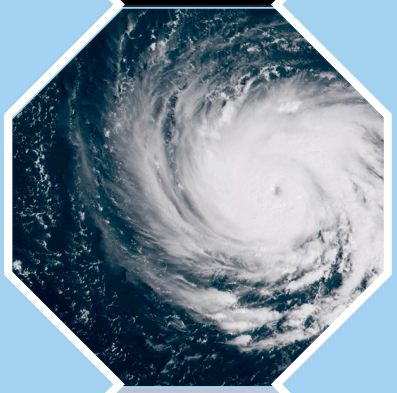


Highlights from the

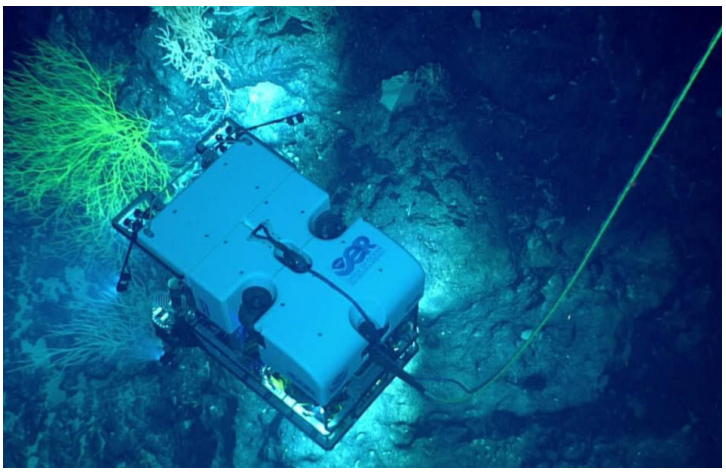
2018

NOAA Science Report

National Oceanic and Atmospheric Administration

U.S. Department of Commerce

Scan the QR code to download the full interactive 2018 NOAA Science Report or access the report at: https://go.usa.gov/xEV73



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It is a great honor to work with scientists of the National Oceanic and Atmospheric Administration (NOAA), the nation's premier ocean, weather and atmospheric science agency. NOAA's research extends from the depths of the ocean to the surface of the sun. NOAA scientists work across the globe sampling the environment, developing technologies to observe the earth, discovering new species, managing our fisheries, protecting our trust natural resources, and advancing our ability to understand and more accurately predict the weather, severe storms and climatic conditions.

NOAA's research is bundled under two priorities in the 2018 NOAA Science Report. First is to produce the best weather prediction system in the world. This past year the finite volume on a cubed sphere dynamic core (FV3), currently in prototype mode, showed significantly better forecast skill of hurricane intensity than operational models. NOAA is also taking weather satellite technology to the next level, with the launch of GOES-17 in March 2018. To give you a sense of the power of this new technology, five days out, NOAA predicted within two miles the precise landfall of Hurricane Florence, which facilitated the safe and effective evacuation of hundreds of thousands of Carolinians. But we won't stop there. In 2018 Congress authorized the Earth Prediction Innovation Center, a community-based approach that will significantly improve upon the global forecast system model. Implementation is already underway.

Our second priority is to grow the American economy through the sustainable management of marine resources, or the "Blue Economy". With the human consumption of protein around the world rising, marine aquaculture has become a critical industry to meet the demand. NOAA scientists recognize this and developed the Gulf AquaMapper to assist operators and coastal states with smart siting of facilities. The AquaMapper is a web-based tool with multiple data layers such as shipping lanes, military operations, and marine protected areas to minimize competing uses. Efficient commerce at our nation's ports is also a big part of the blue economy, and NOAA science is also entering the next generation with "Precision Navigation." In the Port of Long Beach, better real time data on long period swells led to an increase in the allowable draft by four feet, saving $10 million per year in lightering costs and increasing the value of the cargo per vessel by $2 million.

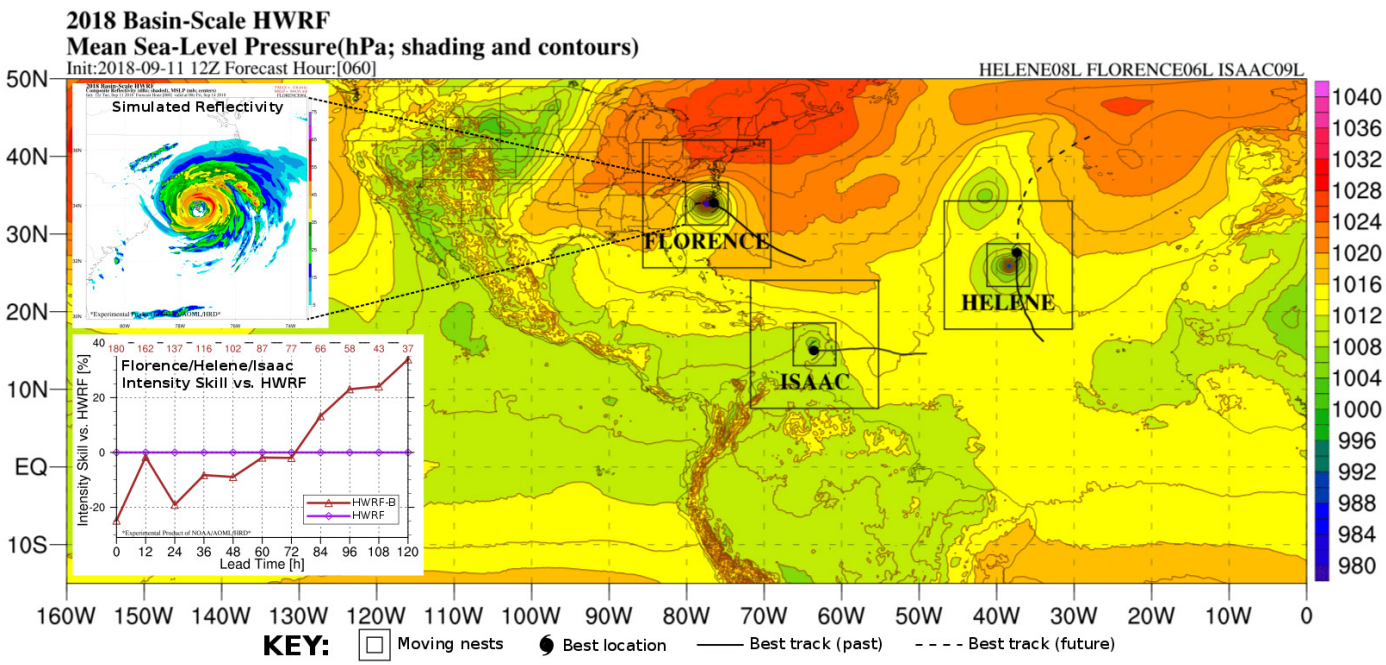
You will see in this summary report that our scientists push the boundaries of knowledge in unmanned systems, fisheries management, protected species, harmful algal blooms, coastal hazards, climate change, invasive species, and much more. I am amazed on a daily basis by the expertise, ingenuity, and commitment to excellence that NOAA scientists and our academic and industry partners share. This report presents many stunning achievements accomplished by NOAA in 2018 that supported sustainable economic growth and saved countless lives.

RDML Tim Gallaudet, Ph.D., USN Ret.
Assistant Secretary of Commerce for Oceans and Atmosphere and
Acting Under Secretary of Commerce for Oceans and Atmosphere

Produce the Best Weather Prediction System

Experimental Model Improves Hurricane Intensity Forecasts

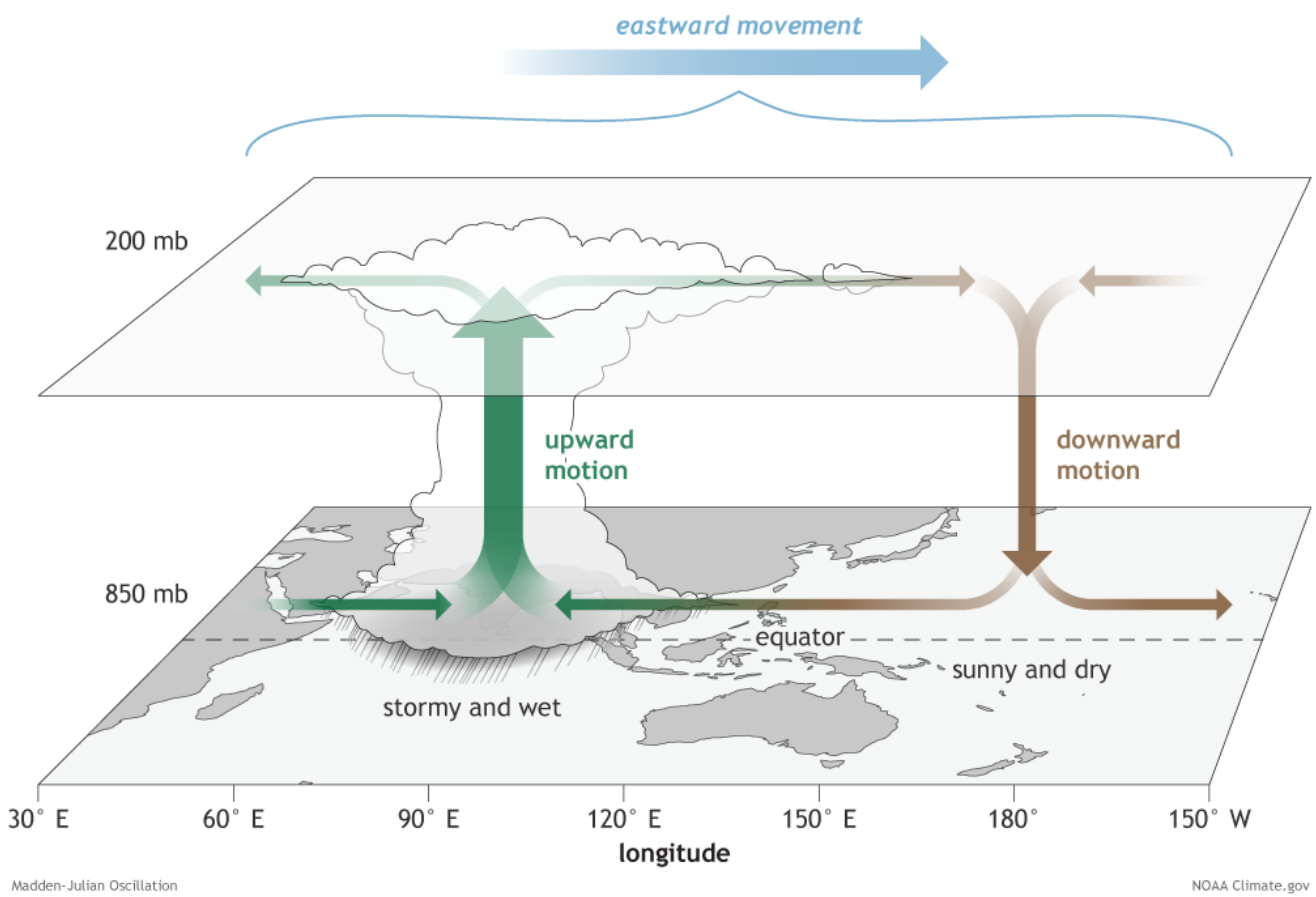
Through the Hurricane Forecast Improvement Project (HFIP), NOAA continues to improve the accuracy of hurricane forecasts with applied research using advanced computer models. For the 2018 hurricane season, operational and real-time experimental models at NOAA have performed exceedingly well as demonstrated by results for Hurricanes Lane, Florence, and Michael. For Hurricane Lane, the experimental Finite-Volume on a Cubed Sphere Global Forecast System (fvGFS) was one of the best performers for track forecast guidance. The Hurricane Weather Research and Forecasting (HWRF) model predicted the rapid intensification of Hurricane Michael at least 60 hours in advance. The experimental basin scale HWRF-B model was run in parallel with operational hurricane models during the 2018 Atlantic hurricane season. In addition to the use of aircraft data for initialization, the experimental system was coupled with an advanced ocean model and tracked each hurricane at a very fine resolution (~1.5 km). HWRF-B outperformed the operational model HWRF, especially during peak hurricane season when Hurricanes Florence, Helene, and Isaac were all active at the same time. HWRF-B outperformed the operational HWRF by at least 20-30 percent in predicting intensity of these three hurricanes at longer forecast lead times. Further, HWRF-B improves upon HWRF in its ability to track multiple storms at the same time which enables the prediction of realistic storm-storm interactions and, thus, maximum intensity and storm structure. This ability to track multiple storms will be used in the next generation Hurricane Analysis and Forecast System (HAFS), under development and transitioned to the FV3 unified forecasting system (FV3-UFS), improving our ability to better forecast hurricane intensity.



The experimental basin-scale HWRF system from NOAA's Atlantic Oceanographic and Meteorological Laboratory and Environmental Modeling Center forecasted realistic radar reflectivity and storm structure days in advance of Hurricane Florence's approach to North Carolina.

Closing the Gap Between Weather and Climate Predictions

Historically, there has been a gap in predictive skill between two weeks and three months into the future--the subseasonal-to-seasonal (S2S) period that spans the continuum from weather to climate timeframes. Predictions on timescales between weather and climate can help energy companies determine how much power to produce to meet demands for upcoming months, assist water resource managers controlling reservoir levels ahead of upcoming water use, and help farmers understand which crops to plant the following season and whether to buy crop insurance. Through cutting-edge research and development, NOAA is gradually improving the accuracy and lead time of S2S forecasts. Predictions in this time period are a major challenge due to the inherent unpredictability of the atmosphere beyond two weeks. Now, NOAA-funded scientists have developed new insights about long-distance relationships between particular atmospheric conditions in the tropics and weather events in the U.S., which helps fill the gap in forecasters' ability to make more accurate predictions during S2S timescales. This new research, part of NOAA Research's S2S Prediction Task Force, builds on ongoing activities within NOAA labs and operational centers. Specifically, scientists at Colorado State University (CSU) found that the Madden-Julian Oscillation (MJO), a series of eastward-moving tropical rainfall patterns, can influence weather in the U.S. in predictable ways within 20-25 days. This work has the potential to enhance previous research, which resulted in the development and operational transition of a tool that uses the MJO and El Niño-Southern Oscillation to provide essential guidance for NOAA's week three to four outlooks. Through these and other achievements, NOAA is steadily closing the S2S gap and improving communities' abilities to plan for and respond to extreme events.

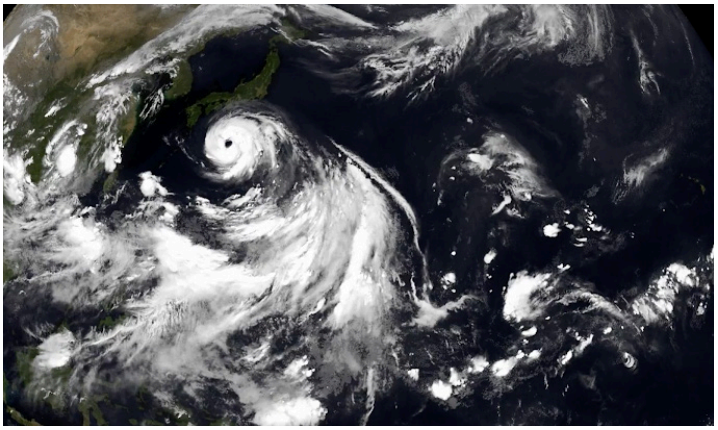


A depiction of Madden-Julian Oscillations which NOAA's Climate Program Office and scientists at Colorado State University have found can influence weather in the U.S. in predictable ways within 20-25 days.

Produce the Best Weather Prediction System

A Revolutionary Global Weather Model

NOAA's newest weather prediction tool, the Next Generation Global Prediction System (NGGPS), will dramatically improve U.S. operational weather and hurricane forecasting. Powered by the efficient and more comprehensive Finite-Volume on a Cubed Sphere (FV3) dynamic core, NGGPS provides a new level of accuracy to weather forecasts. NOAA continues to develop FV3-based global prediction models. During the 2017 hurricane season, the NOAA fvGFS, the FV3-powered prototype for the NGGPS, showed significantly better forecasts of hurricane intensity than current operational models, such as the current Global Forecast System (GFS) or the European Centre for Medium Range Weather Forecasts (ECMWF) model. High-resolution versions of fvGFS, using global-to-regional modeling methods developed at NOAA that allow the model to 'zoom-in' on a region of the world, show even better prediction of Atlantic hurricane strength, nearly matching the accuracy of the best operational models used for hurricane forecasting. A second high-resolution version, zoomed-in over the contiguous U.S., shows promise as the basis of a unified system for both storm-scale and global modeling.



A simulated satellite image from a global experimental 3-km simulation in fvGFS produced by NOAA's Geophysical Fluid Dynamics Laboratory.

NOAA's Air Resources Laboratory tracked ash plumes and sulfur dioxide from the Kilauea volcanic eruption. Photo credit: USGS

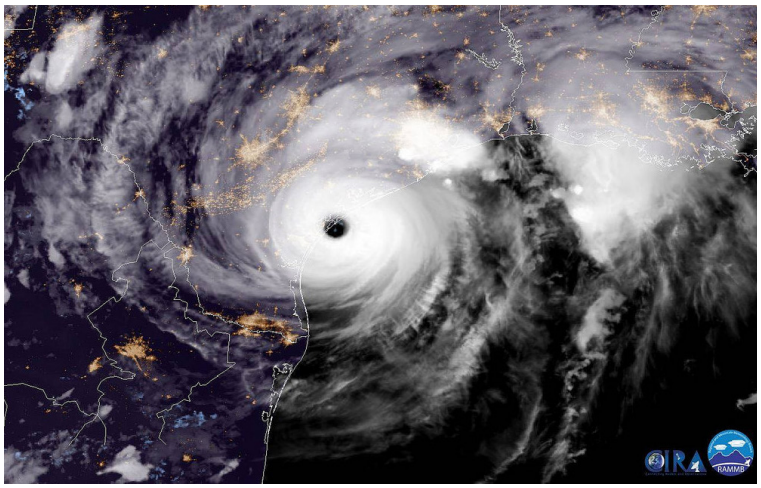
HYSPLIT Tracks SO_2 and Particulate Matter During Kilauea Eruption

During the Kilauea eruption, NOAA Research's Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model provided estimates of the transport and dispersion of harmful sulfur dioxide (SO_2) and volcanic ash in the air. This vital information allowed emergency responders to make evacuation and other safety decisions by estimating when plumes of toxic gas would drift over population centers and where volcanic ash in the atmosphere would present a hazard for aircrafts. NOAA Research scientists are currently investigating new means to more accurately estimate concentrations of chemicals released during volcanic eruptions by combining SO_2 measurements taken downwind from the volcano with forecasts from the HYSPLIT model, incorporating the derived data and re-running HYSPLIT to provide forecast SO_2 concentration. The aim is to develop an automated system that assimilates actual measurements with calculated concentrations and transition it to NOAA NWS for operational use in support of forecasting. This volcanic ash research could result in decreased fuel consumption and reduced delays in flight arrival times for the airline industry thanks to guidance from more precise dispersion forecasts. The economic impact of SO_2 is measurable in terms of population health, lost productivity, and lost wages. In addition to tracking SO_2, NOAA is a contributor to the Interagency Vog Dashboard, a resource designed to forecast and track vog, the volcanic equivalent of smog created when sulfur dioxide from the volcano reacts with carbon dioxide, water vapor, and sunlight.

Development of High Tide Flooding Thresholds and Application to Flooding Outlooks

Coastal flooding damages infrastructure and causes additional hazards when it creeps into busy city centers and streets. In 2018, NOAA released the State of High Tide Flooding and 2018 Outlook to assess coastal high tide flooding based on new national flooding thresholds. This new approach expands the outlook to more than 100 coastal locations and highlights the impact of high tide flooding. This technical report allows NOAA to communicate these new thresholds and the frequency of visible flooding to decision-makers to inform mitigation measures.

NOAA's Center for Operational Oceanographic Products and Services technical report highlights the impact of high tide flooding.



GOES-16 image of Hurricane Harvey approaching the Texas Coast.

Next Generation Satellites Enhance Observational Capabilities

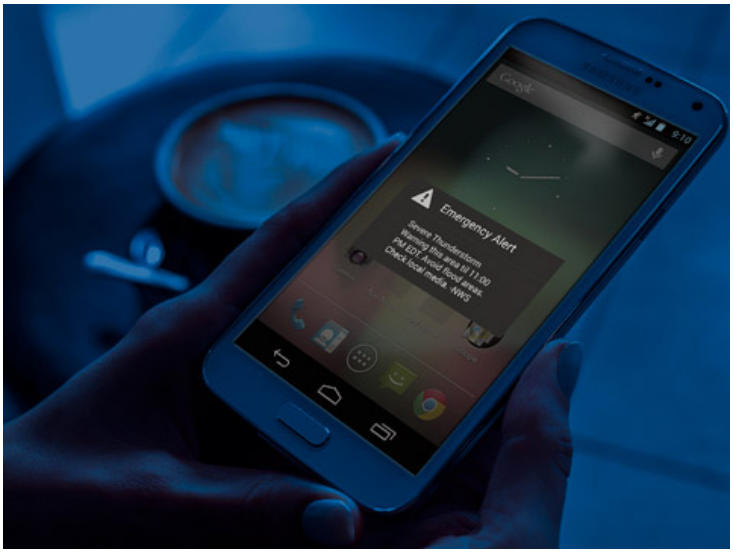
The Geostationary Operational Environmental Satellite R-Series (GOES-R) is the nation's next generation of geostationary weather satellites. Beginning with the successful launch of the first GOES-R (GOES-16) satellite in November 2016, and made operational in December 2017 followed by the launch of GOES-S (GOES-17) in March 2018, these satellites provide continuous imagery and atmospheric measurements of Earth's Western Hemisphere. These measurements include total lightning data and space weather monitoring to provide critical atmospheric, hydrologic, oceanic, climatic, solar, and space data. The GOES-R Series has significantly improved the detection and observation of environmental phenomena that directly affect public safety and our nation's economic health and prosperity. For example, during post-launch testing, GOES-16 provided imagery to forecasters and experimental flood maps to the Federal Emergency Management Agency (FEMA) to aid in the forecast, warning, and recovery from the impacts of Hurricane Harvey. As Hurricane Harvey remained parked along the Texas coast, where it caused torrential downpours and flooding, NOAA NWS personnel used GOES-16 data to provide impact-based decision support to emergency managers. When the storm made landfall, forecasters in Corpus Christi, Texas tracked the location of the eyewall to alert emergency managers when they would have a window of opportunity to evacuate dozens of people to safety before the back end of the hurricane struck.

> *"[GOES-R] puts [the U.S.] on top of the food chain when it comes to weather satellites around the world. Nobody has anything like this."*
> - Al Roker, Today Show 8/25/16

Produce the Best Weather Prediction System

Forecasting a Continuum of Environmental Threats

The NOAA NWS watch and warning process for severe weather has not fundamentally changed in more than 50 years. However, society, technology, and science have made great advances. The Forecasting a Continuum of Environmental Threats (FACETs) paradigm modernizes the high-impact weather forecasting and communication process by adapting to evolving technology. At the core of this paradigm shift is a change in how weather forecasters communicate the public's vulnerability to extreme weather events. By using information based on probabilities, forecasters can provide the public more precise watches and warnings. This framework will enable decision-makers who require more advanced notice, such as hospitals, schools, and large venues, to set their own threat thresholds based on their specific needs. It will also enable new science advances, such as Warn-on-Forecast and Phased Array Radar, to be fully leveraged into better warnings and forecasts for society. Since hazardous weather forecasting is a physical science done by humans for humans, social and behavioral science is fully integrated into FACETs research and development. Collaborative research projects between NOAA Research, NOAA NWS, and academic partners are beginning to move us toward the FACETs paradigm. Several experiments conducted in the NOAA Hazardous Weather Testbed in the last two years brought together NOAA NWS forecasters, researchers, and partners such as emergency managers and broadcasters, to evaluate early prototypes of forecast and warning technology based on the FACETs approach. Results from these experiments are being shared with NOAA NWS to facilitate plans to transition FACETs concepts toward operational use.



Several NOAA offices including the National Severe Storms Laboratory, Office of Weather and Air Quality, Earth System Research Laboratory Global Systems Division, Atlantic Oceanographic and Meteorological Laboratory, and the National Centers for Environmental Prediction are developing ways to provide the public more precise watches and warnings for severe weather.

Fire Weather Decision Support and Incident Meteorologist Deployment

The NOAA NWS Fire Weather Program provides critical forecasts for the safety, protection and operational intelligence of the fire-fighting community. Services range from daily, routine forecasts defined for land management protection zones to site-specific spot forecasts. The site-specific spot forecasts provide fire officials and emergency managers with tailored, location-specific forecasts using weather parameters defined and requested directly by incident management. When it comes to in-the-field decision support, the NOAA NWS Incident Meteorologist (IMET) program is ready to go at a moment's notice when fire outbreaks occur. With an average of 140 IMET dispatches per year, IMET staff are sent directly to fire incidents with specialized equipment designed to support all levels of incident management with operational forecasts. These IMETs spend 10 to 14 days camping at the actual site of the fires, issuing forecasts and warnings tailored to the incident itself. In 2017, IMETs were immediately on site during the devastating California Santa Ana fires in northern and southern parts of the state. In total, 2017 saw 200 IMET dispatches nationally, with a NOAA NWS response time, from request to the arrival of the IMET, of less than 24 hours. This immediate and timely response defends the lives of all responding fire fighters and enables the effective defense of public lives and personal assets in the path of nearly every significant wildfire.

Incident Meteorologists (IMET) from NOAA's Analyze, Forecast, and Support Office work on the scene of wildfires.

Potential for Arctic Regions and Mid-Latitude Weather Linkages

Arctic weather has impacts reaching beyond just the Arctic, potentially affecting tens of millions of people. Scientists have been studying the influence of Arctic weather on mid-latitude weather in an effort to provide longer term forecasts. However, the meteorological processes involved are complex and assessments continue to be controversial. NOAA Research and NOAA NWS have made progress toward clarifying the situation in the last year. Recent case studies have shown the Arctic is not the primary cause for the evolution of midlatitude weather, but warmer Arctic temperatures can prolong cold spells in the midlatitudes by reinforcing a wavy jet stream. Wavier jet stream patterns allow cold air from the Arctic to easily flow into the Midwest and eastern United States.

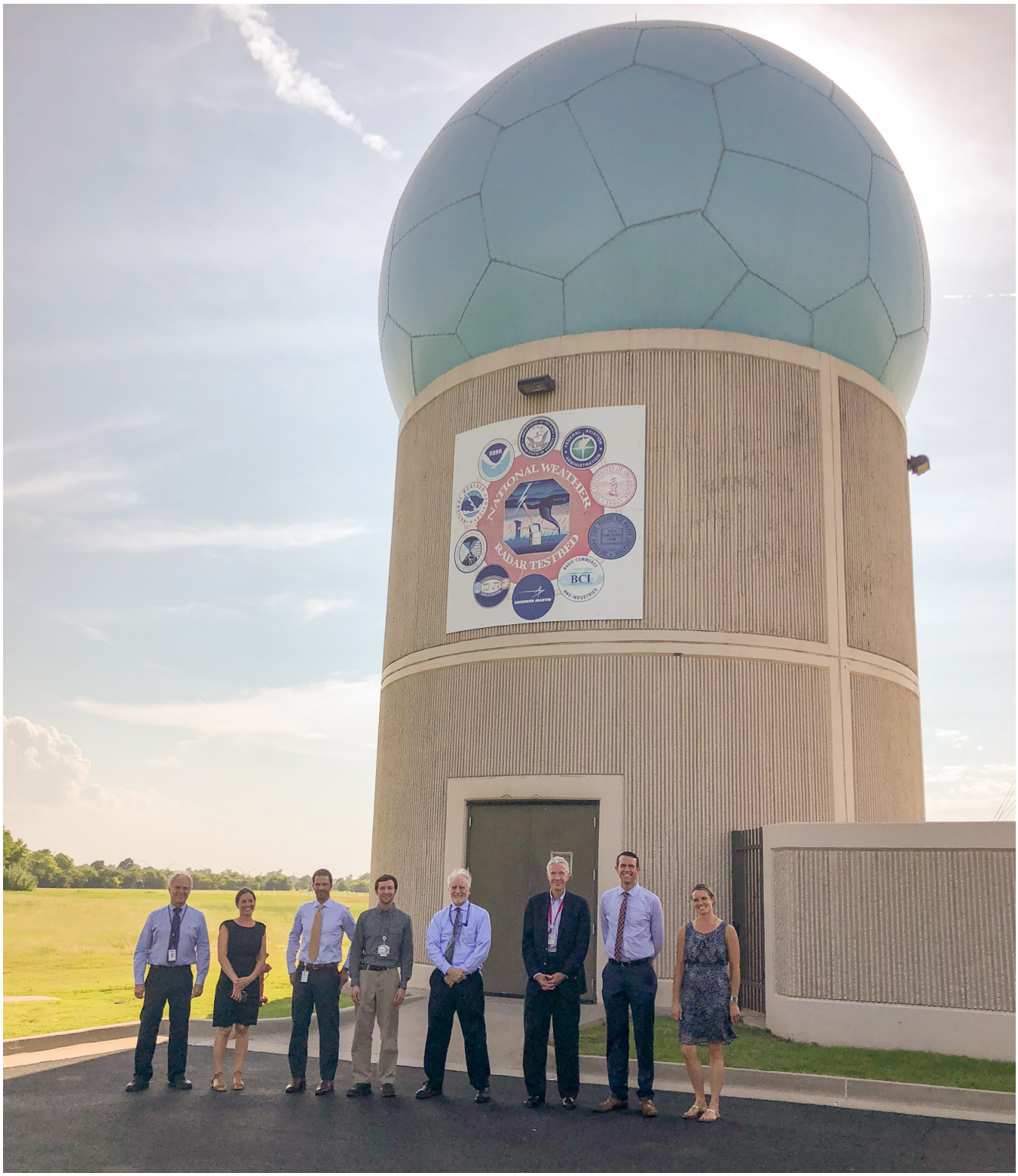
Scientists from NOAA's Pacific Marine Environmental Laboratory are studying whether a warming arctic may cause severe winter weather in midlatitudes.

Produce the Best Weather Prediction System

Tracking Precipitation to Provide Flash Flooding Forecasts at the Neighborhood Level

Flash flooding kills more people in the U.S. than tornadoes and hurricanes and is second only to extreme heat fatalities. To better protect people in the U.S., NOAA Research has developed a system called the Flooded Locations and Simulated Hydrographs (FLASH) project to advance the state of flash flood prediction through newly developed Multi-Radar/Multi-Sensor rainfall estimation and extreme precipitation analysis tools and hydrologic forecast models. FLASH begins with rainfall rates measured by radar and uses a sophisticated modeling system to track what every raindrop is doing on the ground: whether it infiltrates into the soil or flows across impervious roads, parking lots, and waterways. The system models where water will go and when and where it will become a flood, with updates as frequent as every two minutes - a key attribute for cities that can flood quickly. In 2016, research indicated that the FLASH system doubles accuracy of the current operational flash flood prediction system and improves the spatial resolution by 500 percent. These new high-resolution tools will provide reliable flash flood forecasts at the neighborhood level as well as provide up to 12 hours of forecast lead time, affording critical time for community response, saving lives and mitigating damage to property. FLASH improves NOAA NWS forecasters' ability to identify rare, severe flash floods from minor ones, enabling them to communicate this information to local emergency managers and the public. The FLASH forecasts are particularly useful over small, fast-reacting headwater basins and in urban catchments, complementing the new National Water Model for flood modeling and prediction.

The Flooded Locations and Simulated Hydrographs (FLASH) tool from NOAA's National Severe Storms Laboratory, Office of Weather and Air Quality, and National Centers for Environmental Prediction tracks what every raindrop is doing on the ground to provide reliable flash flood forecasts at a neighborhood level.



Dr. Neil Jacobs, Assistant Secretary of Commerce for Environmental Observations and Prediction, visits NOAA's National Weather Radar Testbed in Norman, Oklahoma.

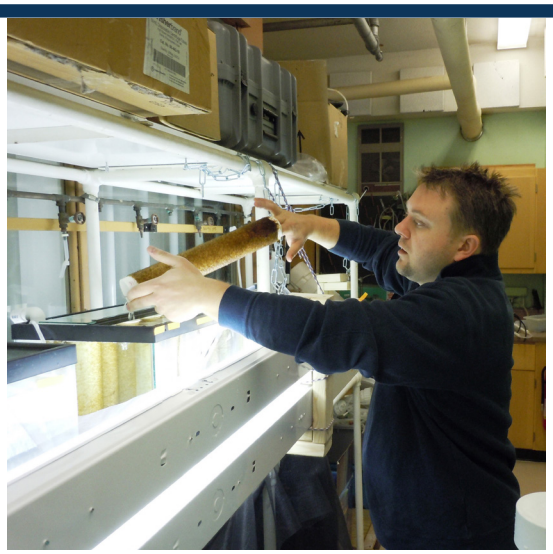
Left to right: Mike Jain, Amanda Netburn, Neil Jacobs, Danny Wasielewski, Steve Koch, Mark Weber, Alek Krautmann, Brittany Croll

New Techniques and Tools to Expand Aquaculture

NOAA is developing new techniques and tests to expand aquaculture production. Researchers with NOAA Fisheries have been helping aquaculturists, notably, GreenWave Organization's Thimble Island Ocean Farm, develop culturing strategies to grow a new crop: sugar kelp. Sugar kelp is being developed for a variety of uses, from food to potential biofuels as well to diversify the portfolio for shellfish growers and others in the seafood sector. Aquatic plant farming, primarily seaweed, also represents a significant sector of global aquaculture production (30.1 million metric tons, valued at $11.6 billion). Seaweed farming is just now being established in the U.S. and shows promise to become an important contributor to future U.S. marine aquaculture production. NOAA researchers are helping this company and its academic partner, the University of Connecticut, develop techniques for growing the kelp across its entire life cycle — from spore culture to maturity — and harvesting strategies.

Developing new crops is not the only way to expand aquaculture. When the sewage treatment plant on Connecticut's Mystic River was upgraded in 2015, few residents imagined local shellfish farmers might benefit, let alone oyster and clam growers across the country. Now this is a possibility, depending on the results of a novel water quality-testing project led by New Hampshire Sea Grant in partnership with Connecticut Sea Grant which could open nearly 800 acres now off limits for commercial shellfishing. While river water quality improved following the treatment plant upgrades, researchers have to demonstrate that levels of harmful bacteria and viruses in the water meet public health safety standards before currently-closed areas can be opened to harvest. Sea Grant's work in the Mystic River supports Connecticut's shellfish industry, which generates more than $30 million in farm-gate sales annually and provides more than 300 jobs statewide. Test results thus far show favorable results, and this method could ultimately be adopted by shellfish managers working under National Shellfish Sanitation Program regulations.

"For shellfish farmers, the implications are huge, because it could increase the size of our growing areas," Steve Plant, Connecticut Cultured Oysters.

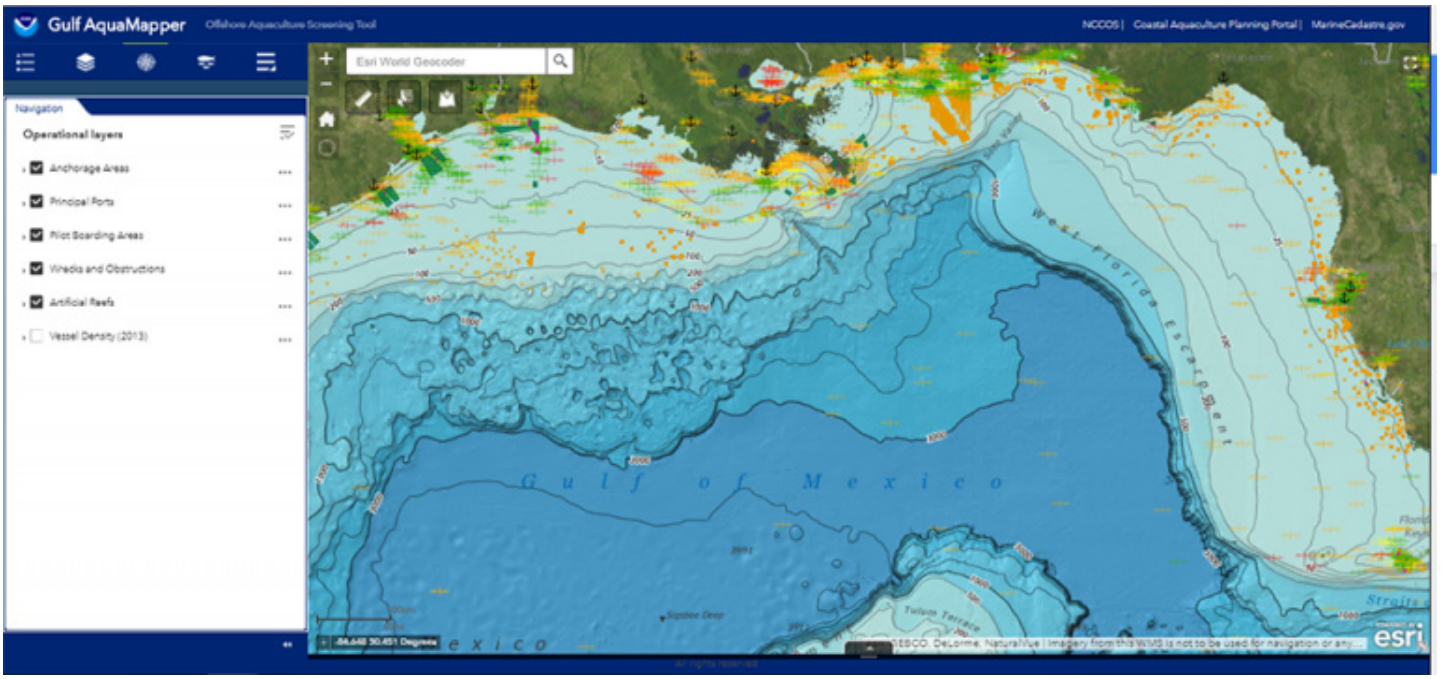


A researcher at NOAA's Milford Laboratory develops culture strategies (top) for sugar kelp (bottom, photo credit Ron Gautreau, GreenWave).

New Hampshire and Connecticut Sea Grant test water quality to open new areas for commercial shellfishing

Gulf AquaMapper: NOAA Develops Tools for Aquaculture Siting in the Gulf of Mexico

NOAA developed the Gulf AquaMapper, a web-based tool for exploration, permitting, and siting of offshore aquaculture in the Gulf of Mexico. The Gulf AquaMapper is a geodatabase featuring aquaculture-relevant GIS data for biological, navigational, military, social, economic, physical, and chemical parameters. The mapper marks the first spatial planning tool designed specifically for aquaculture in the Gulf of Mexico and integrates more than 50 types of data. With this tool, NOAA seeks to streamline the permitting process by reducing logistical and economic inefficiencies for coastal managers and aquaculture investors. This is one of more than 30 tools in NOAA's Coastal Aquaculture Planning Portal with specific applications for planning and siting of aquaculture operations and industries. The product provides a user-friendly interface that serves as a single resource for private industry and coastal managers focused on identifying suitable areas for aquaculture development. Multiple data layers, such as shipping lanes, military operating area boundaries, and marine reserves, can be viewed simultaneously for a more comprehensive assessment of competing uses. Maps can be printed and shared to inform a more detailed site assessment to verify environmental conditions and establish site-specific designs.



The interface of Gulf AquaMapper shown above was created by NOAA's National Centers for Coastal Ocean Science as a web-based tool for exploration, permitting, and siting of offshore aquaculture in the Gulf of Mexico.

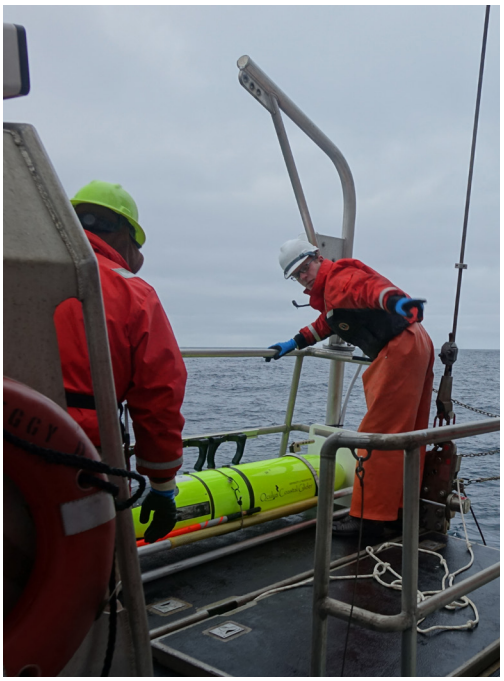
NOAA Advances Precision Navigation Services to Enhance U.S. Commerce

Comparable to the way car technology supports drivers, NOAA has launched a new program to develop the next generation of marine navigation tools that provide mariners with the information they need to safely and efficiently transport maritime commerce. This next generation of products is referred to as Precision Navigation. Precision Navigation seamlessly integrates high-resolution bathymetry with real-time and forecast data—such as water levels, currents, salinity, temperature, and precipitation—to produce a stronger decision support tool to equip mariners for critical go/no-go decisions. This program involves various types and sources of data, requires the coordinated efforts of several NOAA offices, and was first implemented in the Port of Long Beach, CA. In 2018, NOAA established a team dedicated to assist with expanding the program to ports nationwide. Future plans will expand and implement Precision Navigation into the Port of New York/New Jersey which supports more than $184 billion in commerce, as well as the Lower Mississippi River Port Complexes. Researchers are currently conducting a socio-economic study to examine the return on investment of the Precision Navigation program.

Precision Navigation from NOAA's Office of the Coast Survey provides mariners with the information they need to safely and efficiently transport maritime commerce.

Oculus Coastal Glider in the Arctic Identifies Important Ecosystem Transition Area

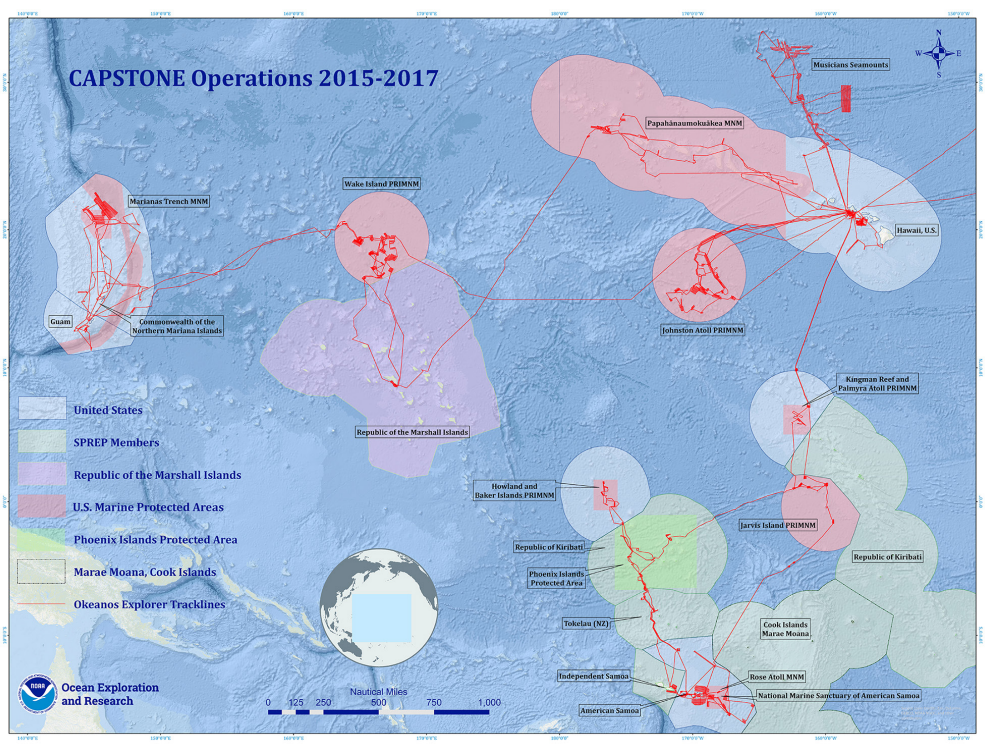
The Oculus Coastal Glider is a new glider specifically engineered to work in the difficult conditions of the Arctic. It can rapidly change its depth for more efficient and adaptive surveys in shallow shelf environments. Measurements collected during the successful 2017 summer mission in the Bering Sea revealed new detailed information for an important transition area that divides the ecosystems of the northern and southern Bering Sea shelf. Observations by the Oculus Glider suggests the existence of numerous eddies that can influence food availability for commercially important species. Incorporating this higher resolution sampling, not previously available through shipboard and moored buoy observations, into the Bering Sea Observing Network will improve the understanding of the effects of small-scale ocean conditions on the ecosystem. These developments are being used to assess critical ecosystem-level baselines in a rapidly changing Arctic and will enable NOAA and its partners and stakeholders to strengthen foundational science and improve stewardship of ocean resources in this remote and complex area. Increased understanding of the effects of the environment on distribution and survival of commercially important fish species is critical for sustainably managing the fisheries.

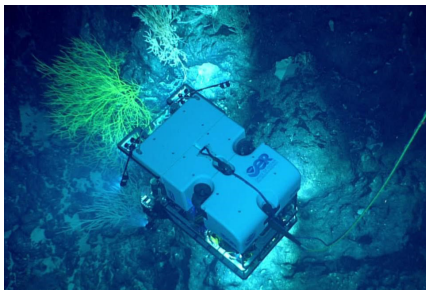


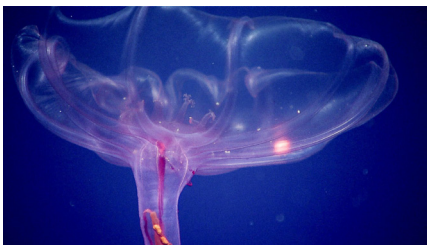
Scientists from NOAA's Pacific Marine Environmental Laboratory prepare to launch Oculus Coastal Glider.

NOAA Concludes the Ocean Exploration Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE)

From July 2015 - September 2017, NOAA and partners conducted the Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE) using NOAA Ship *Okeanos Explorer*. CAPSTONE was a major multi-year foundational science effort focused on deepwaters of central and western Pacific U.S. marine protected areas (MPAs). The initiative provided timely, actionable information to support decision making, and also served as an opportunity for the nation to highlight the importance of these remote and largely unexplored areas. Throughout CAPSTONE, NOAA conducted 24 expeditions, 187 remotely operated vehicle dives, and mapped more than 635,000 km^2 of seafloor, an area close to the size of Texas, in and around the Pacific Remote Islands, Papahānaumokuākea, Marianas Trench, and Rose Atoll Marine National Monuments, the Hawaiian Islands Humpback Whale and American Samoa National Marine Sanctuaries, and the high seas. The campaign contributed a wealth of publicly available data, including high-resolution maps for large portions of the Pacific Ocean, first documentations of several underwater cultural heritage sites, the discovery of potential new species, range expansions of numerous known species, and important insights into geological, oceanographic, and biological processes. These data and information improve our understanding of how underwater geological features are formed across the central and western Pacific and help to identify biogeographic patterns and natural and cultural resources. CAPSTONE results also allow decision-makers to better address emerging regional priorities such as deep-sea mineral locations, sustainable fisheries, and potential U.S. Extended Continental Shelf designations. More than 260 scientists, students, and managers participated in CAPSTONE expeditions via telepresence technology, and live video feeds from these expeditions received more than 16.5 million views.







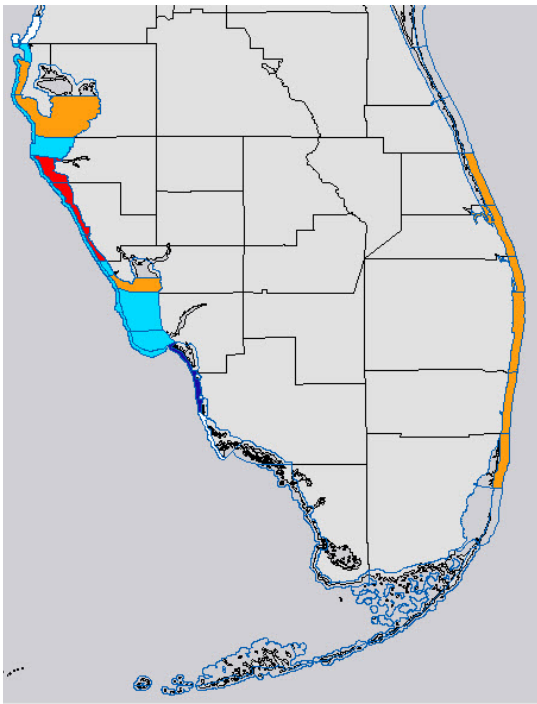
The Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE) operating areas from 2015 - 2017 (top left). Using a Remotely Operated Vehicle Deep Discoverer (top right) NOAA's Office of Ocean Exploration and Research observed a deep-sea swimming sea cucumber (middle right) and a ghostlike octopod (bottom right).

NOAA Plays a Leading Role in Forecasting and Response to 2018 Florida Red Tide

NOAA has played a major role in the response and mitigation of harmful algal blooms (HABs) in Florida through the delivery of the Gulf of Mexico HAB Forecast Bulletin and by providing critical support of research and response activities. For decades, coastal communities on Florida's Gulf Coast have dealt with the impacts of red tide, a HAB caused by the algal species *Karenia brevis*. Under favorable ocean conditions, these microscopic organisms bloom in the Gulf of Mexico and spread along the Florida coasts. The toxins produced by this species can poison fish, marine mammals, turtles, and other aquatic wildlife. They also can result in severe respiratory impacts for beachgoers through ocean spray and other means. Florida has experienced higher-than-average bloom severity in 2018, resulting in major impacts to the tourism and leisure industries along its coasts.

The NOAA HAB Forecast Bulletin provides state and local officials and the public with weekly warnings at county levels that show bloom extent and trajectory, as well as projections of areas where public health is likely to be impacted. In October 2018, NOAA began initial testing on an improved version of the forecast that will lead to warnings that can be delivered for individual beaches on a daily basis. If successful, this will mark a significant advancement in NOAA's ability to provide actionable information at a scale that is highly valuable to the public. In addition to the forecast, NOAA provides financial support for assisting with the mobilization of research and analytical services by local officials during blooms. Awards in 2018 have provided for a team from the Florida Fish and Wildlife Research Institute and Mote Marine Lab to join an expanded NOAA-led sampling cruise to map the extent of red tide in southwest Florida and for research on potential treatments for birds and other animals sickened by toxins from the bloom. In addition, NOAA provided over $800 thousand in grant awards to Florida to support additional research on HABs to further assist with response and mitigation efforts. NOAA Florida-related HAB efforts alone demonstrate the value of the agency's applied research portfolio and resulting delivery of science products and services that meet the needs of coastal communities.

Dead fish on a Florida beach due to red tide. NOAA's National Centers for Coastal and Ocean Science and Atlantic Oceanographic and Meteorological Laboratory are supporting research on response and mitigation efforts.

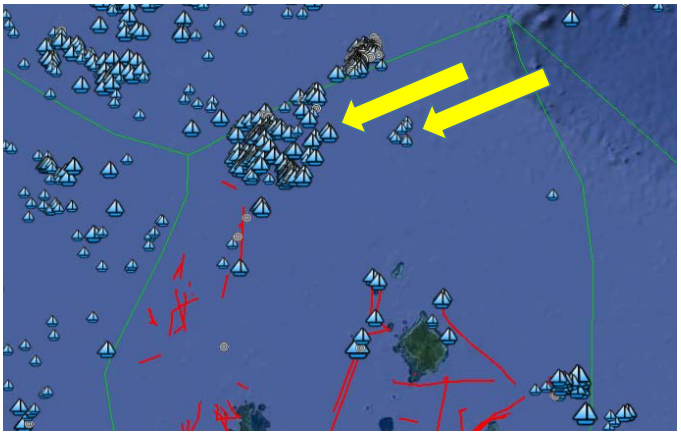


NOAA's harmful algal bloom (HAB) Forecast Bulletin from the Center for Operational Oceanographic Products and Services provides the public weekly warning at county levels.

National Estuarine Research Reserves (NERRS) Provide Science Platform for Coastal Resilience

NOAA partners with coastal states to maintain 29 sites designated to protect estuarine systems. Collectively, these sites form the National Estuarine Research Reserve System (NERRS) which provides real-life labs for coastal monitoring, conservation, and research. Recent studies in the NERRS have made key contributions to our understanding of how to protect coastal communities from coastal hazards. Research in New Hampshire's Great Bay reserve demonstrated the value of NERRS to serve as a natural buffer against storm surge, sea level rise, and runoff. Findings from this work, available online, are supporting land use decisions and policy. Researchers working at the Guana Tolomato Matanzas reserve in Florida are field testing and optimizing a new nature-based shoreline protection technique that is already showing benefits. Scientists and engineers installed a series of "gabion-break" structures that run parallel to the shore to dissipate waves using a combination of wooden breaks and shell filled cages. The research shows that this unique hybrid design is fostering oyster settlement and reef development and allowing sediment accretion and the expansion of marsh grasses in a section of Florida's Intercoastal Waterway with heavy boat traffic. Over the past ten years, the NERRS Science Collaborative has supported the Hudson River Sustainable Shorelines Project, which engages a regional research team to quantify the ecological functions and physical stresses on the full range of Hudson River shorelines. The team recently developed, tested, and trained land managers to use rapid assessment protocols allowing state regulators to rapidly determine the environmental success of restored shoreline projects. Ongoing collaboration with a variety of partners has enabled this research to better inform state funding and permitting programs and has inspired a number of new sustainable shoreline projects along the Hudson River.

A monitoring protocol is tested at the Hudson River National Estuarine Research Reserve (photo credit: Hudson River NERR).

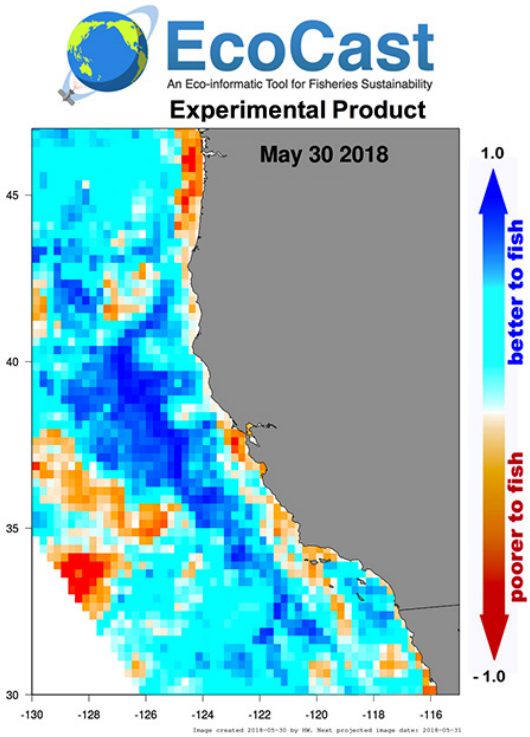


NOAA's National Center for Environmental Information detects boats with the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on the Joint Polar Satellite System (JPSS) satellites without a vessel monitoring system (VMS), representing potential illegal fishing.

Shining a Light on Illegal Fishing

Illegal, unreported, and unregulated (IUU) fishing is a global problem that threatens ocean ecosystems and sustainable fisheries. IUU fishing poses not only an environmental threat to fish stocks and their ecosystems, but also a threat to food security and socio-economic stability in many parts of the world, with developing countries most at risk. NOAA's new Boat Detection products detect vessels by light, including fishing vessels using lights to attract fish, with the day/night band of the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on the Joint Polar Satellite System (JPSS) satellites. Scientists cross-matched VIIRS boat detections with ship tracks coming from GPS beacons such as Vessel Monitoring System (VMS) or Automatic Identification System (AIS) devices. This capability can be used to identify vessels detected by VIIRS, but lacking AIS or VMS, and represent potential illegal fishing in certain fishing grounds.

EcoCast: A Dynamic Ocean Management Tool to Reduce Bycatch and Support



EcoCast is a dynamic ocean management tool that aims to minimize fisheries bycatch and maximize fisheries target catch in real-time from NOAA's Southwest Fisheries Science Center.

New computer-generated daily maps will help fishermen locate the most productive fishing spots in near real-time while warning them where they face the greatest risk of entangling sea turtles, marine mammals, and other protected species. Scientists developed the maps, the products of a system called EcoCast, to help reduce accidental catches of protected species in fishing nets. Traditional ocean management strategies tend to be static with boundaries that are fixed in space and time. To capture broad-scale oceanic processes and protect highly migratory species, for example, these regions become larger than necessary with opportunity costs for commercial fisheries.

EcoCast uses a dynamic management strategy, which better aligns scales of management to the scales of variability of the features and resources being managed. By incorporating real-time satellite, buoy, modeled and observed data, EcoCast provides management recommendations that reflect current marine state. EcoCast will help fishermen, managers, scientists, and others understand in near real time where fishing vessels have the highest probability of catching targeted species and where there is risk of catching protected species. In doing so, EcoCast aims to improve the economic and environmental sustainability of fisheries and reduce bycatch of protected species.

Currently, NOAA Fisheries closes a large area off the West Coast to the swordfish fishery seasonally to protect leatherback turtles, which travel widely and can be caught incidentally in the nets. With EcoCast, fisheries managers could outline small "dynamic closures" that shift according to the likely locations of the species they are trying to protect. Since they concentrate protection where it is needed most, dynamic closures for leatherback sea turtles could be two to ten times smaller than the current static closures while still safeguarding the species that need protection.

EcoCast is available now and is being developed by a consortium of scientists, managers, and members of the fishing industry. The EcoCast team is made up of scientists from several universities (San Diego State University, University of California Santa Cruz, University of Maryland, Old Dominion University, Stanford University) and NOAA Fisheries, working in direct collaboration with resource managers, fishing industry, and other stakeholders. Fishermen have participated throughout the development of EcoCast, which boosts its usefulness to the fishing fleet.

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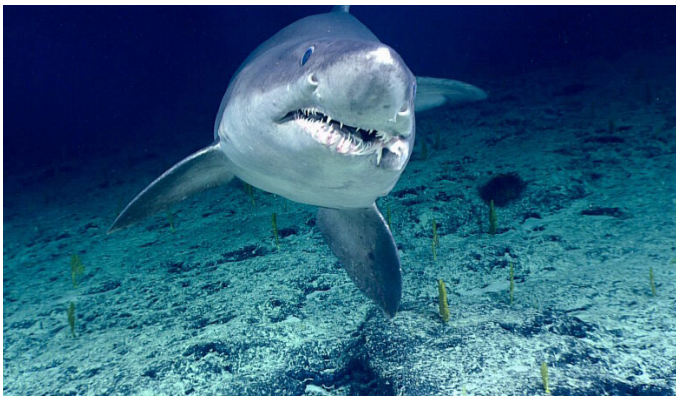
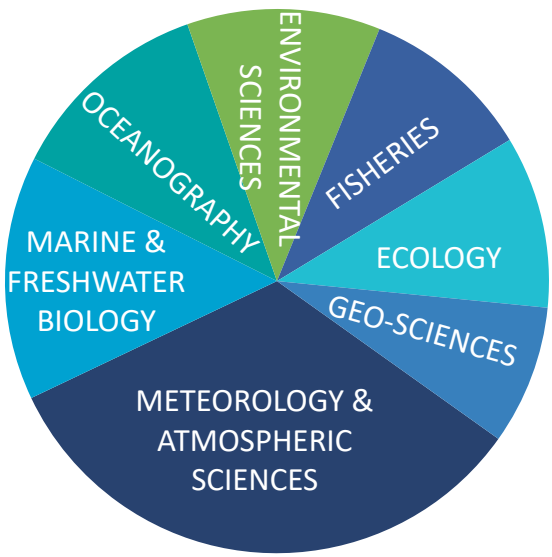


Bibliometrics

NOAA Peer-Reviewed Articles 2011-2017

13,621	138	234,166	92%
Total Articles	H-Index	Times Cited	% of Articles Cited

Top Research Areas

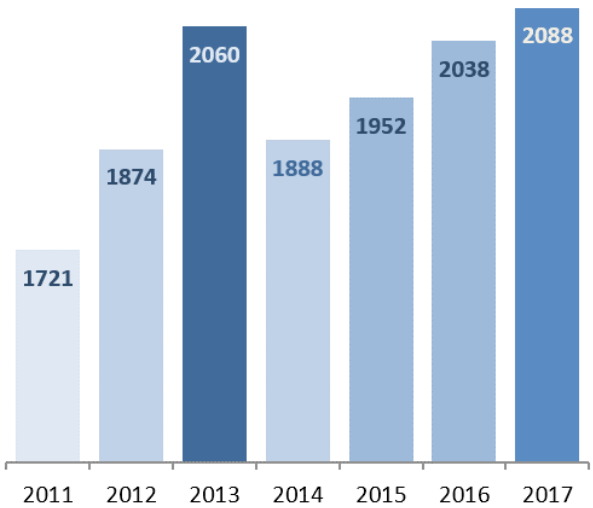


WoS Subject Area	# of Articles
Meteorology & Atmospheric Sciences	4815
Oceanography and Marine Sciences	8533
Marine & Freshwater Biology	*2110*
Oceanography	*1777*
Environmental Sciences	*1673*
Fisheries	*1491*
Ecology	*1482*
Geo-sciences	1205

Note some articles fall into more than one WoS subject area.

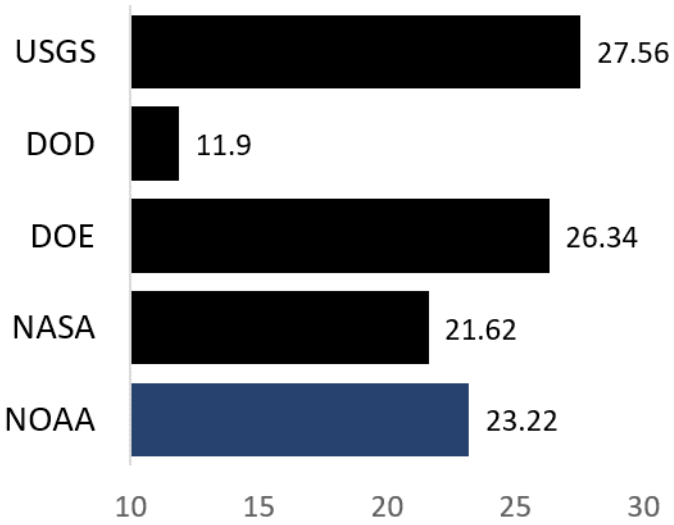
Articles Per Year

Year	# of Articles
2011	1721
2012	1874
2013	2060
2014	1888
2015	1952
2016	2038
2017	2088

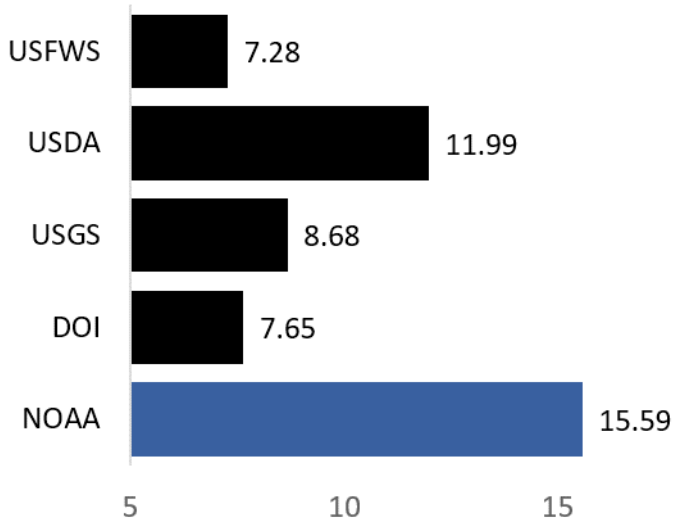


Percentage of Articles in Top 10% of Articles Cited

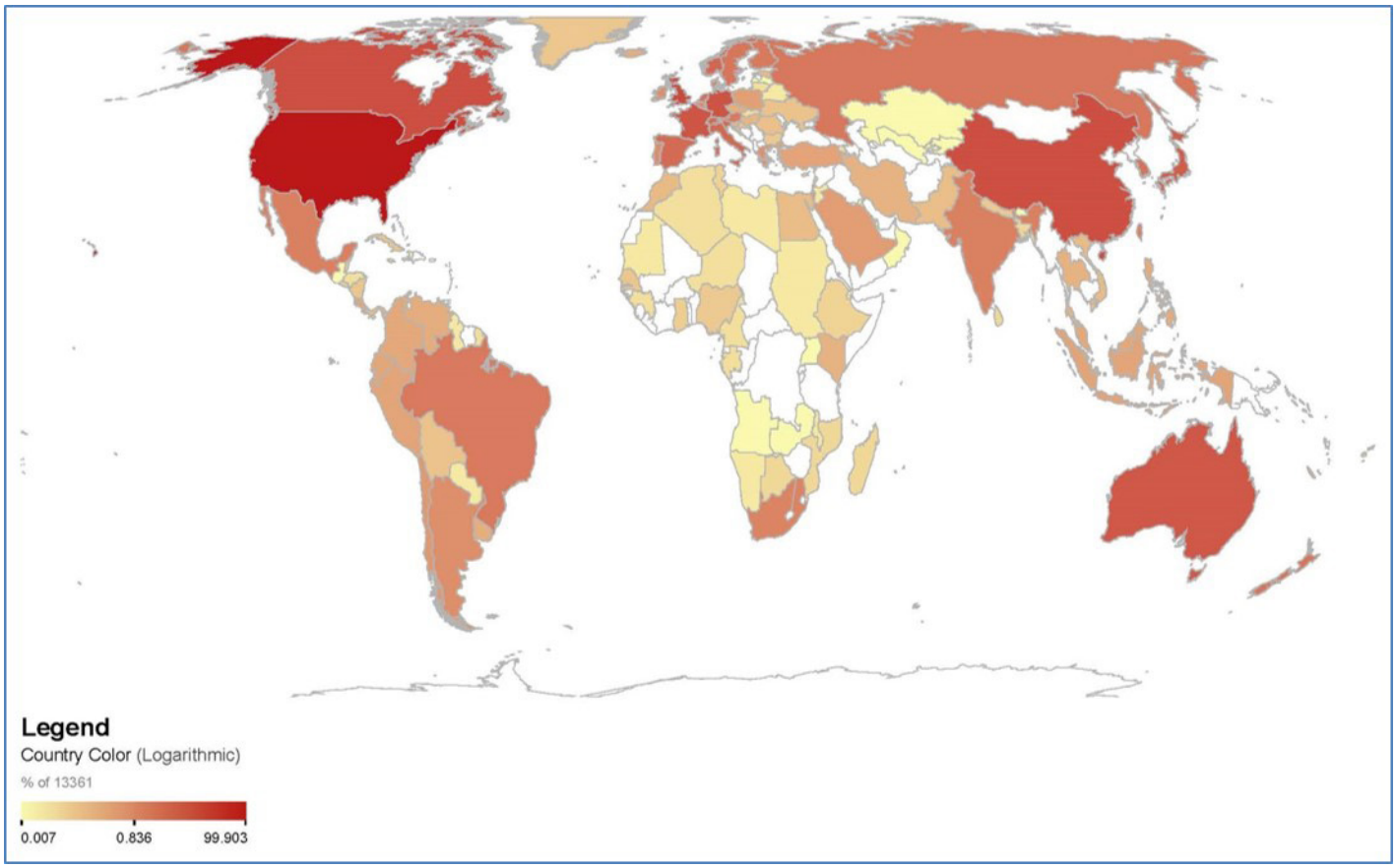
Meteorology & Atmospheric Sciences



Fisheries



International Collaborations



How to Read this Map

This choropleth map *shows the world map using the equal-area Eckert IV projection. Each country may be color coded in proportion to a numerical value which represents co-authorship on NOAA publications.. Minimum and maximum data values are given in the legend.*

Scientific Awards and Achievements

External Scientific Awards

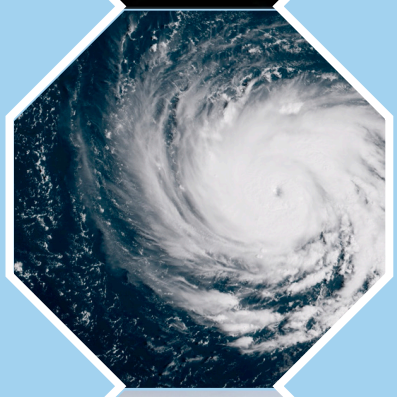
Award	Recipient(s)	Award Organization
Charles L. Mitchell Award	Daniel Keeton	American Meteorological Society
NASA Outstanding Leadership Medal	Dennis Chesters	National Aeronautics and Space Administration
Selected as an AMS Fellow	Mitch Goldberg	American Meteorological Society
2018 CALCON Technical Meeting Recognition Award	Bruce Guenther	Characterization and Radiometric Calibration for Remote Sensing
2018 Robert H. Gibbs, Jr. Memorial Award for excellence in systematic ichthyology	Thomas Munroe	American Society of Ichthyologists and Herpetologists
Climate Adaptation Leadership Awards for Natural Resources	Marine Mammal Climate Vulnerability Team:Chris Orphanides, Debi Palka, Diane Borggaard, Mike Asaro, Dave Gouveia, Jenny Litz, Melissa Soldevilla, Laura Engleby, Dori Dick, Roger Griffis, Matt Lettrich	National Fish, Wildlife and Plants Climate Adaptation Strategy
MBNMS Volunteers of the Year	Scott Benson and Karin Forney	Monterey Bay National Marine Sanctuary (MBNMS)
Distinguished Professional Achievement Award	Rachel Johnson	California-Nevada Chapter of the American Fisheries Society (AFS)
AIFRB Outstanding Group Achievement Award	Paul Crone as a PI for Center for the Advancement of Population Assessment Methodology (CAPAM)	The American Institute of Fishery Research Biologists (AIFRB)
2018 AMS Weather Analysis and Forecasting Committee Early Career Award	Curtis Alexander	American Meteorological Society
FLC Far West Region award for Outstanding Partnership	Wind Forecast Improvement Project - 2 Team	Federal Laboratory Consortium Far West Region
First Prize for an Outstanding Scientific Publication	Dominikus Heinzeller	Society of Friends and Sponsors of the Institute of Meteorology and Climate Research

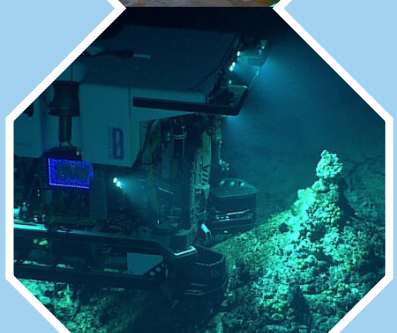
Award	Recipient(s)	Award Organization
2018 Sverdrup Gold Medal Award	Michael Alexander	American Meteorological Society
AMS Fellow	Michael Alexander	American Meteorological Society
2018 Bernhard Haurwitz Memorial Lecturer	George Kiladis	American Meteorological Society
AMS Fellow	Jeffrey Whitaker	American Meteorological Society
AMS Fellow	Roger Pulwarty	American Meteorological Society
American Indian Science and Engineering Society (AISES)Sequovah Fellowship Award	Roger Pulwarty	American Indian Science and Engineering Society (AISES)
Union Fellow	Walter H. F. Smith	American Geophysical Union
Finalist for the Samuel J. Heyman Service to America Medals	Tim Schmit	Partnership for Public Service
CO-LABS Governor's Award for High-Impact Research	Steven Miller, Dan Lindsey, Curtis Seaman	CO-LABS
NOAA David Johnson Award	Scott Rudlosky	National Space Club and Foundation
NASA Group Achievement Award to the GOES-R Team	Don Hillger, Dan Lindsey (and many others)	National Aeronautics and Space Administration
AMS Conference on Hurricanes and Tropical Meteorology: Most questions asked	John Knaff	American Meteorological Society
James R. Holton Award	Angel Adames-Corralia	American Geophysical Union
2018 Ascent Award	Yi Ming	American Geophysical Union
2018 AGU Fellow	Tom Delworth	American Geophysical Union
Bannan I. Miller Award	Kieran Bhatia	American Meterological Society
Revelle Medal	Isaac Held	American Geophysical Union

Scientific Awards and Achievements

Award	Recipient(s)	Award Organization
Highly Cited Researchers for 2018	Thomas Delworth, John Dunne, Paul Ginoux, Steve Griffies, Issac Held, Larry Horowitz, Vaishali Naik, Gabriel Vecchi, and Andrew Wittenbreg	American Geophysical Union
Banner I. Miller Award	Jason Dunion	American Meteorological Society
Laureate Award for Dual Defense Use	Joe Cione, Altug Aksoy, Brittany Dahl, Kelly Ryan, and Jun Zhang	Aviation Week
Award for Early-Career Professional Achievement	Gina Eosco	American Meteorological Society

National Oceanic and
Atmospheric Administration





Scan the QR code to download the full interactive 2018 NOAA Science Report or access the report at: https://go.usa.gov/xEV73