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Testimony to the
Environment Subcommittee of the
Committee on Science, Space, and Technology
United States House of Representatives

Field Hearing: Weathering the Storm: Improving Hurricane Resiliency through Research
July 22, 2019

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Good morning Chairwoman Fletcher, Ranking Member Marshall, and Members of the Subcommittee. I am Dr. Louis Uccellini, Director of the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS). Within the NWS, NOAA's National Hurricane Center (NHC) issues the official forecast for all Atlantic and eastern Pacific tropical cyclones (hurricanes, tropical storms and tropical depressions) and their precursors. It is my honor to testify before you today on the state of the United States hurricane forecasting capability; our efforts to improve our understanding and prediction of hurricane impacts from storm surge, heavy precipitation, and high winds; and what hurricane research focus areas are needed to improve prediction.

I come before you today to report that hurricane forecasting accuracy has improved tremendously over the past two decades. The NHC track (storm location) forecast errors have decreased every decade since forecast accuracy records were established in the 1960's, and NHC has set new records almost every year. For perspective, the average two-day Atlantic forecast location error was reduced from around 300 miles (approximately 260 nautical miles (n mi), see Fig. 1) in the 1960s to near 85 miles in the 2010s. The five-day forecast for storm location is now better than the day-and-a-half forecast was in the 1970s. There has also been about a 25 percent reduction of intensity errors at day five in 2010-2018 as compared with 2000-2009.
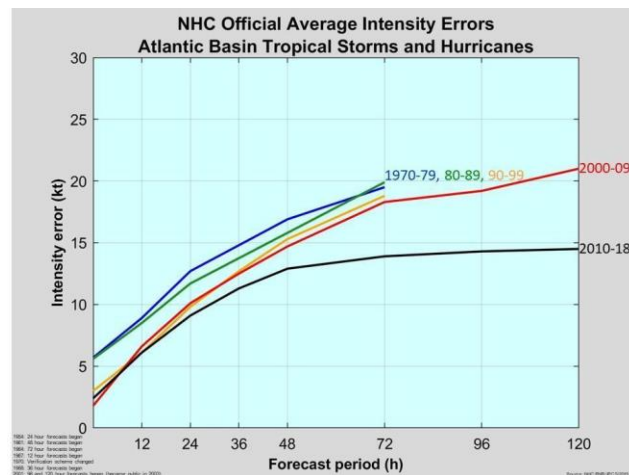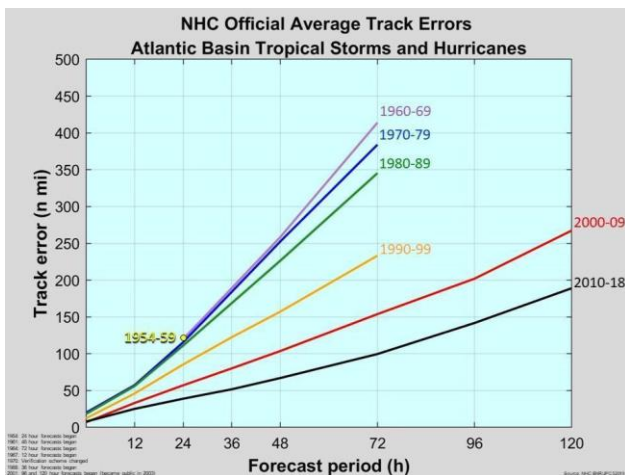
Figure 1. NHC Atlantic hurricane and tropical storm track and intensity forecast errors

These improvements in NOAA's hurricane forecasts have helped emergency managers make more timely, focused, and accurate community preparation and evacuation decisions (see Figure 2). The increasing accuracy of our forecasts is from improvements in weather prediction models, access to high quality global data, and our skilled forecasters. The NWS Environmental Modeling Center (EMC), NOAA's Office of Oceanic and Atmospheric Research (OAR), and our partners in government and academia developed these models. Also contributing are advances in our ability to measure the atmospheric and ocean conditions from satellites and NOAA hurricane hunter aircraft that are used to collect observations for the models, and running these ever-increasingly complex models on the latest supercomputers. These high-resolution models, and multiple "ensembles" of the models, provide our forecasters with the guidance they need to make accurate predictions. Official hurricane forecasts are made by NHC's "hurricane specialists." These forecasters apply their experience and knowledge about the hurricane, the computer models and other inputs to make forecasts that, on average, are more accurate than every individual computer model prediction.
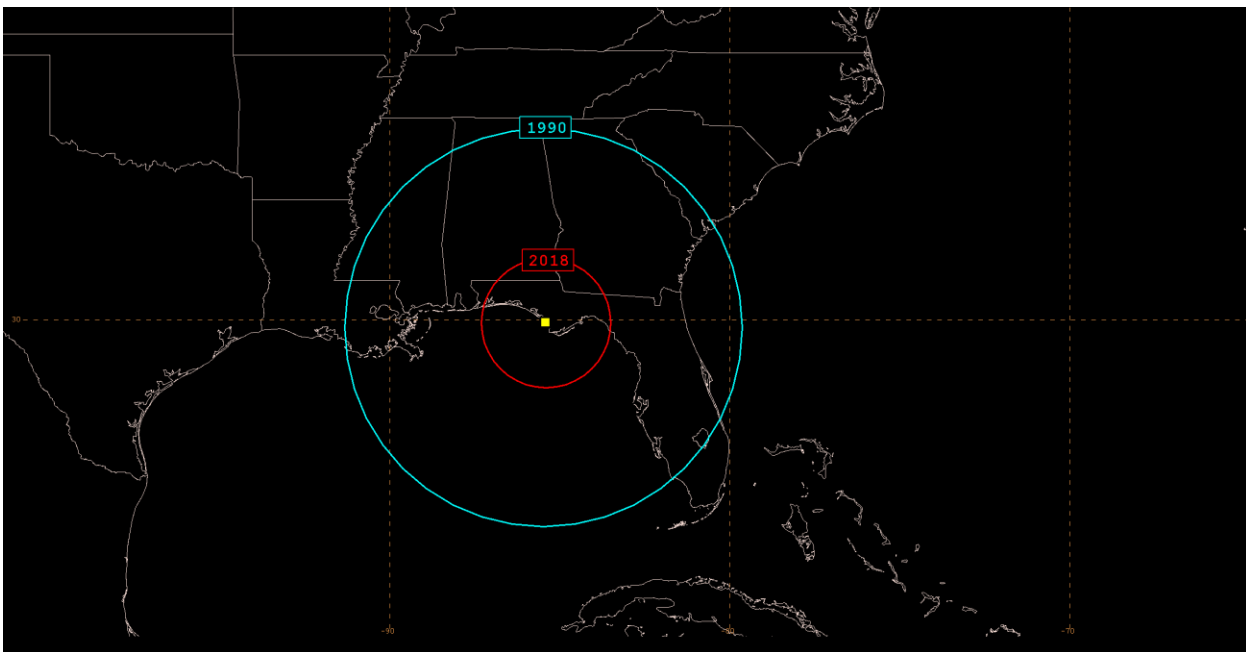

Figure 2. Average NHC three-day forecast track error in 2018 (red) compared to 1990 (blue).

The Hurricane Challenge and NOAA's Recent Advances in Hurricane Products and Services

The U.S. Gulf and east coasts, adjacent inland areas, and U.S. territories have experienced many devastating hurricanes and tropical storms over the years, causing enormous damage and loss of life. Looking back at U.S. hurricane history, about 90 percent of fatalities directly attributable to the forces of tropical weather systems are due to water, not wind. These water fatalities are either from storm surge or from inland flooding. Storm surge incidents accounted for about half of the deaths attributed to

water. Storm surge from individual hurricanes has taken thousands of lives in this country, and it remains one of, if not the greatest, threats for large loss of life in a single-day event.

To reduce storm surge impacts, during the past few years NWS began implementing new storm surge products. These include watches and warnings specifically for storm surge. The NWS also introduced potential inundation maps to provide the public, emergency managers, and others with more information specific about storm surge and inundation. These enhancements have helped emergency management officials with coastal evacuations.   This year, the NHC is extending the storm surge watch and warning capability to Puerto Rico and the U.S. Virgin Islands.

For storm surge, small changes in the hurricane structure, size, and forward speed can make a big difference on the ground in terms of impacts. For example, a 30 mile change in track could mean the difference in a particular location between a few feet of storm surge versus water rising to over 10 feet deep (see Figure 3).
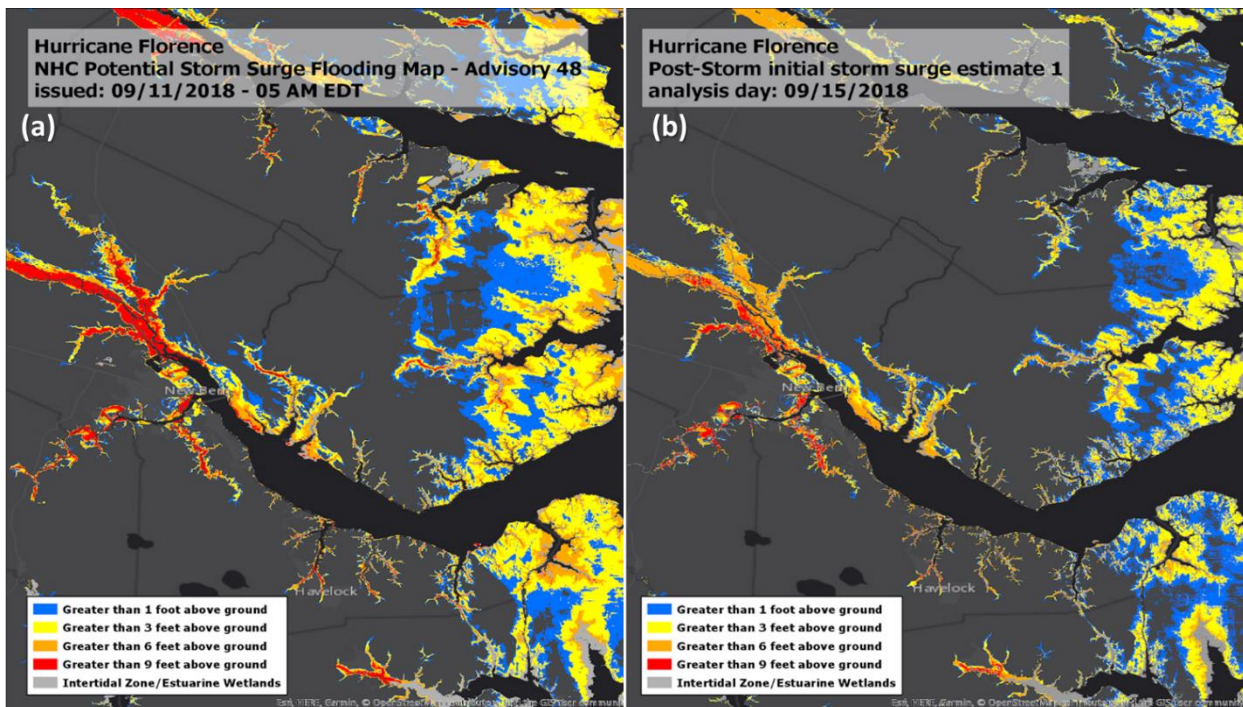

Figure 3. Example of new NOAA storm surge inundation mapping for Hurricane Florence. (a) shows the NWS storm surge forecast available publicly while (b) shows the post-storm analysis of what occurred.

Beyond storm surge accounting for about half of the number of deaths, freshwater floods from excessive rain are responsible for another quarter of the casualties. These floods can occur as much as hundreds of miles inland and away from the center of the storm, and days after the storm makes landfall.

Over the past two hurricane seasons, we have demonstrated increased skill on precipitations forecasting. For Hurricane Harvey, the NWS predicted over 40 inches of rain and historic catastrophic flooding two

days before it occurred. Forecast amounts were increased to over 50 inches as the event unfolded, particularly in the Houston area. Historic flooding with totals of 50-60 inches of rainfall were observed. Forecasting these amounts of rainfall that far in advance was unprecedented. The NWS communicated those predictions to the emergency management community and that led to their proactive actions, even to close the City of Houston on Saturday ahead of the heaviest rains. Our private sector partners, both in the media and private weather companies, also helped communicate the impacts of this forecast for record rainfall and flooding.

At our new National Water Center, NOAA is developing inundation mapping graphics that will better convey the extent of the flooding and, just as importantly, which areas will not flood. This experimental tool was used last year during Hurricane Florence. Florence was another slow-moving hurricane that dumped record rainfall—over 40 inches in North Carolina. Five days before landfall the NWS accurately predicted huge rainfall amounts, over 20 inches, and refined our forecasts to over 40 inches about three days before landfall (see Figure 4).   We are working to improve rainfall inundation mapping so the public can better understand how deep the water will be from inland and river flooding from excessive rain. While deaths directly attributable to storm surge have decreased markedly, people continue to perish due to flooding,.
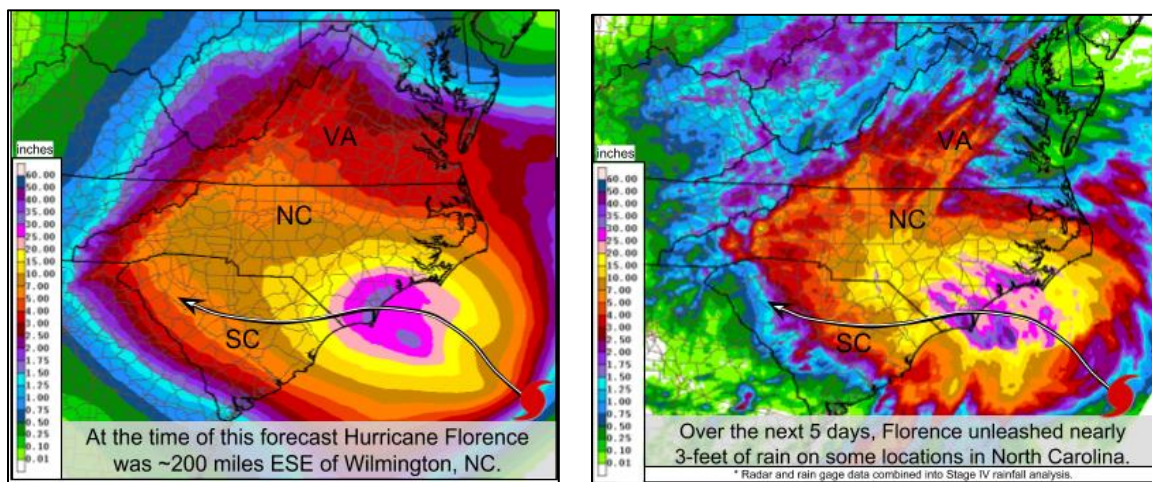

Figure 4. Day 5 rainfall forecast from Hurricane Florence (left) and observed rainfall from Hurricane Florence (right).

Giving accurate hazard information as far in advance as possible of a storm is crucial. While some hurricanes, like Florence, form far from land and give residents many days to prepare, that is not always the case. Hurricane Michael, for example, came ashore at Category 5 intensity just a few days after forming. To extend lead time, NHC has recently implemented the capability to issue its full product suite, including "warnings," prior to the formation of a tropical cyclone. This has enabled preparations to begin earlier, which is especially important for storms that form close to the U.S. coast. In fact, this new service has added 15 hours, on average, of lead time over the last two years for those storms like Harvey and Michael that formed close to the coast.

To help decision makers prepare, NOAA also implemented a very helpful and popular "time-of-arrival" graphic in the past few years. It depicts the time when tropical storm force winds could begin at a location, signifying the time when outside preparedness activities can be too dangerous to conduct. This

timing information is important because there are critical decision points in advance of a storm when preparations must be completed.

The new storm surge and time of arrival products account for and can convey forecast uncertainty. For example, the time of arrival products provide emergency managers with a range of times when tropical storm conditions could begin based on the underlying forecast uncertainty. Future products will continue to provide uncertainty information using past forecast errors and output from ensemble modeling systems.

Forecast accuracy is not the only hurricane challenge. Effective communication about storms is also critical. An important strategy in our operational communications, development of new products and warnings, and outreach and education efforts, is to increase attention on the individual impacts from wind and water hazards that could occur in each community—namely winds, tornadoes, storm surge, inland flooding, and ocean waves and rip currents. The storm surge watches and warnings are an example of one new hazard-specific information.

Hurricanes and tropical storms are not only coastal event. In fact, the highest storm surge measured in Hurricane Florence was 100 miles inland from the Atlantic coastline where river channels narrow and water collects. The most deadly aspects of hurricanes, storm surge and inland rain, are highly dependent on the size, structure, and forward speed of the storm, not just the wind category. In fact, over the past 10 years, Category 1 hurricanes have produced around $100 billion in damage and killed more than 150 people in the United States. There is no such thing as a "just a" Category 1 hurricane or "just a" tropical storm; it is about the impacts of these storms.

Certain parts of the country have gone years without experiencing a major hurricane. NOAA is working to help these communities prepare for a hurricane that may impact their community. The introduction of new hurricane storm surge products and warnings increased public and partner focus on preparing in advance for that hazard. To adequately prepare, the public needs to recognize that overall hurricane activity has almost no relationship to hurricane impacts in any one community. "It only takes one." One of the best examples is 1992 that was overall a below-average year for the number of hurricanes in the Atlantic, with only one "major" hurricane forming. But, that one was Andrew, which struck South Florida as a Category 5, the most intense rating on the Saffir-Simpson hurricane wind rating scale and caused catastrophic damage when it moved across the southern portion of the state.

While U.S. hurricane related deaths have gone down by about two-thirds, much work remains to reduce further the loss of life from tropical cyclones. NOAA's public outreach messaging is not only about the hurricane hazards themselves, but also about what people should be doing to get ready, starting well in advance of the next hurricane, and about resiliency in the face of the hazards that could occur where they live

Hurricane Science and Technology

As noted earlier, there has been tremendous progress made in hurricane prediction. The new supercomputers for which Congress appropriated funds have allowed us to run more complex, sophisticated and accurate forecast models, including the new Hurricane Weather Research and Forecast (HWRF) model. The HWRF model represents a significant step forward in our prediction of hurricane

structure and intensity. The research and development has been a joint effort between NOAA, primarily NWS and OAR, and academic partners as part of the Hurricane Forecast Improvement Project (HFIP). This advancement highlights the importance of the research and operational entities working hand-in-hand to transfer promising research techniques into operations. Improvements in NOAA's hurricane prediction will continue to follow the guidelines outlined in the Weather Act. The Weather Act expands NOAA's critical mission areas, including improvements through HFIP—improved modeling and computing capacity, working with the private and academic sectors to obtain the best possible data, further research on hurricane behavior to better predict rapid intensification.

Another joint effort between NWS and OAR, the Joint Hurricane Testbed (JHT), is a virtual environment for cutting-edge technology testing and demonstration funded by the U.S. Weather Research Program (USWRP). The JHT connects the tropical cyclone research community with forecast operations. Since its inception, nearly 20 years ago, the JHT has supported nearly 100 projects, averaging around 10 at a time, and demonstrated great success by transferring about two-thirds of the projects into NWS operations, resulting in improved NOAA services for the public. This year, the current six JHT research and development projects will be completed. NOAA plans to fund three JHT projects during the program's next round, beginning later this year.

Intensity forecasts have improved, but not as much as the track forecasts. The NHC now usually can capture the trend of strengthening or weakening, but we need to learn more through the research community to better predict the extent of these trends. "Rapid Intensification" remains a particularly difficult phenomenon to predict accurately. There are still parameters we need to understand better to improve those forecasts. Understanding storm structure and the upper atmosphere contributions, including how storms react to moderate amounts of environmental wind "shear," will help us better predict their roles in the intensity challenge.

HFIP is a multi-year, multi-million dollar effort to improve hurricane forecasts, and it can be largely credited with the advances in forecasting noted over the past decade. NOAA met the five-year HFIP goal to reduce hurricane forecast track and intensity errors by 20 percent. Recent HFIP-funded enhancements that have been made to the operational HWRF have made it our best-performing intensity model over the 2013-2018 period. HFIP is also supporting promising work to help identify and adjust for biases in the primary track and intensity models. In addition, HFIP supported the development of the new time of arrival product, and will continue to support new product development and evaluation. HFIP's current ambitious goals are to improve track and intensity forecast accuracy by another 50 percent over the next 10 years, to extend high-accuracy forecasts from five to seven days, and to further infuse social and behavioral science into the product development process.

NOAA's flagship operational weather model—the Global Forecast System (GFS)—is undergoing a significant upgrade to include a new dynamical core called the Finite-Volume Cubed-Sphere (FV3). This upgrade will drive numerical weather prediction into the future with improved forecasts of the jet stream and associated weather, tropical cyclone intensity and five-day track forecasts, as well as precipitation forecasts across the U.S. and worldwide. NOAA's FY20 Budget request includes $15 million for the Earth Prediction Innovation Center (EPIC) to advance a community weather model that is accessible by the public. EPIC leverages partnerships to accelerate advances designed to meet NOAA's operational forecast mission to protect life and property and improve economic growth.

Hurricane forecast operations continue to rely on aircraft reconnaissance. The NOAA Gulfstream-IV (G-IV) and two Lockheed WP-3D (P-3) Orions are part of NOAA's fleet of highly specialized research and operational aircraft. These aircraft are operated, managed and maintained by NOAA's Office of Marine and Aviation Operations (OMAO), based in Lakeland, Florida. The G-IV flies at high altitudes around and ahead of a tropical cyclone, gathering critical data that depict the atmospheric steering flow, and those data feed into and result in improved accuracy from hurricane forecast models. The P-3s are NOAA's hurricane research and reconnaissance aircraft flying into the eye of the storm. These versatile turboprop aircraft are equipped with an unprecedented variety of scientific instrumentation, radars and recording systems for both in-situ and remote sensing measurements of the storm and its environment. These two aircraft have led NOAA's continuing effort to monitor and study hurricanes. Additionally, ten WC-130J aircraft are configured specially for hurricane reconnaissance, and operated by the U.S. Air Force Reserve from the 53rd Weather Reconnaissance Squadron, 403rd Wing, located at Keesler Air Force Base in Biloxi, Mississippi. When flying a hurricane mission, military air crews fly directly through the eye of the storm several times each flight. Both the NOAA and USAF aircraft collect data and transmit them in near real time by satellite directly to EMC to be incorporated into the forecast models, and to NHC, so forecasters can analyze and predict changes to the hurricane's path and strength. The men and women of NOAA's Aircraft Operations Center and the U.S. Air Force are heroes who fly into and around hurricanes to give us the critical data we need to forecast the storms and warn the nation.

These aircraft data are key. For example, last year was the first year NOAA's P-3 aircraft flew into hurricanes in the Central Pacific. The model forecast track for Hurricane Lane was erratic at best until data from NOAA flights were incorporated into the models. The computer forecasts then gave NOAA forecasters confidence that Lane would make a sharp left turn, as they had been predicting.

NOAA anticipates data from new Unmanned System (UxS) technologies will contribute significantly to improving the understanding of tropical cyclone processes and ultimately to improvements in track and intensity predictions. NOAA is working with the private sector and other federal agencies to identify, evaluate, and transfer to operations innovative and cost-effective UxS capabilities that meet NOAA's observing requirements, and help form a comprehensive observing strategy for the future. In the recent past, unmanned aerial systems (UASs) have improved hurricane observations. In the 2017 hurricane season, NOAA joined with NASA to fly the unmanned NASA Global Hawk ahead of and above Hurricanes Franklin and Harvey, launching dropsondes that collected data to be assimilated into the operational GFS model and HWRF. That year marked the first time that Global Hawk dropsondes were assimilated in real-time into the GFS model. In 2016 scientists also launched six small "Coyote" drones from a NOAA P-3 Hurricane Hunter during Hurricane Maria to collect unique data from within the eyewall in the lower part of the storm, where the hurricane gains strength from the ocean and it is very dangerous for manned aircraft to fly. The low-level observations of wind speed, wind direction, atmospheric pressure, temperature, moisture, and sea-surface temperature provide more detail on hurricane strengthening than dropsondes that record a single point of data at any one level. These observations can provide information needed to improve intensity predictions. The FY20 President's Budget includes an increase of $4 million for a new operational program for unmanned systems within OMAO. A centralized, NOAA-wide UxS program will more efficiently manage and standardize acquisition and procedures for use of UxS. NOAA will leverage labs and programs within all of its line offices that have extensive experience in unmanned systems research and development to create a more organized and cost-effective corporate operation in OMAO.

NOAA researchers partnered with NOAA/National Ocean Survey Integrated Ocean Observing System regions to deploy autonomous underwater gliders to better understand how the upper ocean contributes to hurricane intensity. These gliders collect information in the Atlantic Warm Pool, an area of the ocean commonly associated with hurricane development and intensification. Hurricanes Harvey, Irma, Jose, and Maria passed directly over, or very close to the gliders, providing valuable information to NOAA researchers and forecasters. The ocean data collected by the gliders totaled over 4,000 temperature and salinity profiles. Correct representation of ocean conditions during a hurricane has been shown to significantly reduce the error in intensity forecasts.

Data from satellites are a critical component of NOAA's observation network. Satellites provide more than 95 percent of the data assimilated into NOAA's operational numerical weather prediction (NWP) models of which over 80 percent are from polar-orbiting satellites. NOAA has managed the operation of polar-orbiting operational environmental satellites (POES) since 1966 and geostationary operational environmental satellites (GOES) since 1974. NOAA also uses complementary satellite data from other collaborating national and international space agencies, either in joint mission like the JASON ocean altimetry series and Metop satellites in which NOAA is a partner, or NASA Earth Observing System, Japan's Global Change Observation Mission-Water 1 and Himawari, and Europe's Meteosat missions where NOAA is a key data user. Over the decades, these systems have supported weather and environmental monitoring programs that users in the U.S. and around the world rely on for accurate data and imagery.

NOAA's POES provide full global coverage for a broad range of weather and environmental applications. These satellites are crucial for NOAA's operational three to seven-day weather forecasts and are used to initialize the NWP models because they can uniquely measure the vertical profiles of temperature and moisture. The high resolution sounders on NOAA-20, the Cross-track Infrared Sounder (CrIS), and Advanced Technology Microwave Sounder (ATMS) have been instrumental in providing significant improvements to NOAA's weather forecasts. The European Metop satellite constellation, also provides observations that NOAA assimilates into its operational numerical weather prediction models.

Data, imagery, and products from NOAA's GOES satellites are vital for observing and tracking tropical cyclones and their precursor disturbances, which leads to more timely, accurate, and actionable warnings. This past winter GOES-17 in the GOES West position joined GOES-16 in the GOES East position as the current NOAA operational geostationary satellite constellation. These are two of four satellites in the GOES-R Series and users are excited about the technological advances of these new GOES satellites, which includes improvements to the spatial, temporal, and spectral resolutions of existing data for Earth monitoring and new observations, such as lightning data. The resolution of GOES visible satellite images have improved to around a quarter of a mile, and forecasters can see images (pictures) every minute. The one-minute images allow us to better observe the early stages of tropical cyclone formation and learn on a scale that has not before been available to us. The imagery is helping us better understand eye-wall reformation, which is critical to understanding the intensity fluctuations that hurricanes undergo. New satellite-based lightning data from GOES are showing promise for better anticipating rapid intensification. Data from partner missions are also becoming increasingly important for characterizing surface winds, sea state, and inferring ocean heat content. Data from geostationary and polar orbiting satellites also provide products that are used by our forecasters to

detect areas of flooding from the larger perspective. These products and imagery also assist with post-event recovery and damage assessments.

NOAA Enhances Communities' Coastal Resilience

NOAA's National Ocean Service (NOS) provides science-based products and services to reduce impacts of extreme weather, respond to emergent issues, and support long term resilience.

During the 2018 hurricane season, NOAA partnered with the U.S. Navy in an effort utilizing autonomous underwater gliders for the improved understanding and forecasting of the ocean's impact on Hurricane intensity. The Navy transferred 10 gliders to NOAA for deployment in the Caribbean and made data from an additional 20 gliders available to researchers in the Gulf of Mexico. NOAA is working with the Navy to identify partnership opportunities for the 2019 hurricane season.

NOS provides a suite of services and expertise to help communities anticipate the impacts of storm surge and other coastal hazards. StormQuicklook provides near real-time ocean and weather conditions during major coastal storms and will be incorporated into the soon-to-be released Coastal Inundation Dashboard. NOS partners in the Integrated Ocean Observing System to deploy autonomous vehicles and other sensors to improve storm forecasts. The Digital Coast, a web-based resource of data, tools, and trainings, offers hundreds of state-of-the-art products, from authoritative data sets to interactive mapping tools for more informed coastal planning. For example, in preparation for Hurricanes Harvey, Irma, and Maria, these tools were used to provide the elevation models and sea level rise data needed to develop storm surge forecast maps.

After a storm passes, NOS has a number of services that make the immediate emergency response more effective. Our navigation response teams conduct surveys that are essential to reopening ports and waterways to commerce and shipments of fuel and other emergency supplies. The National Geodetic Survey conducts aerial surveys to assess damage and prioritize response actions, such as when chemical spills or storm debris are posing a continuing threat to life, property, and natural resources. The NOAA Office of Response and Restoration works with the U.S. Coast Guard (USCG) and other incident responders to ensure that response actions protect sensitive natural and cultural resources that are at risk.

During disasters in recent years, impacted states and territories have requested federal assistance to mitigate the oil and hazardous substance threat posed by thousands of displaced vessels. NOAA's Office of Response and Restoration has supported this effort through information management support, providing initial classification of debris through remote sensing data, and providing support in environmental protection and compliance associated with vessel removal activities. For example, after Hurricane Irma hit Florida, NOAA's Marine Debris Program Regional Coordinators reviewed all planned USCG vessel removal operations throughout the state. In cases in which vessel removals could potentially harm natural or cultural resources, NOAA coordinated with specialists in the field to ensure best management practices were followed, to document impacts, and to keep the USCG Incident Command informed. In addition, NOS also trains over 2000 state, local and federal responders each year, in courses such as Science of Coastal Natural Disasters and Science of Oil Spills, to ensure that they are well-equipped with the knowledge to make critical decisions.

NOAA is also a key contributor to FEMA's Daily Operations Brief, providing response and recovery officials with critical information before, during, and after disasters.

Puerto Rico greatly relies on its coastal protection from coral reefs for the safety of human life, property, and commerce. Through participation in the National Disaster Recovery Framework, NOAA received a direct Mission Assignment from FEMA in 2018 totaling $895 thousand to support a request from the Commonwealth for coral reef damage assessment, emergency restoration, and long-term recovery planning following Hurricanes Maria and Irma. Mission Assignments are work orders, with or without reimbursement, issued by FEMA to other federal agencies directing the completion of a task in response to a Stafford Act event. Two teams of scientists worked to evaluate the damage to coral reefs around the archipelago of Puerto Rico. One team quantified the extent of reef damage while the second team reattached at-risk coral colonies to prevent their death and to help rebuild the reef structure. NOAA continues to support planning of long-term restoration activities.

NOAA supplemental funding is tracked by FEMA's Program Management Office (PMO), an effort by the interagency Recovery Support Function Leadership Group (RSFLG) to track and display on a public-facing website (https://recovery.fema.gov/) all supplemental funding, which Congress allocated after the historic 2017 Hurricane Season.

NOAA participated in the development of "An Economic and Disaster Recovery Plan for Puerto Rico", known as the Governor's Plan for "Transformation and Innovation in the Wake of Devastation," and helped develop Courses of Action for the Natural and Cultural Resources Recovery Support Function.

The Coastal Zone Management Act (CZMA) provides the framework for NOAA's partnership with states and territories for collaborating on resilience efforts. Through this voluntary partnership, NOAA provides financial incentives and technical assistance to states and communities to develop and implement policies and plans for coastal hazards, such as flooding, erosion, sea-level rise, and changes in Great Lakes levels. For example, the Texas General Land Office, supported in part by NOS funding, developed the Texas Coastal Resiliency Master Plan. NOS funding also supports on-the-ground resilience actions that protect coastal communities. For example, outside of Houston, Texas, NOS supported the conversion of an abandoned golf course into a wetland and greenspace to absorb floodwaters. During Hurricane Harvey, approximately 200 homes in that neighborhood were protected from flood waters, and when the project is complete, up to 3,000 homes will be protected.

National Coastal Resilience Fund
The National Coastal Resilience Fund is a partnership between NOAA and the National Fish and Wildlife Foundation (NFWF) that funds projects that increase the resilience of coastal communities while enhancing fish and wildlife habitat. In 2019, the fund will invest up to $29 million in the restoration or expansion of natural coastal structures to help absorb the impacts of hurricanes and floods and protect coastal communities.

Research on Coastal Resilience
NOS's Ecological Effects of Sea Level Rise (EESLR) Program assesses the vulnerability of natural ecosystems, evaluates the potential for natural structures (e.g., barrier islands, wetlands, etc.) to reduce coastal inundation, and develops best practices for the inclusion of ecosystems in coastal protection

strategies. In many cases, fostering natural coastal features provides a cost-effective alternative to rigid hardened structures.

Conclusion

NOAA and the weather enterprise have made significant strides in the accuracy of hurricane forecasts and have shown the importance of developing products to better communicate the potential impacts from tropical systems and hurricanes. Effective communication products and accurate forecasts are both essential to further our effort to become a weather-ready nation.

Thank you for the opportunity to appear before you today. I look forward to answering any questions you may have.

NATIONAL WEATHER SERVICE
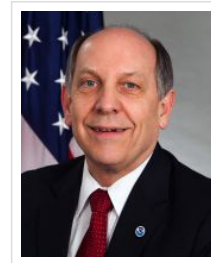### NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Dr. Louis W. Uccellini

National Weather Service Organization
National Program

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Dr. Louis W. Uccellini is the National Oceanic and Atmospheric Administration's Assistant Administrator for Weather Services, and Director of the National Weather Service. In this role, he is responsible for the day-to-day civilian weather operations for the United States, its territories, adjacent waters, and ocean areas.

Prior to this position, he served as the Director of the National Centers for Environmental Prediction (NCEP) for 14 years. He was responsible for directing and planning the science, technology, and operations related to NCEP's nine centers: Central Operations, Environmental Modeling Center, Ocean Prediction Center, Hydrometeorological Prediction Center, Climate Prediction Center, all in Camp Springs, MD; the National Hurricane Center in Miami, FL; Storm Prediction Center in Norman, OK; Space Weather Prediction Center in Boulder, CO; and the Aviation Weather Center in Kansas City, MO. With his leadership, the 13 year effort to plan, develop and build the new NOAA Center for Weather and Climate Prediction (the NCWCP Building) at the University of Maryland M Squared Research Center was completed; as was the implementation of a Seamless Suite of Models from the S2S to Mesoscale modeling systems based on the principle of multi model ensembles.

Dr. Uccellini was the Director of the National Weather Service's Office of Meteorology from 1994 to 1999, Chief of the National Weather Service's Meteorological Operations Division from 1989 to 1994, and section head for the Mesoscale Analysis and Modeling Section at the Goddard Space Flight Center's Laboratory for Atmospheres from 1978 to 1989.

Dr. Uccellini received his Ph.D. (1977), Master (1972) and Bachelor of Science (1971) degrees in meteorology from the University of Wisconsin-Madison. He has published more than 70+ peer-reviewed articles and chapters in books on subjects including analysis of severe weather outbreaks, snowstorms, gravity waves, jet streaks, cyclones, and the use of satellite data in analysis and modeling applications and more recently the basis for the Joint Center for Satellite Data Assimilation, the WMO based Grand Challenge for Seamless Prediction and the Restructuring of the NWS to Build a Weather Ready Nation. He is the co-author of a widely acclaimed two-volume American Meteorological Society (AMS) monograph Northeast Snowstorms, published in 2004, and authored chapters in the 1990 AMS publication Extratropical Cyclones, the 1999 AMS publication The Life Cycles of Extratropical Cyclones, and the 2008 AMS publication Synoptic Dynamic Meteorology and Weather Analysis and Forecasting.

Dr. Uccellini is the Permanent US Representative at the World Meteorological Organization, and has served on many national and international research and field experiment programs. He has received many awards in recognition of his research and operational achievements including the Maryland Academy of Sciences Distinguished Young Scientist Award (1981), the NASA Medal for Exceptional Scientific Achievement (1985), the AMS's prestigious Clarence Leroy Meisinger Award (1985), the Cleveland Abbe Award (2016), and the National Weather Association's Research Achievement Awards for Significant Contributions to Operational Meteorology (1996). He was elected as President of the AMS in 2012- 2013 and served as Co-Chief Editor of Weather and Forecasting from 1988- 1992. In 2001 he received the U.S. Presidential Meritorious Executive Rank Award and in 2006 he received the U.S. Presidential Distinguished Rank Award.

Back to NWS Biographies Page