Jun Zhang, Hyun-Sook Kim, Gustavo Goni, Frank Marks, Joe Cione, Joaquin Trinanes, Ulises Rivero), PMEL (Dongxiao Zhang, Chidong Zhang, Chris Meinig), EMC (Avichal Mehra), and the University of Puerto Rico (Julio Morell).

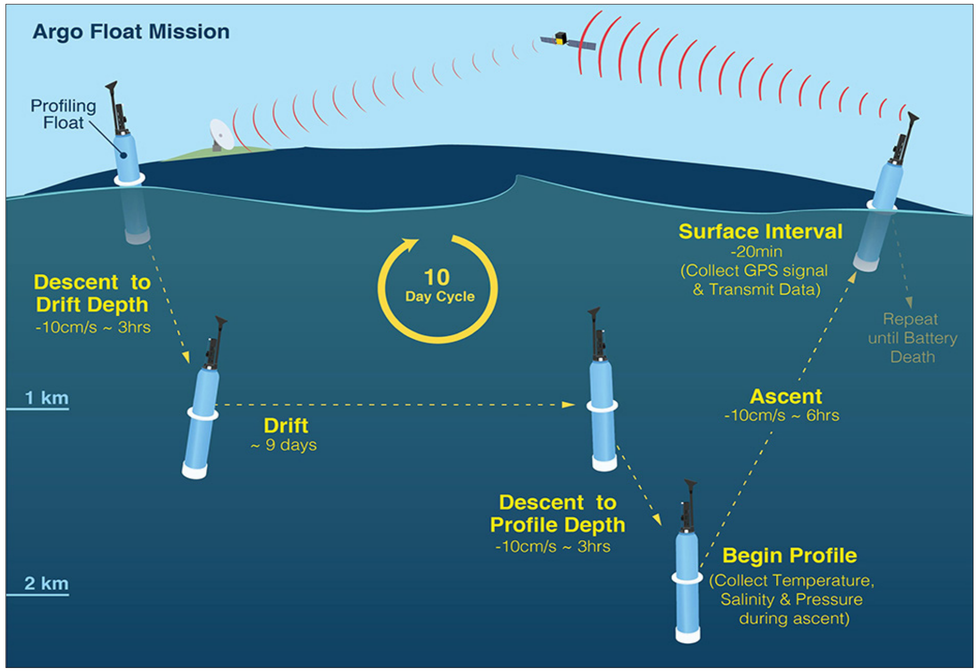
Recounting the Argo Program's Two Decades of Ocean Observations

NOAA's groundbreaking Argo program was highlighted in a recent article in *Frontiers in Marine Science*.* The Argo program began in 1998 when a team of international scientists proposed the idea for a global array of autonomous floats to measure the temperature and salinity of the upper 2,000 meters 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 the large data gaps that existed in ocean observations.

Since its inception, the Argo program has collected, processed, and distributed more than two million vertical profiles of temperature and salinity from the upper ocean. The initial goal of Argo called for the deployment of 3,000 profiling floats in a 3° x 3° array across the open ocean between 60°N–60°S. These floats would be deployed by participating countries, but the data would be shared internationally.

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 Argo data collected by US scientific and governmental institutions before their transmission to three international data acquisition and distribution centers that distribute Argo data to the world. Data from Argo floats are freely available in real-time and widely used in ocean and atmospheric models.

The name Argo was chosen because of the program's partnership with the Jason earth observing satellites that measure the shape of the ocean surface. In Greek mythology, Jason sailed aboard his ship called *Argo*. In oceanography, Jason and Argo together would provide regular global sea surface height and subsurface temperature and salinity measurements.



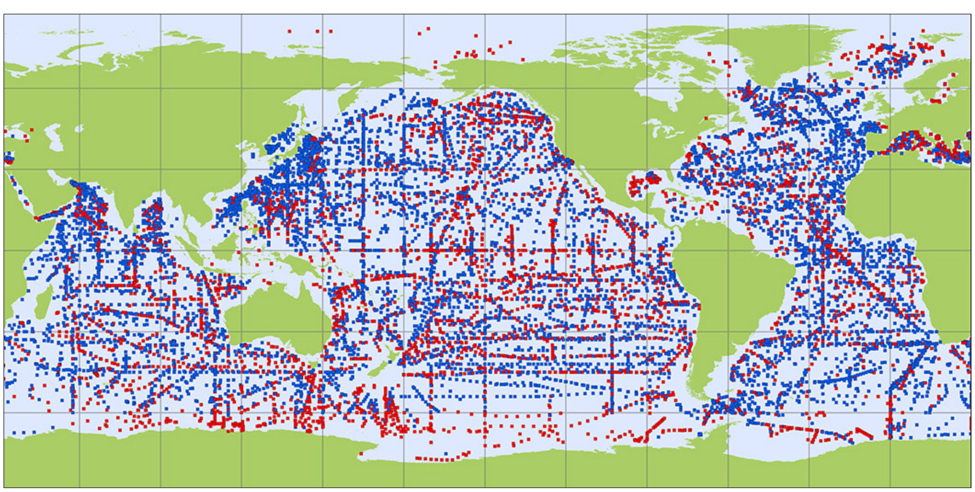
A schematic illustration of the standard 10-day Argo "park and profile" mission (Source: Woods Hole Oceanographic Institution).

The standard Argo mission, known as "park-and-profile," is shown in the schematic above. To begin, a float descends to the target depth of 1,000 m to "park" and drift with ocean currents. Every 10 days the float descends to 2,000 m where it then collects a vertical profile of temperature and salinity as it rises to the surface. The data are transmitted, and the float's position is determined by either the Argos System or the Global Positioning System. The float then returns to its target park pressure, and the cycle is repeated. Deployments of Argo floats began in 1999, and the 3,000-float goal was reached in November 2007.

Today, Argo is an international collaborative project involving 34 countries that have deployed more than 15,000 floats. After two decades Argo has surpassed its original goals and continues to look for ways to improve and expand its coverage. Argo's nearly global coverage is crucial for the detection of climate change signals, an estimation of the ocean's heat content, and for observations of the intensification of the global hydrological cycle.

Looking forward, advances in machine learning algorithms have the potential to provide an important resource to the Argo community by helping meet the challenge of maintaining the quality of data from more floats and diversified missions as the program continues to expand.

In October 2019, NOAA's Global Ocean Monitoring and Observing Program awarded $3 million in funding for new projects that will expand the Argo program's ability to measure ocean chemistry, enabling scientists to improve their understanding of key biogeochemical and biological ocean phenomena.



Global map that shows the launch location of all profiling floats deployed through the Argo program in January 2020. Blue dots indicate floats that transmit their data via the Argos satellite system, whereas red dots are for floats that use the Iridum satellite constellation (Source: JCOMMOPS).

---

*Wong, A.S.P., *et al.*, 2020: Argo data 1999-2019: Two million temperature-salinity profiles and subsurface velocity observations from a global array of profiling floats. *Frontiers in Marine Science*, 7:700 (https://doi.org/ 10.3389/ fmars.2020.00700).

NOAA Premieres New National Marine Ecosystem Status Web Tool

NOAA launched its new National Marine Ecosystem Status web tool (https://ecowatch.noaa.gov/home) in October that shows the status of marine ecosystems across the US. The tool provides easy access to NOAA's wide range of essential coastal and marine ecosystem data in one location for the first time.

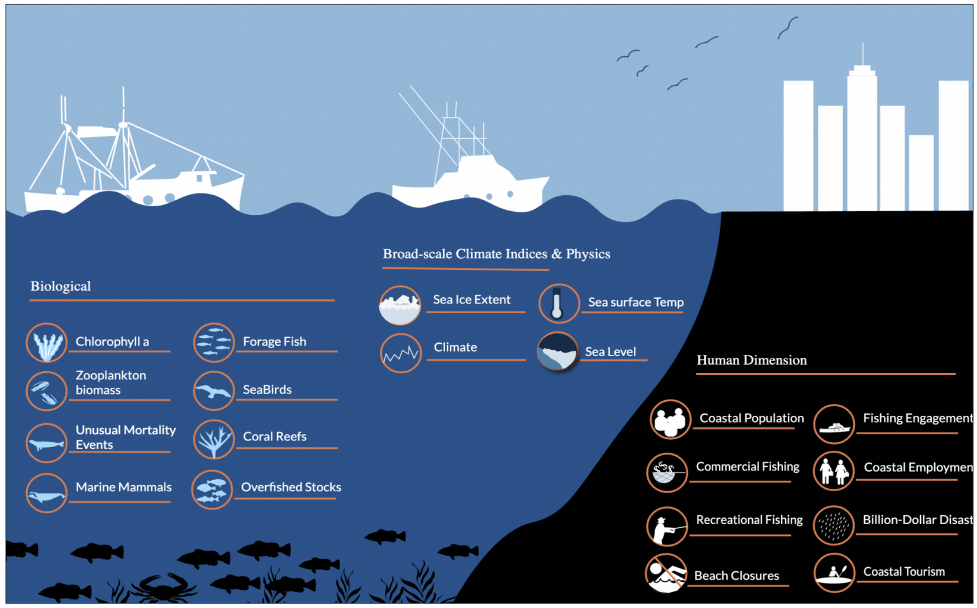
Christopher Kelble, PhD, an AOML oceanographer, contributed to the effort by participating as a member and then as the co-chair of the Ecosystem Indicators Working Group of NOAA's Research Council. The group reviewed indicators of marine ecosystem conditions and selected a standardized suite of indicators to assess the condition and trends of all US marine ecosystems.

"The standardized indicators had to span the range of ecosystem components—from the climate to the physical and chemical environment to biological components to human dimensions—for it to be a comprehensive assessment of the ecosystem condition," said Kelble.

The new web tool assesses status and trends at the national level within seven ecosystem regions: Alaska, Hawaii-Pacific Islands, the California Current, Gulf of Mexico, Caribbean, Southeast US, and Northeast US.

"Prior to this effort there were a multitude of ecosystem indicators spread across hundreds of websites that assessed marine ecosystem status in the US," Kelble said. "Now for the first time at NOAA we have a single website that assesses ecosystem conditions from physics to whales using standard indicators and data sources across US marine ecosystems and at the national level."

The National Marine Ecosystem Status website provides the interested public, educators, outreach specialists, natural resource managers, and others with a starting point to explore the status of these seven marine ecosystem regions and the nation at-a-glance. It also provides access to all NOAA websites with ecosystem data on specific themes for more technical audiences.



Graphic from the National Marine Ecosystem Status website that lists marine ecosystems and their icons for each of the key indiators highlighted on the site.

Ecological indicators touch upon key components of the ecosystem, including human activities and human well-being. This is essential, as key ecosystem components, from sea surface temperatures to coastal tourism, are interconnected.

For example, broad-scale climate patterns such as the Pacific Decadal Oscillation impact the temperature of the ocean. These broad-scale climate patterns interact with shorter scale climate patterns/shifts to impact plankton. Plankton are the basis for the marine food web and a primary food source for various types of marine organisms including fish and marine mammals. This means that shifts in plankton productivity can have a direct effect on fisheries and the seafood industry. Humans also rely on various ocean services such as tourism, seafood, and recreational activities.

The National Marine Ecosystem Status web tool provides the public with a resource for quickly viewing the status and changes in the marine ecosystems they are dependent upon.

"They will also be able to go directly to the data sources for these indicators to find more detailed information," said Kelble. "Ideally this will allow our stakeholders to better understand the changes occurring in these ecosystems and the benefit each ecosystem provides to society via the human dimensions indicators."

Remembering Greg Banes

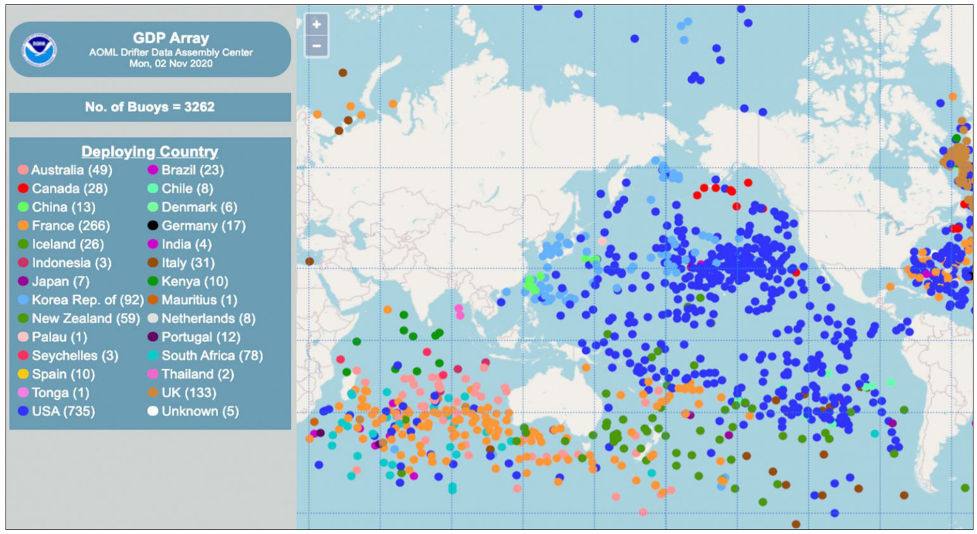
AOML was saddened by the death of Greg Banes, a former maintenance mechanic with AOML's Facilities Management Group, who passed away in Miami on November 29, 2020. He was 66 years old. Born and raised in Miami, Greg began his time at AOML in 1978 after serving 3 years with the US Army. For 37 years Greg was a mainstay at AOML, working to keep the facility functioning and in good repair, a job that kept him perpetually busy. He retired in 2015 with 40 years of federal service. Greg was a loving husband, father, and good friend to many at AOML and will be missed. He is survived by his wife Earlene, his son Greg Jr., and daughters Kimberly, Candis, Tiara, and Shavon, as well as grandchildren, siblings, relatives, and countless friends.

Global Drifter Program Launches New Interactive Map Tool

The Global Drifter Program's Drifter Data Assembly Center (DAC) at AOML has launched a new interactive map of the global drifter array. This new tool features the ability to zoom and scroll, hover the cursor over a drifter to view its identification number, and click to see additional data/metadata on an ID card—including deployment information, manufacturer, and drifter type—that can be viewed as a high-resolution image with an additional click. A user can also search for a specific drifter using its identification number.

"This new tool provides value for different types of users. A user can find out who is deploying drifters and where they are, while someone else can use the tool to visualize drifter data, evaluate their quality, and see if a drifter has lost its sea anchor" said Rick Lumpkin, PhD, an AOML oceanographer and principal investigator of AOML's component of the Global Drifter Program.

The Global Drifter Program is part of the Global Ocean Observing System and is a scientific project of the Data Buoy Cooperation Panel. Drifters are deployed in the global ocean to measure sea surface temperature and ocean currents, but most are also equipped to gather measurements of other variables.



Static image of the interactive map that shows the global drifter array. Credit: NOAA-AOML.

As a drifter moves, guided by currents, measurements of atmospheric pressure, winds, wave spectra, and salinity can also be obtained. These data, collected by sensors within the drifter, are transmitted to satellites. Tracking the location of drifters over time has enabled scientists to build a profile of ocean currents.

"In the past, when we would get asked for information regarding a specific drifter, we would generate this type of ID card on the fly. Now this is automatically done for every drifter in the global array, giving the user immediate access to the information they are looking for by either searching for an ID number or by finding it themselves on the map," said Lumpkin.

The interactive map launched by the Drifter Data Assembly Center at AOML can be accessed at:

https://www.aoml.noaa.gov/phod/gdp/interactive/drifter_array.html

New Report Updates Global Projections for Future Coral Bleaching Conditions

The United Nations Environment Programme report on coral bleaching projections for 2020 was recently published,* updating research performed in 2017 that used a previous generation of global climate models to project coral reef bleaching globally. Ruben van Hooidonk, PhD, a University of Miami-Cooperative Institute coral researcher at AOML, is the lead author for the report.

Scientists have observed three global coral bleaching events. The most recent event began in 2014 and extended into 2017, becoming the longest and most widespread bleaching occurrence ever recorded. This type of prolonged disturbance did not allow corals sufficient time to recover during cooler seasons, as was observed in past bleaching events. The new report suggests that this may become the new normal for the world's coral reefs.

Dr. van Hooidonk used data from the previous climate models to create projections of coral bleaching under different global emission scenarios. He then used the new generation of climate models (CMIP6) to determine how the projections were different from previous projections. "Using the latest climate models, the projected year of annual severe bleaching is 2034; this is 9 years earlier than was projected using the previous generation of climate models," said van Hooidonk.

The projected exposure to bleaching conditions varies greatly across the globe. Coral reefs in areas that are expected to experience bleaching events much later than other reef areas could serve as temporary refugia. These areas may also support the blue economy with ecosystem goods and services for longer. The projections made in this report are important for guiding management and conservation planning, can inform policy, and can also be used as a tool for education and outreach programs.

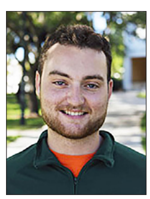
*van Hooidonk, *et al.*, 2020: Projections of future coral bleaching conditions using IPCC CMIP6 models: Climate policy implications, management applications, and regional seas summaries. United Nations Environment Programme, Nairobi, Kenya, 104 pp.

Welcome Aboard

Dr. Sherry Chou joined AOML's Physical Oceanography Division in November as a University of Miami-Cooperative Institute post-doctoral researcher. While at AOML, Sherry will perform research related to the Atlantic Tradewind Atmosphere Mesoscale Interaction Campaign (ATOMIC) in the northwestern tropical Atlantic. She recently received her PhD in Physical Oceanography from the University of Hawaii at Manoa.

Dr. Xuelei Feng joined AOML's Hurricane Research Division in October as a University Corporation for Atmospheric Research (UCAR) project scientist. Xuelei will support AOML's Observing System Analysis group. Working with Dr. Lidia Cucurull in Boulder, Colorado, he will focus on improving the impact of radio occultation observations in NOAA's forecast models. Xuelei holds a PhD in Climate Dynamics from George Mason University.

Annette Hollingshead joined the Office of the Director in November as AOML's new Research to Operations Transition Manager. Annette will work closely with scientists across AOML to coordinate the transition of their research into operational products and/or applications. She will also work closely with the staff of OAR's transition manager and other programs to develop and implement NOAA's transition policies and best practices. Prior to joining AOML, Annette worked as a NOAA affiliate at the National Centers for Environmental Information (NCEI) in Asheville, North Carolina. She holds a MS degree in Meteorology from the University of Hawaii at Manoa.



Patrick Kiel joined AOML's Ocean Chemistry and Ecosystems Division in November for a year-long internship with the Acidification, Climate, and Coral Reef Ecosystems TEam (ACCRETE). Patrick recently completed his undergraduate studies at the University of Miami's Rosenstiel School. He will work on a database tool for coral nurseries that will catalog and compare the phenotypic properties of *Acropora cervicornis* genotypes to enhance informed restoration efforts for NOAA's Coral Reef Conservation Program.

Dr. Hyun-Sook Kim joined AOML's Physical Oceanography Division in November as a new federal Oceanographer. Hyun-Sook comes to AOML with an extensive background in dynamically coupled ocean-hurricane modeling, including data assimilation. Prior to her arrival at AOML, Hyun-Sook worked with NOAA's Environmental Modeling Center on the development and improvement of NOAA's operational hurricane forecast systems and collaborated in data impact studies to assess how various observing platforms that operate with different spatial and temporal strategies contribute to improving hurricane intensity forecasts. Hyun-Sook will collaborate with scientists in both the Physical Oceanography and Hurricane Research divisions at AOML in leading the lab's Ocean Modeling team. She holds a PhD in Physical Oceanography from the University of Rhode Island.

Congratulations

NOAA's P-3 Hurricane Hunter flight crews that participated in the search and rescue efforts for the vessel *Bourbon Rhode* and its crew on September 27-28, 2019 received a Department of Commerce Gold Medal in December for their courage, dedication, and heroism. Among the scientific crew for the missions were Trey Alvey, Heather Holbach, Kelly Ryan, Kathryn Sellwood, and Jon Zawislak—all Cooperative Institute staff with AOML's Hurricane Research Division.

AOML Director Dr. John Cortinas has been named to become a member of the American Meteorological Society's new Culture and Inclusion Cabinet. The cabinet was formed "to accelerate the integration of a culture of inclusion, belonging, diversity, equity, and accessibility across the AMS and evaluate and assess progress towards culture and inclusion strategic goals within the Society."

Ramon Hurlockdick, an IT specialist with AOML's Office of the Director, received a 2020 NOAA-Office of Oceanic and Atmospheric Research award in October for Administrative/Technical Support. Ramon was recognized for his work on the AOML Admin System that has facilitated improved financial, property administration, and communication at AOML.

Alejandra Lorenzo, an IT specialist with AOML's Computer Networks and Services group, received a NOAA-Office of Oceanic and Atmospheric Research 2020 EEO/Diversity Award for Exemplary Service in October. Alejandra was recognized for her long-term outreach, mentorship, and support of STEM education for women and minority students.

Dr. Renellys Perez, an oceanographer with AOML's Physical Oceanography Division, received a NOAA-Office of Oceanic and Atmospheric Research 2020 EEO/Diversity Award for Exemplary Service in October. Renellys was recognized for her long term educational outreach activities and mentorship of women and minority communities.

Dr. Robert Rogers, a meteorologist with AOML's Hurricane Research Division, has been appointed as an Editor of the American Geophysical Union's *Journal of Geophysical Research-Atmospheres*. Rob will review papers to ensure they adhere to the policies and standards of excellence established for the journal. His term as editor runs from December 1, 2020 through December 31, 2023.

Dr. Luke Thompson, a bioinformatician and Associate Research Professor at the Northern Gulf Institute (NGI) at Mississippi State University and based in AOML's Ocean Chemistry and Ecosystems Division, accepted the position of NGI Program Coordinator at AOML, effective December 1, 2020. In this role, Luke will serve as a liaison between AOML and NGI.

U.S. Department of Commerce

Mr. Wilbur L. Ross, Jr.
Secretary of Commerce
www.doc.gov

National Oceanic and Atmospheric Administration

Mr. Benjamin P. Friedman
Acting Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator
www.noaa.gov

Office of Oceanic and Atmospheric Research

Mr. Craig N. McLean
Assistant Administrator
www.oar.noaa.gov

Atlantic Oceanographic and Meteorological Laboratory

Dr. John V. Cortinas
Director

Dr. Molly O. Baringer
Deputy Director

LCDR Andrew R. Colegrove
Associate Director

Dr. Frank D. Marks
Hurricane Research Division Director

Dr. Christopher R. Kelble (Acting)
Ocean Chemistry and Ecosystems Division Director

Dr. Gustavo J. Goni
Physical Oceanography Division Director

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

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

Keynotes editor: Gail Derr

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

Burt, J.A., E.F. Camp, **I.C. ENOCHS**, J.L. Johansen, K.M. Morgan, B. Riegl, and A.S. Hoey, 2020: Insights from extreme coral reefs in a changing world. *Coral Reefs*, 39(3):495-507.

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

CIONE, **J.J.**, G.H. Bryan, R. Dobosy, **J.A. ZHANG**, G. de Boer, **A. AKSOY**, J.B. Wadler, E.A. Kalina, **B.A. DAHL**, **K. RYAN**, J. Neuhaus, E. Dumas, **F.D. MARKS**, A.M. Farber, T. Hock, and **X. CHEN**, 2020: Eye of the storm: Observing hurricanes with a small Unmanned Aircraft System. *Bulletin of the American Meteorological Society,* 101(2):E186-E205.

Dong, J., B. Liu, Z. Zhang, W. Wang, A. Mehra, **A.T. HAZELTON,** H.R. Winterbottom, L. Zhu, K. Wu, C. Zhang, V. Tallapragada, **X. ZHANG**, **S. GOPALAKRISHNAN**, and **F. MARKS**, 2020: The evaluation of real-time Hurricane Analysis and Forecast System (HAFS) Stand-Alone Regional (SAR) model performance in 2019 Atlantic hurricane season. *Atmosphere,* 11(6):617.

DONG, **S.**, **H. LOPEZ**, **S.-K. LEE**, **C. MEINEN**, **G. GONI**, and **M. BARINGER**, 2020: What caused the large-scale heat deficit in the subtropical South Atlantic Ocean during 2009-2012? *Geophysical Research Letters*, 47(11): e2020GL088206.

ENOCHS, I.C., **N. FORMEL**, **D. MANZELLO**, **J. MORRIS**, **A.B. MAYFIELD**, **A. BOYD**, **G. KOLODZIEJ**, G. Adams, and **J. HENDEE**, 2020: Coral persistence despite extreme periodic pH fluctuations at a volcanically acidified Caribbean reef. *Coral Reefs*, 39(3):523-528.

Frys, C., A. Saint-Amand, **M. LE HÉNAFF**, J. Figueiredo, A. Kuba, B. Walker, J. Lambrechts, V. Vallaeys, D. Vincent, and E. Hanert, 2020: Fine-scale coral connectivity pathways in the Florida Reef Tract: Implications for conservation and restoration. *Frontiers in Marine Science,* 7:312.

Guimond, S.R., **P.D. REASOR**, G.M. Heymsfield, and M.M. McLinden, 2020: The dynamics of vortex Rossby waves and secondary eyewall development in Hurricane Matthew (2016): New insights from radar measurements. *Journal of the Atmospheric Sciences,* 77(7): 2349-2375.

KIM, **D.**, **S.-K. LEE**, and **H. LOPEZ**, 2020: Madden-Julian Oscillation-induced suppression of northeast Pacific convection increases U.S. tornadogenesis. *Journal of Climate,* 33(11):4927-4939.

KIM, **D.**, **S.-K. LEE**, **H. LOPEZ**, **G.R. FOLTZ**, V. Misra, and A. Kumar, 2020: On the role of the Pacific-Atlantic SST contrast and associated Caribbean Sea convection in August-October US regional rainfall variability. *Geophysical Research Letters*, 47(11):e2020G087736.

KO, **M.-C.**, **F.D. MARKS**, **G.J. ALAKA**, and **S.G. GOPALAKRISHNAN**, 2020: Evaluation of Hurricane Harvey (2017) rainfall in deterministic and probabilistic HWRF forecasts. *Atmosphere,* 11(6):666.

LE HÉNAFF, **M.**, V.H. Kourafalou, Y. Androulidakis, **R.H. SMITH**, H.-S. Kang, C. Hu, and J. Lamkin, 2020: In situ measurements of circulation features influencing cross-shelf transport around northwest Cuba. *Journal of Geophysical Research,* 125(7):e2019JC015780.

Tomenchok, L.E., **M.L. GIDLEY**, K.D. Mena, A.C. Ferguson, and H.M. Solo-Gabriele, 2020: Children's abrasions in recreational beach areas and a review of possible wound infections. *International Journal of Environmental Research and Public Health*, 17(11):4060.

Wachnicka, A., J. Browder, T. Jackson, W. Louda, **C. KELBLE**, O. Abdelrahman, E. Stabenau, and C. Avila, 2020: Hurricane Irma's impact on water quality and phytoplankton communities in Biscayne Bay (Florida, USA). *Estuaries and Coasts*, 43(5):1217-1234.

WANNINKHOF, **R.**, **D. PIERROT**, **K. SULLIVAN**, **L. BARBERO**, and **J. TRINANES**, 2020: A 17-year dataset of surface water fugacity of CO_2 along with calculated pH, aragonite saturation state, and air-sea CO_2 fluxes in the northern Caribbean Sea. *Earth System Science Data*, 12(3):1489-1509.

XU, **Y.-Y.**, W.-J. Cai, **R. WANNINKHOF**, J. Salisbury, J. Reimer, and B. Chen, 2020: Long-term changes of carbonate chemistry variables along the North American east coast. *Journal of Geophysical Research-Oceans,* 125(7): e2019JC015982

Zink, I.C., J.A. Browder, **C.R. KELBLE**, E. Stabenau, C. Kavanagh, and Z.W. Fratto, 2020: Hurricane-mediated shifts in a subtropical seagrass associated fish and macroinvertebrate community. *Estuaries and Coasts*, 43(5):1174-1193.

Zou, Z., S. Li, J. Huang, P. Li, J. Song, **J.A. ZHANG**, and Z. Wan, 2020: Atmospheric boundary layer turbulence in the presence of swell: Turbulent kinetic energy budget, Monin-Obukhov similarity theory and inertial dissipation method. *Journal of Physical Oceanography,* 50(5):1213-1225.