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Testimony to the
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The Future of Forecasting: Building a Weather-Ready Nation on All Fronts

Introduction

Chairwoman Johnson, Ranking Member Lucas, and members of this Committee, it is my honor to testify before you today on the current status of, and future opportunities for, the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS). The NWS' mission is to save lives and property of the American people and to enhance our national economy. We meet this mission by providing the best forecasts and warnings in the world and delivering Impact-based Decision Support Services (IDSS) to core partners in the emergency management community and other public safety officials at the Federal, state and local government levels across the entire country.

The NWS is entrusted with the responsibility to provide weather, water and climate information, forecasts, and warnings to the public, businesses, and governments to enable informed decisions on a range of issues and scales—local to global and short-term to long-term. As such, we work closely with other parts of NOAA, with the larger community of federal, state, local, tribal, and territorial emergency management officials and water resource managers; the academic and research communities; and the commercial weather enterprise to deliver the best possible information. As directed by Executive Order 14008 Sec 211d, NOAA, the White House Office of Science and Technology Policy (OSTP) and the Federal Emergency Management Agency (FEMA) together with the interagency are examining ways to improve and expand climate services for the public. The NWS mission could not be more crucial in the face of extreme weather and water events whose frequency and severity are exacerbated by our changing climate.

History

As you may be aware, I plan to retire on January 1, 2022, after a 50 year career in weather

research, operations and government administration. For the last nine years, it has been my humble privilege to lead one of the most dedicated workforces in government at the National Weather Service. As MSNBC's Brian Williams recently said on one of his newscasts:

“The National Weather Service is a National Treasure. Their meteorologists are the essence of public service. They're on duty 24-7, they are busy. In fact, tonight issuing warnings as Hurricane Nicholas heads inland bringing awful flooding from Houston all the way east to New Orleans and beyond.”¹

I could not say it any better than that. An amazing team of dedicated individuals doing amazing work on a 24/7 basis to keep our nation safe from extreme weather events every day of the year.

I took the reins of the NWS in February, 2013, when the agency was having financial difficulties and had, arguably, lost the faith of Congress. My goal was to instill transparency in the restructured NWS budget process, headquarters management and governance, and to regain your confidence and support, on behalf of the American people, for one of the best agencies in the Federal Government. I believe I have accomplished that task. Throughout my tenure, your trust in the new leadership team and unequivocal support for the NWS workforce has been unwavering. You have worked to ensure the NWS has the needed resources and staffing to accomplish its mission. I most sincerely thank you for that support, while also realizing there is still much more to do in the face of the increasingly extreme weather, water, and climate events that are impacting our country.

Evolving to Build a Weather-Ready Nation

A seminal moment for me, and for the entire weather community, occurred in 2011. There was a large tornado outbreak across the southern states. Innovative research and our technology improvements, radars and forecast models, allowed us to begin discussion of the potential for a large severe weather outbreak more than five days in advance. The event was very well forecast and warned, but still 316 people lost their lives. This 2011 outbreak was similar in intensity and number of strong tornadoes to an outbreak that occurred in 1974, long before we had the observing and warning capabilities we have today. In fact, the NWS did not even warn for those tornadoes, and 314 individuals died then. With all the advanced forecasts and warnings, what went wrong in 2011? How can the broader weather and emergency management enterprise can make more progress in saving lives?

In order to better understand why so many lives were lost in the April 2011 tornado outbreak and in the Joplin, Missouri tornado in late May of that year, NOAA and NSF organized a “vital conversation” in Norman, Oklahoma - the location of NOAA's severe weather research and operations center - in December, 2011. First responders and public safety officials from around the

¹ [Transcript: The 11th Hour with Brian Williams, 9/13/21 \(msnbc.com\)](#)

country - including from Alabama and Joplin - and social science experts as well as leaders from the private sector and academic communities joined this meeting to assess what we collectively missed, and learn what not to repeat. The conclusions and lessons learned from that week-long meeting were that we had to go beyond the forecasts and warnings and address the needs of on the ground decision makers by preparing communities for upcoming extreme events and linking forecasts and warnings to key decision points related directly to saving lives and property. It was from this conversation that we came to embrace the concept of Impact-based Decision Support Services – IDSS – and commit to building a Weather-Ready Nation through partnerships with the public safety officials and emergency managers at every level of government. The events of 2011 forced us to reflect on the quote from Allan Murphy from his article in *Weather and Forecasting*, June 1993, “First, it should be understood that forecasts possess no intrinsic value. They acquire value through their ability to influence the decisions made by users of the forecasts.”² It was true then and it is still true today.

The Commerce Department, NOAA, and NWS are strongly committed to ensuring that the United States become a Weather-Ready Nation³ (WRN) - prepared and resilient in the face of increasing threats from extreme weather, water, and climate events. As far back as 2010, Congress recognized that NWS’ current operations were based on tools, workflows, and structures that were not designed to meet our Nation’s increasing vulnerabilities to extreme weather events. Seeing the need for NWS to change, Congress mandated two studies.⁴ The first examined the NWS Modernization and Associated Restructuring (MAR) of the 1990s as a backdrop for moving forward and addressed “lessons learned to support future improvements to NWS capabilities.” The follow-on study focused on NWS operations and addressing user needs. The studies, completed in 2012 and 2013, respectively, reaffirmed NOAA’s Weather-Ready Nation concept.

In response to these studies, we restructured the NWS budget and headquarters to better align resources to function, enhance transparency, and link programmatic management structure to performance outcomes. This portfolio-based budget and streamlined headquarters organization and governance structure now reflects our core competencies and mirrors the weather forecast process by aligning our resources with the following functional categories: observations; central processing; analysis, forecast and support; dissemination; science and technology infusion; and facilities infrastructure. Based on recommendations from these Congressionally-directed studies, the NWS also retained a leading management and organization consultant to perform an

² https://journals.ametsoc.org/view/journals/wefo/8/2/1520-0434_1993_008_0281_wiagfa_2_0_co_2.xml

³ <https://www.weather.gov/wrn/>

⁴ ² “Weather Services for the Nation: Becoming Second to None,” August 2012, National Academy of Sciences (NAS), <https://www.nap.edu/catalog/13429/weather-services-for-the-nation-becoming-second-to-none> ; “Forecast for the Future: Assuring the Capacity of the National Weather Service” 2013, National Academy of Public Administration (NAPA), <https://www.napawash.org/studies/academy-studies/forecast-for-the-future-assuring-the-capacity-of-the-national-weather-servi..>

Operations and Workforce Analysis (OWA).⁵

The OWA focused ways the NWS could implement its strategic vision to provide IDSS to build a Weather-Ready Nation. This vision was subsequently codified in the Weather Research and Forecast Innovation Act of 2017 - aka “The Weather Act,” - led by this Committee. In general, the OWA noted the high level of partner support for the NWS, its products and services, and the concept of IDSS. It found the NWS professional workforce to be highly skilled, trained, and motivated in their mission delivery. The OWA also highlighted the previous concern from Congressional studies that the NWS structure, workflow, and operational processes should continue to be improved.

The OWA formed the basis for our ongoing “Evolve Program” initiatives. The Evolve Program was created in 2017 to carry out NWS reforms and the WRN strategic vision. The program has 20 reform initiatives in various stages of completion. A subset of these key OWA recommendations have been implemented, including the GS-5-12 Career Progression, and Weather Balloon Auto-launchers, with the NWS currently working on the Collaborative Forecast Process/National Blend of Models.

We are excited about the ideas and actions generated by the OWA that continue to inform our Evolve Program initiatives, implement the directives of the Weather Act, and continuously improve the NWS as we connect our forecasts and warnings to decision makers at every government level, and work with our partners to build a Weather-Ready Nation. The NWS Strategic Plan⁶, issued in April 2019, continues to ensure the U.S. is a Weather-Ready Nation by keeping NWS focused on providing IDSS for extreme weather, water, and climate events. Moving forward, the NWS is committed to keeping pace with stakeholder and societal needs for forecasting that protects life and property for all and enhances the national economy.

Improving Forecasts and Services for Extreme Weather

In order to achieve a Weather-Ready Nation and implement the vision set forth by Congress in the Weather Act, the NWS is focused on improving our science and technology, services, workforce, and partnerships. We are working to sustain and upgrade our observations infrastructure, including observations from geostationary and polar orbiting satellites, which provide critical data to numerical weather prediction models. To meet the increasing demands for

⁵ Congress funded this initiative starting in Fiscal Year 2014, stating its “[support for] efforts by NWS to develop a framework for continuous improvement.” Congress reiterated that support in the NWS fiscal 2016 and 2017 budgets, and codified it in the Weather Research and Forecast Innovation Act (April 2017):SEC. 409. NATIONAL WEATHER SERVICE; OPERATIONS AND WORKFORCE ANALYSIS. The Under Secretary shall contract or continue to partner with an external organization to conduct a baseline analysis of National Weather Service operations and workforce.

⁶ <https://www.weather.gov/news/192203-strategic-plan>

more accurate and reliable forecasts and warnings, we are refocusing the NWS workforce to meet IDSS needs of our core partners in the emergency management community while simultaneously strengthening the robustness of multiple pathways to reliably disseminate our forecasts, watches, and warnings to all communities that need this information. We are improving an integrated weather-water approach to advance environmental predictions, especially along our coasts, so we can continue supporting an active and engaged collaboration across the entire weather, water, and climate enterprise.

NWS strives to integrate the best advances in science and technology to provide the most accurate and timely forecasts possible. Much of our success comes from scientific and technological breakthroughs made by NOAA and external research that spans across disciplines, time, and space scales. The dynamic systems of this planet are interconnected in rich and complex ways, and success in forecast improvement comes by looking broadly across those linkages.

NWS has evolved to provide more than just short-term weather forecasts and warnings. This work is focused on the IDSS, especially for federal, state, local, tribal, and territorial emergency managers. Our prediction capabilities are becoming a fusion point that emergency managers, broadcasters, federal agencies, and the public increasingly turn to as the accessible, trusted source that distills scientific information into an accessible forecast, focused on impacts. The NWS achieves this by applying both the physical and social sciences to the provision of forecasts, warnings and IDSS. We use an Earth systems approach that examines the atmosphere, oceans, land, ice, and space. We then determine the best ways to communicate forecasts and warnings to ensure maximum preparedness and response in the face of any extreme event. This is how we have improved our ability to save lives and protect property. Emergency managers have told us that our forecasts have changed the way they do their work. They are becoming more proactive, and IDSS allows decision makers at all levels of government to make more informed decisions in the face of extreme events, as illustrated by the two quotes below:

“Partnership with the NWS has revolutionized the EM community from one that reacts to events to one that proactively prepares and stays ahead of extreme events.” - Eric Waage (Director, Emergency Management, Hennepin County, Minnesota)

"I've never had an interaction with an NWS employee that didn't end with, 'How can I do better for you?' You save lives. This [the local presence] is not just a 'nice to have', it's an absolute necessity." - Jonathan Gaddy (Assistant Director, Alabama Emergency Management Agency)

The figure below captures the NWS' current forecasting and service delivery model, updated as a result of our effort to build a WRN. The model is built upon observations and numerical weather prediction, and culminates with the final decision making, employing NWS IDSS as the lynchpin

of a Weather-Ready Nation, as shown below:



Several weather events have demonstrated the value of IDSS. In January 2016, based on NWS forecasts and IDSS, New York City essentially closed ahead of a predicted major snowstorm. This allowed much quicker recovery efforts to bring the NYC area back to normal operations. This type of rapid recovery did not happen 10 years ago. It’s the confidence in the forecasts that enables these types of decisions. Many other examples of successful IDSS for severe weather, flooding, snowstorms, fires are documented in recent journal articles⁷.

We are making progress across all elements of the forecast and delivery process illustrated above.

⁷ Louis W. Uccellini and John E. Ten Hoeve. Evolving the National Weather Service to Build a Weather-Ready Nation: Connecting Observations, Forecasts, and Warnings to Decision-Makers through Impact-Based Decision Support Services. Bull. Amer. Meteor. Soc., Volume 100, 1923-1942 <https://doi.org/10.1175/BAMS-D-18-0159.1>

Hosterman, H.R., J.K. Lazo, J.M. Sprague-Hilderbrand, and J.E. Adkins. 2019. Using the National Weather Service’s Impact-Based Decision Support Services to Prepare for Extreme Winter Storms. Journal of Emergency Management. 17(6):455-467. DOI:10.5055/jem.2019.0439;

Lazo, J.K., H.R. Hosterman, J.M. Sprague-Hilderbrand, and J.E. Adkins, 2020: Impact-Based Decision Support Services and the Socioeconomic Impacts of Winter Storms. Bull. Amer. Meteor. Soc., 101, E626–E639

Nevertheless, we still have work to do. We are constantly striving to better predict extreme weather events. Our forecasts of track, rainfall, and flooding for major hurricanes, such as Dorian in 2019, and Laura and Ida this year were excellent, and our IDSS for the emergency managers proved critical. However, we can always improve our IDSS and our forecast models and forecasts themselves. For Hurricane Ida, we had a very good forecast, even with the extreme precipitation that fell in the New York City area. Our forecasters highlighted the risk for excessive rainfall and even declared a *Flash Flood Emergency*⁸ for all of New York City – for the first time ever.

The sad realization is that neither the people of the NYC metro area nor the NWS had ever before experienced record rainfall rates like those that occurred with Ida, measured at 3.15” over one hour during an event that produced up to 8”. It was a sobering and horrible event. The subway system and many buildings were flooded over large segments of NYC. At least 42 people lost their lives in New York and New Jersey due to the flash flooding from the extreme rainfall caused by the remnants of Ida. The infrastructure and people were not prepared to deal with this record-setting rain and subsequent flooding that affected large segments of the city. This is why we need to redouble our efforts on IDSS and continue to work with local decision makers and the larger weather enterprise to address these extreme events that are increasingly being fueled by the changing, warmer climate. Impacts from climate change are now unequivocally upon us and it is increasing the number of extreme weather events that we must prepare for and respond to.

From a precipitation prediction perspective, on one hand, we've come a long way. Medium range forecasts highlighted the threat of a tropical system interacting with a front and upper jet in the Northeast US several days in advance, even before Ida made landfall in Louisiana. The NWS increased the number and urgency of messaging about rainfall amounts as the event approached and *Flash Flood Watches* were issued over 2 days in advance. We have the operational High Resolution Ensemble Forecast models, which has hourly precipitation rate information and was used extensively in this event. Dire and prescient messages were issued with 4-6 hour lead time. Historic Flash Flood Emergencies were also issued. Nevertheless, many people died. Three inch per-hour rainfall rates over the most urban part of the country had not happened before on this scale - and with tragic consequences. On the other hand, we see these events with extreme rainfall rates are posing enormous forecast challenges and point to the need for additional research in both the physical and social sciences to improve our understanding, related precipitation forecast process, and the provision of IDSS in the face of these increasingly severe and frequent extreme weather and water events.

Improving precipitation prediction was a key motivation for the foundation of the US Weather Research Program (USWRP) in the 1990s, as codified by the Weather Act, and it continues to contribute to the advances noted above and to supporting NOAA's testbed activities. To accelerate progress, NOAA has developed a strategy - the Precipitation Prediction Grand Challenge. While

⁸ https://www.weather.gov/mob/Severe_Flood

there is no silver bullet to dramatically improve precipitation prediction for the 21st Century climate, we can deliver a portfolio of coordinated efforts across the value chain -- scientific understanding, observations, models, forecasters, services, social science, user engagement – culminating in improved IDSS and people understanding the potential impacts and taking appropriate action.

Addressing another mandate of the Weather Act, the NWS is working with our interagency partners to advance services as part of the Interagency Council on Advancing Meteorological Services (ICAMS). Established in 2020 and co-chaired by OSTP and NOAA, ICAMS is an unprecedented opportunity for interagency coordination to advance meteorological services.

To make this all happen and improve IDSS requires a thoughtful, interrelated effort to continue to change the NWS.

Collaborative Forecast Process & the National Blend of Models

The OWA also revealed weather forecast *process* improvements necessary for building a Weather-Ready Nation. While working with emergency managers, our forecasters often hear about the need to have consistent forecast information from one NWS field Weather Forecast Office to the next, and from national centers to the local level. Weather doesn't respect county, state, or congressional district boundaries, and we have had two adjacent weather offices issuing inconsistent forecasts for areas right next to each other. One way to achieve this consistency goal—as recommended by the OWA—is the NWS' development of a Collaborative Forecast Process (CFP). This process can ensure NWS provides weather and water data, forecasts, and warnings for the protection of life and property and the enhancement of the national economy in the most efficient, effective, and consistent way possible. The CFP develops a single authoritative source for forecasts by layering national and local expertise onto a common starting point. This process can reduce duplication and increase consistency.

A central tool developed by the NWS to facilitate consistency and allow forecasters to work more with decision makers is the National Blend of Models (NBM). Understanding what makes up a “blend of models” is important. NOAA runs ensembles of weather models on our high-performance supercomputing system. Non-NOAA entities also run weather models. The output of all of these models individually provides guidance to issue weather forecasts. Research has shown that by averaging the output of various model parameters (e.g., temperature, wind, pressure) and combining the best aspects of each, the “blended” or ensemble forecast guidance provides increased skill and accuracy.

The use of blends has been around for more than a decade and began in NWS field offices. Essentially, the NBM is a bottom-up approach, with our field forecasters recognizing the need to examine multiple models, and developing a rudimentary version they could use at local and

regional levels. To ensure national consistency, a national scale blended model output was required. In the aftermath of Hurricane Sandy, Congress recognized the potential benefits of this approach and funded NOAA to develop and implement a national blend of models through the Disaster Relief Supplemental Appropriations Act of 2013.

In response to various recommendations and assessments, the NBM Project was officially launched in 2013. This project is an effort to develop a nationally consistent set of foundational gridded guidance products based on well-calibrated NWS and non-NWS model information.

Today, the NBM is operating in an experimental status in accordance with an approval memo for the Experimental Implementation of Guidance from the National Blend of Models signed in August 2016. NBM version 4.0 has been running on the NOAA operational supercomputer since September 29, 2020, and is available for experimental use by NWS offices.

There is a tremendous amount of model information that goes into the blend – much more than any single forecaster can assimilate. There are 23 different deterministic and ensemble model system inputs including five global models from different weather centers, NWS, Navy, Canadian, European Center for Medium Range Weather Forecasting (ECMWF or “Euro”), and Australian. There are up to 171 short term inputs (including all ensemble members) in the information for precipitation and temperature. Version 4.1, set to be released in January 2023, will have 199 model inputs.

The goal of the NBM is twofold. First, it will provide a common forecast starting point for many parameters our forecasters use for a collaborative forecast, which will allow forecasters to focus on the major weather events impacting their area. Second, we expect this to allow more time for forecasters to spend on IDSS, which our partners tell us is essential during extreme weather events. We have all seen the increasing impacts over the past few years in these extreme weather events ranging from heavy rains and floods, to hurricanes, winter storms, tornadoes, drought and wildfires. With the exponential growth in demand for IDSS, it is past time to reassess the workload of our forecasters and partner with our National Weather Service Employees Organization (NWSEO) to increase the agility of the workforce across our organization. This will be critical to allow the NWS to provide improved information needed by our core partners, and “increase impact-based decision support services” as specified by Title IV, Section 405 of the Weather Act throughout the emergency management community to be ready for, and respond to, extreme weather and water events.

Improving Staffing and Labor Relations

In early 2021, NWS management and NWSEO reached agreement on a subsequently ratified new Collective Bargaining Agreement (CBA). This labor pact, replacing its predecessor, which was nearly two decades out of date, better serves the needs of the NWS workforce and the agency.

The effort to update and modernize our CBA began more than 5 years ago. Though negotiations were strained at times, including an impasse in 2019, both sides remained committed to the need to reach agreement on a modern CBA that better serves the needs of the agency and employees. To that end, both parties re-engaged and refocused negotiations in earnest - at the height of the pandemic no less - to reach agreement. The shared NWS-NWSEO goal with this new CBA is to ensure that we honor, protect, and maintain the highly skilled and dedicated NWS workforce, which is the key to our success. I would like to personally thank NWSEO President John Werner and his leadership team for their efforts on this. I believe we have seen the dawn of a new day in NWS labor relations.

Hiring staff for critical operational positions remains a top priority of the NWS and for NOAA. Vacancies in operational units cause significant strain on our ability to consistently operate 24/7/365 and deliver the life-saving services the public and our partners expect. We continue to staff our agency to our appropriation funding levels, and currently we have one of the lowest vacancy levels in years, with respect to our funded positions. The NWS, working closely with NOAA and the Department of Commerce leadership and workforce management units, has placed a huge emphasis on hiring and reforming staffing practices over the past few years. As a result of this effort - and incorporating recommendations from the GAO in early 2017 - the NWS ended FY 2020 with its highest staffing level since 2016. This summer, our funded vacancy rate was less than 2%. Even through all this success, we will not rest on our advancements. As we continue to make focused improvements, it is incumbent upon the entire organization to reevaluate staffing needs, and ensure our workforce matches the increasing forecast, warning, and IDSS workload, and is equipped to handle an increasingly dynamic and diverse user community. Our customer base includes all public safety officials, private sector partners, nonprofits that support the response to disasters, and the public that are connected through cell phones and other communication and social media platforms.

To make systemic improvements, we worked with NWSEO to create and implement our GS 5-12 Career Progression. This places our field meteorologists into a single career track and allows them to progress non-competitively from the GS -5 level to the GS-12 level, based on completing competencies at each progressive level. Moving to a single career progression for meteorologists provides staff with a clear career path and opportunity to advance, and the ability to contribute to office operations based on their competencies. Having all meteorologists in one career progression provides more flexibility to field units when assigning work, allowing offices more resources to provide IDSS to the communities and partners they support. This is also reducing the administrative burden involved with hiring and promoting field staff and lowering the yearly relocation costs NWS pays for internal promotions. All will have new promotion potential to a higher grade, and a clear pathway to achieve it.

Since we implemented our 5-12 career progression program in the summer of 2019, we

transitioned over 900 employees into new position descriptions and performance plans, and began competency training and assessments for over 100 employees who are new to our 5-12 career progression program. We provided training to our managers on the new career progression that the 5-12 initiative offers and on their responsibilities related to managing the transition process for the workforce. We just finished our second year of the 5-12 career progression program, and it has met one of our most important goals for the program - growing the number of NWS employees on board while promoting on station.

As you are well aware, the nature of large wildfires is changing; they are burning hotter and moving faster and are more destructive than ever before, especially as the drought worsens in the western states. We recognize the stress the increased workload is putting on our Incident Meteorologists (IMETs) and on the staff that have to fill in when they are deployed away from their home office. We are training more forecasters to become IMETs, and we now have 89 qualified IMETs ready to go, which is 10 more than we had last year, and we have 18 IMETs in training.

However, an area of concern is that IMET pay, and additional premium pay such as for overtime or night and Sunday pay. This compensation can cause an IMET to bump up against the statutory pay limitations for Federal employees, requiring them to work without additional compensation or else be taken “off the line” and replaced by a different IMET. Avoiding requiring IMETs to work without additional pay will limit the number of IMETs that we have available at any given time.

The NWS is committed to cultivating a diverse and inclusive workforce and to building a culture that affords employees equal opportunities to develop to their full potential. In line with Executive Order 14035, titled Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce, the NWS has developed and revised policies and organizational metrics to promote and track hiring and recruitment activities of our offices and units. These revised policies and metrics are intended to accelerate hiring at our nation’s Minority-Serving Institutions (MSIs).

Through the first half of this year, the NWS participated in the NOAA’s Educational Partnership Program with MSIs, including the NOAA Cooperative Science Center in Atmospheric Sciences and Meteorology led by Howard University, the Hollings Scholarship Program, a K-12 Initiative, and the Pathways Internship Program, which included thirty (30) female and nineteen (19) minority participants. Through mid-2021, the NWS hired forty-eight (48) minority employees out of 200 new hires. Of those same 200 newly hired individuals, fifty-nine (59) were over 40 years of age; fifty-nine (59) were female.

Using prototypes, such as the STEM Immersion Presentation developed by our forecast office in Jackson, MS, suggestions from employee resource groups, and national initiatives, the NWS is committed to developing middle and high school students in STEM fields. Our offices will continue to engage with nearby educational centers, including two-year institutions, to recruit for

occupations at the NWS. We are beginning to use Direct Hire authority whenever possible and will continue to employ conventional postings, college and recruitment fairs, and other new and innovative hiring practices, some of which are still being developed. We see a bright future for all current and future employees.

We will continue to work with our NWSEO partners to ensure that the workforce has what it needs to successfully accomplish our mission, and that we all have sufficient flexibility to meet the ever-increasing demand for decision support services.

The Government Accounting Office (GAO) recently completed reviews of NWS efforts to move forward, including our successful hiring advances within appropriated resources and the Evolve Program designed to guide our reform efforts to improve the provision of IDSS and strengthen our workforce and organizational structure. We are pleased with GAO's fair and thorough work in completing this report and welcome their final findings and recommendations. We appreciate the opportunity to engage with the GAO, and their constructive, helpful reviews.

Conclusion

NWS forecasts, warnings, and community-based preparedness programs are vital for enhancing the economy and saving lives and property. The NWS mission has never been more crucial given exacerbating weather, water and climate extremes. It all starts with a commitment to enhance environmental observations; research and improve forecasts and warnings; increase IDSS delivered through a robust dissemination system; and support our people - forecasters, modelers, technicians and managers. The end state is a Weather-Ready Nation in which businesses, governments, and the public are prepared to use forecasts to mitigate impacts. Despite our best efforts, extreme weather events still pose challenges to the larger forecast community and will continue to threaten lives and property across the United States. We recognize that there is always room for improvement. I am very proud of the NWS workforce, especially our people who are on the front lines delivering critical products and services every day to help keep our citizens safe.

The protection of the people of the United States from the devastation that extreme weather, water, and climate events can bring is a duty entrusted to NOAA. Together, we must ensure NWS services and operations live up to this duty. We have come a long way, but there is more we need to do to become a Weather-Ready Nation — to be ready, responsive, and resilient in the face of the extreme weather, water, and climate events we will continue to experience across our country.

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 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, Earth System Prediction Capability for addressing the WMO "Grand Challenge" for seamless weather-climate 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 and again in 2016, he received the U.S. Presidential Meritorious Executive Rank Award and in 2006, he received the U.S. Presidential Distinguished Rank Award. In 2019, Dr. Uccellini was selected as a National Academy of Public Administration Fellow.