

WINNING IN WEATHER:
U.S. COMPETITIVENESS
IN FORECASTING AND MODELING

HEARING
BEFORE THE
SUBCOMMITTEE ON ENVIRONMENT
OF THE
COMMITTEE ON SCIENCE, SPACE,
AND TECHNOLOGY
OF THE
HOUSE OF REPRESENTATIVES
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**WINNING IN WEATHER:
U.S. COMPETITIVENESS
IN FORECASTING AND MODELING**

WEDNESDAY, MARCH 6, 2024

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENVIRONMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to notice, at 10:01 a.m., in room 2318 of the Rayburn House Office Building, Hon. Max Miller [Chairman of the Subcommittee on Environment] presiding.



**SUBCOMMITTEE ON ENVIRONMENT
HEARING CHARTER**

“Winning in Weather: U.S. Competitiveness in Forecasting and Modeling”

Wednesday, March 6, 2024

10:00 a.m.

2318 Rayburn House Office Building

Purpose

The purpose of this hearing is to assess the United States’ leadership in weather forecasting and modeling. The hearing will discuss the impacts of the Weather Act of 2017 and the Weather Act Reauthorization of 2023 in bolstering U.S. competitiveness in the global weather community. This hearing will also discuss the coordination and collaboration of government agencies, the private sector, and academia to implement programs that advance new technologies related to data assimilation and modeling.

Witnesses

- **The Honorable Dr. Neil Jacobs**, Acting NOAA Administrator, 2019-2021
- **Dr. Kevin Petty**, CEO, Aeris LLC
- **Dr. Scott Weaver**, CEO, CLIMET Consulting

Overarching Questions

- What is the current state of the U.S. weather enterprise on a global scale? How does our data assimilation and modeling match up with international counterparts?
- How can we effectively separate climate and weather modeling and data sets to best communicate short- and long-term predictions?
- Is current interagency collaboration producing results when it comes to weather modeling and transitioning new products from research to operations?
- How can weather data be better specialized to meet industry specific needs like forecasting products for the private industry, emergency managers, and the meteorological community?
- How can the U.S. maintain the security of weather enterprise infrastructure from hostile adversaries?

Background

This hearing will examine the sustainability and accuracy of federally-provided weather information as the committee looks at next steps after reauthorizing the Weather Research and Forecasting Innovation Act of 2017. This conversation will include insight on where U.S. capabilities stand compared to that of counterparts around the world; national security risks that may be encountered if U.S. capabilities are lacking; and how the National Oceanic and Atmospheric Administration (NOAA) collaborates with other agencies and the private sector.

International Competition

The United States' global weather model is officially known as the Global Forecast System (GFS). It is created and operated by the U.S. National Weather Service to run four times a day and can make predictions up to 16 days in the future. The computing power behind GFS grew tenfold from 2015 to 2020, with the model able to process eight quadrillion calculations per second. Yet, the European model is still more computationally powerful and generally considered the superior all-around model.¹

The European model is officially known as the European Center for Medium-Range Weather Forecasts (ECMWF). It was created through a partnership between 34 different nations and makes predictions for up to 10 days out. ECMWF is widely considered more computationally powerful because of the math and physics underpinning it and the supercomputer power it runs on. ECMWF's superiority was headlined in 2012 when it accurately predicted Hurricane Sandy would make a hard turn into the northeast coast of the U.S. before the American model did.²

Recently, China has placed an emphasis on utilizing artificial intelligence to increase the accuracy and speed of their weather models. The FuXi-Subseasonal model was developed by scientists from the Shanghai Academy of Artificial Intelligence for Science, Fudan University, and China's National Climate Center. According to the development team, it has a thousand-fold increase in operational speed, higher forecasting accuracy, and longer forecasting period than existing international models.³

Weather Predictors, Networks, and Technologies

Within the federal research enterprise, there should be a distinct difference and separation between weather modeling and climate modeling. Meteorologists analyze current data from a variety of sources to prepare and issue forecasts of approaching weather patterns in the short-term.⁴ Climatologists focus on long-term climate trends affecting a certain population's food production, energy usage, species conservation, and public health.⁵ While the end products of

¹ Matthew Cappucci and Jason Samenow, *So, what exactly are the European and American weather models?*, THE WASHINGTON POST (Nov. 22, 2019), <https://www.washingtonpost.com/weather/2019/11/22/so-what-exactly-are-european-american-weather-models/>.

² *Ibid.*

³ Zhao Yusha, *China's AI weather forecasting model front-runner worldwide*, GLOBAL TIMES (Jan. 11, 2024), <https://www.globaltimes.cn/page/202401/1305205.shtml>.

⁴ National Weather Service, *Careers in Meteorology*, <https://www.weather.gov/careers/meteorology#:~:text=What%20is%20a%20Meteorologist%3F.studies%2C%20or%20forecasts%20the%20weather>.

⁵ Mizzell, Hope, *Climatologist*, South Carolina Department of Natural Resources, <https://www.dnr.sc.gov/education/pdf/Climatologist.pdf>

both research areas are meant to protect the public and property, the timescale related to data collection and packaging into a meaningful product requires distinct research expertise and focus areas.

One tool that the public uses for weather information is Weather Data Receivers. These are low-cost satellite receiving systems that get data and information directly from federal weather satellites like the NOAA Geostationary Operational Environment Satellite (GOES) and the European Space Agency's Meteosat satellites (EUMETSAT). Weather Data Receivers are frequently used by independent meteorologists, agribusiness firms, small airports or flying clubs, marine vessels, and small TV stations.⁶ Farmers and ranchers also use these receivers to make planting and crop management decisions based on rainfall totals, storm predictions, wind speed, freeze predictions, and other risk factors that have the potential to affect crop yield outcomes.⁷

Another public tool is the National Mesonet Program (NMP), which serves as a “network of networks” to deliver critical information to improve weather predictions and warnings to ensure a weather-ready nation. The NMP is the central repository for real-time collection and dissemination of non-federal surface, boundary layer, and tropospheric atmospheric weather observations in the U.S. It is made up of diverse public-private partnerships and acts as a resource to state and local agencies, businesses, researchers, and policymakers. The NMP's 35,000 stations/platforms significantly improve weather prediction, severe weather warnings, and emergency response for all regions of the country.⁸

Of particular interest to the committee is the role of the Interagency Council for Advancing Meteorological Services (ICAMS), which was first established through the Weather Act of 2017. ICAMS is co-chaired by the Director of the Office of Science and Technology Policy (OSTP) and the Under Secretary of Commerce for Oceans and Atmosphere, the latter of whom is also the Federal Coordinator for Meteorology. ICAMS is the formal mechanism by which all relevant federal departments and agencies coordinate implementation of policy and practices to ensure U.S. global leadership in the meteorological services enterprise.

The Interagency Meteorological Coordination Office provides administrative and logistical support to and operates under guidance from ICAMS. The work of ICAMS is organized under four primary committees:

- Services
- Observational Systems
- Cyber Facilities and Infrastructure
- Research and Innovation⁹

⁶ NASA Spinoff, *Weather Data Receiver (1982)*, <https://spinoff.nasa.gov/node/9204>

⁷ Hannan, Joe, *Personal Weather Station for Specialty Crop Management*, Iowa State University Extension and Outreach (2020), <https://www.extension.iastate.edu/smallfarms/personal-weather-station-specialty-crop-management>

⁸ National Mesonet, *The National Mesonet Program*, <https://nationalmesonet.us/>

⁹ ICAMS. ICAMS Organization. (n.d.). <https://www.icams-portal.gov/organization.html>

Legislative History

The Weather Research and Forecasting Innovation Act of 2017 (Public Law 115-25), known simply as the Weather Act, was signed into law in April 2017, capping a bipartisan, bicameral legislative effort that began in 2013 in the House Science Committee.¹⁰ It was widely viewed as the first comprehensive weather authorization since the National Oceanic and Atmospheric Administration Authorization Act of 1992.¹¹

The main goals of the Weather Act were to improve NOAA's weather research through investments in observational, computing, and modeling capabilities; to support improvement in weather forecasting and prediction of high impact weather events; and to expand commercial opportunities for the provision of weather data. Many sections of the bill were inspired by recommendations from reports authored by experts in the U.S. weather enterprise, including a National Academy of Sciences report published in 2012 titled, *Weather Services for the Nation: Becoming Second to None*¹² and a National Academy of Public Administration report published in 2013 titled, *Forecast for the Future: Assuring the Capacity of the National Weather Service*.¹³

Recognizing the immediate and impactful advances in the accuracy and timeliness of weather forecasting that the Weather Act prompted, the National Integrated Drought Information System (NIDIS) Reauthorization Act of 2018 (Public Law 115-423) was signed into law just two years later in January 2019.¹⁴ The bipartisan NIDIS Reauthorization Act extended authorizations and improved several key programs from the Weather Act. Some of the programs, such as the agriculture weather provisions and NOAA's Office of Oceanic and Atmospheric Research, were extended with gradual increases in authorization of appropriations until FY2023. Other provisions, like NOAA Computing Resources, were simply updated with a revised focus based on stakeholder and community feedback since the signing of the Weather Act.

Reauthorizing the Weather Act is an opportunity to modernize U.S. weather policy and better serve American communities. At a hearing on March 23, 2023, titled "Reauthorizing the Weather Act: Data and Innovation for Predictions," the committee heard from private companies in the U.S. weather industry that can provide observations and data to NOAA and other federal agencies. This hearing aims to hear the perspectives of people and groups who use that data.

On November 8th, 2023, the Weather Act Reauthorization (H.R. 6093) passed the committee unanimously. The committee expects the bill to be considered on the Floor by the end of March 2024.

¹⁰ [P.L. 115-25](#)

¹¹ [P.L. 102-567](#)

¹² National Research Council, *Weather Services for the Nation: Becoming Second to None*, THE NATIONAL ACADEMIES PRESS (2012), <https://doi.org/10.17226/13429>.

¹³ National Academy of Public Administration, *Forecast for the Future: Assuring the Capacity of the National Weather Service*, NAPA (2013), <https://www.weather.gov/media/ooe/ForecastfortheFuture-AssuringtheCapacityoftheNationalWeatherService.pdf>.

¹⁴ [P.L. 115-423](#)

Chairman MILLER. The Committee will come to order. Without objection, the Chair is authorized to declare recesses of the Committee at any time. Welcome to today's hearing entitled "Winning in Weather: United States Competitiveness in Forecasting and Modeling." I recognize myself for 5 minutes for an opening statement.

I'd like to welcome everyone to this morning's hearing, "Winning in Weather: United States Competitiveness in Forecasting and Modeling." This is the Environment Subcommittee's third hearing this Congress related to reauthorizing the *Weather Research and Forecasting Innovation Act of 2017*, an important effort for the Committee at large. Today's hearing continues our examination of United States' weather policy and how best to update the crucial work started by the *Weather Act* 7 years ago.

In November, this Committee unanimously passed the *Weather Act Reauthorization*, and now we look toward the future of the United States' leadership in weather forecasting. Today, we will hear from witnesses who all have extensive experience in the United States weather enterprise. Their testimonies will help us assess the United States' leadership in weather forecasting and in modeling.

It's easy to see that weather data doesn't just help determine the day's clothing. It enhances our national economy and security by assisting long-term decision making. There are serious economic and humanitarian implications to not being able to predict weather correctly or precisely, and we cannot afford to let the United States fall behind on the world stage.

From my conversations with farmers back home in Ohio, I know that seasonal weather predictions are vital to American agriculture. Without accurate predictions in this sector, planting and harvesting is put at major risk. Weather is also critical to the insurance industry and how to best ensure homes from Cleveland to Worcester. And last but certainly not least, modeling and forecasting is crucial to all aspects of manufacturing, from planning around supply chain constraints for peak production to determining the safest transportation routes for the final product.

The purpose of today's hearing is to discuss the impacts of the *Weather Act of 2017* and the *Weather Act Reauthorization of 2023* in bolstering U.S. competitiveness in the global weather community. We'll also discuss the coordination and collaboration between government agencies, the private sector, and academia to implement programs that advance new technologies related to data assimilation and modeling. Whether the data comes from NOAA (National Oceanic and Atmospheric Administration), State services, or commercial providers, we must ensure that all tools at our disposal are used to make the public aware of extreme weather conditions.

The United States faces the unique challenge of having some of the widest variety of weather events in the world. Just last week, the Smokehouse Creek fire in the Texas panhandle and southwestern Oklahoma grew to over a million acres in a matter of just days. At the same time, northern California was hit by a massive blizzard which dumped feet of snow on some areas and blew gusts of wind over 100 miles per hour. In my home State of Ohio, there

were nine confirmed tornado touchdowns on February 28 just alone.

Through innovation to improve the accuracy and timeliness of weather models, as well as public awareness, we can all save lives and property at risk from these events. Today, we will identify actionable items NOAA can pursue to build trust and education in weather forecasting products. When an EF-4 tornado or a wildfire is bearing down on U.S. citizens, there should be no doubt on the accuracy of the models and what the best course of action is to be. Additionally, by working together and increasing partnerships between NOAA and the commercial sector, the users of weather data will be better equipped to strengthen both short and long-term weather predictions, benefiting Americans across all sectors.

I want to once again thank all of our witnesses for being here, and I look forward to each of your testimonies as we are here this morning.

[The prepared statement of Chairman Miller follows:]

I want to welcome everybody to this morning's hearing, *Winning in Weather: U.S. Competitiveness in Forecasting and Modeling*. This is the Environment Subcommittee's third hearing this Congress related to reauthorizing the *Weather Research and Forecasting Innovation Act of 2017*, an important effort for the Committee at large.

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Additionally, by working together and increasing partnerships between NOAA and the commercial sector, the “users” of weather data will be better equipped to strengthen both short- and long-term weather predictions, benefitting Americans across all sectors.

I want to thank all our witnesses for being here. I look forward to each of your testimonies.

Chairman MILLER. I now recognize the Ranking Member, the gentlewoman from North Carolina, for an opening statement.

Ms. ROSS. Thank you, Chairman Miller, for holding this important hearing.

As extreme weather increasingly impacts the lives of the American people—and also, I want to thank all of our witnesses for sharing your time and expertise with us today. It’s much appreciated.

Accurate weather forecasts and warnings are essential to the protection of American lives, property, and commerce. Americans rely on dependable and accessible weather information to make important decisions every single day. Timely and accurate weather prediction is especially important in the face of extreme weather events. According to NOAA, last year, the United States experienced a record number of individual weather and climate disasters that each caused over \$1 billion dollars in damage.

Climate change is causing an increase in the occurrence and severity of extreme weather events in the United States. That’s a fact. Forty years ago, these billion-dollar disasters occurred once every 4 months. Today, they occur about once every 3 weeks. My home State of North Carolina has experienced many of these disasters. The severity and frequency of extreme precipitation events has been increasing over the past few decades and is only expected to worsen.

The dangers and damage associated with severe storms cannot be stopped entirely, but they can be mitigated, including by providing the impacted communities with appropriate warnings. To that end, it is critical that we ensure our weather forecasting and communication abilities are of the highest possible quality to protect American lives and property.

The importance of partnerships and collaboration among our government, academic, and industry partners cannot be understated. The integration of high-quality data collection with cutting-edge weather prediction technologies and fundamental science forms the backbone of reliable weather forecasting in this country. And this is only achieved through the collaboration of the U.S. weather enterprise.

Collaboration within government is also important. There is expertise and weather-relevant research being carried out across our government. The Interagency Council on Advancing Meteorological Services, or ICAMS, that was born out of this Committee’s work in the *Weather Act of 2017* seeks to advance U.S. weather forecasting capabilities by synthesizing the efforts of multiple government agencies, along with private-public partnerships.

This Committee has heard from several experts, including our North Carolina State Climatologist, that these types of collaborative efforts are essential to improving weather forecasting and warnings in the United States. One major hurdle to improving our Nation’s forecasting system is a lack of computing resources avail-

able for NOAA to support operational forecasts and data dissemination.

Last year, I co-sponsored the *Advanced Weather Model Computing Development Act*, a bipartisan bill introduced by Chairman Miller that passed the House. This important legislation enables NOAA to leverage the Department of Energy's high performance computational resources and collaborate on resource-research to improve weather and climate modeling.

While the refinement of accurate weather forecasts is highly important, we must also consider the unique needs of various end users across the United States. This is as much a social science challenge as a data or modeling challenge. The integration of timely, accurate weather information with effective and accessible communication is essential to our goal of protecting American lives and property.

I look forward to hearing from our witnesses about how Congress can continue to support NOAA, other government agencies, academia, and industry in improving the Nation's weather forecasting and warnings capabilities.

Thank you, Mr. Chairman, and I yield back.

[The prepared statement of Ms. Ross follows:]

Thank you, Chairman Miller, for holding this important hearing, as extreme weather increasingly impacts the lives of the American people; and thank you to our witnesses for sharing your time and expertise with us today.

Accurate weather forecasts and warnings are essential to the protection of American lives, property, and commerce. Americans rely on dependable and accessible weather information to make important decisions every single day. Timely and accurate weather prediction is especially important in the face of extreme weather events. According to NOAA, last year, the U.S. experienced a record number of individual weather and climate disasters that each caused over one billion dollars in damage.

Climate change is causing an increase in the occurrence and severity of extreme weather events in the United States. Forty years ago, these billion-dollar disasters occurred once every four months. Today, they occur about once every three weeks. In my home state of North Carolina, the severity and frequency of extreme precipitation events has been increasing over the past few decades and is only expected to worsen.

The dangers and damage associated with severe storms cannot be stopped entirely, but they can be mitigated, including by providing impacted communities with appropriate warnings. To that end, it is of critical importance to ensure that our weather forecasting and communication abilities are of the highest possible quality to protect American lives.

The importance of partnerships and collaboration between our government, academic, and industry partners cannot be understated. The integration of high-quality data collection with cutting-edge weather prediction technologies and fundamental science forms the backbone of reliable weather forecasting in this country, and this is only achieved through the collaboration of the U.S. Weather Enterprise.

Collaboration within the government is also important. There is expertise and weather-relevant research being carried out across our government. The Interagency Council on Advancing

Meteorological Services, or ICAMS, that was born out of this committee's work in the *Weather Act of 2017*, seeks to advance U.S. weather forecasting capabilities by synthesizing the efforts of multiple government agencies along with private-public partnerships. This Committee has heard from several experts, including our North Carolina State Climatologist, that these types of collaborative efforts are essential to improving weather forecasting and warnings in the United States.

One major hurdle to improving our nation's forecasting system is a lack of computing resources available for NOAA to support operational forecasts and data dissemination. Last year, I co-sponsored the *Advanced Weather Model Computing Development Act*, a bipartisan bill introduced by Chairman Miller that passed the House. This important legislation enables NOAA to leverage the Department of En-

ergy's high performance computational resources and collaborate on research to improve weather and climate modeling.

While the refinement of accurate weather forecasts is highly important, we must also consider the unique needs of various end-users across the United States. This is as much a social science challenge as a data or modeling challenge. The integration of timely, accurate weather information with effective and accessible communication is essential to our goal of protecting American lives and property.

I look forward to hearing from our witnesses about how Congress can continue to support NOAA, other government agencies, academia, and industry in improving the nation's weather forecasting and warnings capabilities.

Thank you, Mr. Chairman, and I yield back.

Chairman MILLER. Thank you, Ms. Ross.

I now would like to recognize the Ranking Member of the Full Committee, the gentlewoman from California, for an opening statement.

Ms. LOFGREN. Thank you, Mr. Chairman.

This hearing features experts with relevant expertise in a whole range of issues that we'll explore today surrounding the U.S. weather enterprise's efforts to improve the Nation's weather and climate forecasting, as well as modeling capabilities. A topic that I've been focused on in these weather hearings is the need for improvement in the subseasonal to seasonal or S2S—there's got to be an acronym for everything—forecasts and products, the S2S predictions are important to community and to industry, including and maybe even especially agriculture so that adequate decisionmaking and planning can be made relative to water management, infrastructure development, electricity market demands, as well as flood protection. Advancements are going to require additional research and development in quite a number of areas, and I look forward to hearing from these experts about that.

While improving modeling is important, as the Ranking Member just mentioned, there needs to be also a focus on improving the end products and the delivery of services. Dr. Petty, in his testimony, mentioned that when weighing the success in forecasting, there needs to be other meaningful metrics that are more aligned to NOAA's mission to protect lives and property. Who is the audience? What information will the end users find most useful? How should that information be delivered in the most effective way?

In reaching this goal of improving meteorological services, there need to be effective collaboration between Federal agencies that have relevant expertise and among the broader U.S. weather enterprise. When different agencies compete for limited funding, they become even more protective of what they have, and that sometimes constrains collaboration. At a time of constrained resources, what more could Congress do to encourage interagency collaboration? And how can the private sector and academia engage in these efforts and support advancement of meteorological sciences? These questions need to be answered to ensure that we're leveraging the Nation's full expertise to further the development of weather and climate research, forecasting, and communication.

On the topic of funding today, later today, we'll be voting on the Fiscal Year 2024 appropriation agreement that includes funding for NOAA. I'm glad that, as compared to previous budgets that would have cut NOAA by 22 percent, the budget now would keep NOAA at level funding. And obviously, level funding in a time of inflation

is not an increase, but it is certainly an improvement over the 22 percent proposed cut.

I also want to mention the *Weather Act Reauthorization* bill that Chairman Lucas and I advanced to improve NOAA's forecasting and modeling abilities by expanding existing and creating new programs. I hope this bill makes it to the President's desk this year. However, I worry that stagnant funding provided to NOAA would undoubtedly slow advancement, even with the good provisions of this bill.

I want to thank the Chairman, the Ranking Member, and each of the expert witnesses who are here today, and I yield back, Mr. Chairman.

[The prepared statement of Ms. Lofgren follows:]

Good morning. Thank you to Chairman Miller and Ranking Member Ross for holding today's hearing on weather and climate modeling and forecasting. Today's hearing features experts with relevant expertise in a range of issues that we will explore today surrounding the U.S. Weather Enterprise's efforts to improve the nation's weather and climate forecasting and modeling capabilities.

A topic that I continue to be focused on in these weather hearings is the need for improvement in the subseasonal to seasonal, or S2S, forecasts and products. S2S predictions are critical to communities and to industry, including agriculture, for informing adequate decision making and planning related to water management, infrastructure development, and electricity market demands. Advancements in S2S prediction will require further research and development in a number of areas, including in coupled numerical weather-climate systems. I look forward to hearing the expert panel's recommendations for improving subseasonal to seasonal modeling.

While improving modeling is important, there needs to be just as much focus on improving the end products and delivery of services. As Dr. Petty mentions in his testimony, when weighing our success in forecasting, there need to be other meaningful metrics that are more aligned to NOAA's mission to protect lives and property. It is essential to understand who the audience is, what information the end user finds most useful, and how that information should be delivered in the most effective way.

In reaching this goal of improving meteorological services, there needs to be effective collaboration between federal agencies that have relevant expertise, and among the broader U.S. Weather Enterprise. When different agencies are competing for limited funding, they become even more protective of what they have. At a time of constrained resources, what more can Congress do to encourage inter-agency collaboration? How can the private sector and academia engage in these efforts and support advancement of meteorological services? These questions need to be answered to ensure that we are leveraging the nation's full expertise to further the development of weather and climate research, forecasting, and communication.

On the topic of funding, later today, we will be voting on the fiscal year 2024 appropriation agreement that includes funding for NOAA. I am pleased to see the reversal of the previous stance by the majority to cut NOAA's budget by as much as 22%. The budget now would keep NOAA's spending essentially flat. While the reversal is welcome, I remain concerned about how NOAA will be able to achieve its goal to improve models and forecasts rapidly.

The *Weather Act Reauthorization* bill that I cosponsored with Chairman Lucas aims to improve NOAA's forecasting and modeling abilities by expanding existing and creating new programs. While I do hope this bill makes it to the President's desk this year, the stagnant funding level provided to NOAA will undoubtedly slow advancement.

Thank you to the expert panel for being here this morning. I look forward to your testimony and the discussion. I yield back.

Chairman MILLER. Thank you, Ms. Lofgren.

I ask unanimous consent to enter into the record the opening statement of Chairman Lucas. Without objection, so ordered.

[The prepared statement of Chairman Lucas follows:]

I want to thank the gentleman from Ohio, Chairman Miller, for holding today's hearing.

This hearing couldn't come at a more crucial time. Last week, the Smokehouse Creek fire burned over 1 million acres in Western Oklahoma and the Texas Panhandle. This has earned it the unpleasant distinction of being the second largest wildfire in U.S. history.

While evaluation is still on going, early reports indicate that about 500 structures were destroyed, thousands of cattle were killed, and tragically one life was lost. Last week, I took some time to drive through the western most parts of my district to see the damage, and I can tell you that many families will struggle to fully recover for years to come.

Where I'm from, land is your livelihood. Even if your house is still standing, you can lose the very backbone of your career and income if your property is damaged or thrown off from the delicate balance you have cultivated.

If it wasn't for some strong south to north wind at just the right time last week, I could have been in that category. I had to move cattle into fields that were less likely to burn if the fire kept moving our way. It's not a fun activity, but a necessary one to protect my family's business.

This personal experience very much relates to today's hearing. I looked at the Oklahoma Mesonet to see the most up to date conditions in my area. I closely monitored the National Weather Service's fire weather outlooks for the coming days, so I knew what to expect. And I made critical decisions based on the weather data, models, and forecasts that were available to me.

It's been seven years since the passage of the *Weather Act of 2017*. The tools and data I used last week are more accurate and readily available than they were before that bill. But I believe there is more we can do for the U.S. weather enterprise to be at the forefront of forecasting and modeling.

The *Weather Act Reauthorization of 2023* and H.R. 4866, the *Fire Weather Development Act of 2023*, are both bills that passed with bipartisan support out of this Committee. Both bills will further improve the weather data, models, and forecasts to meet the unique needs of our country and protect lives and property.

I thank our witnesses for sharing their expertise with us and I look forward to a productive discussion. Thank you and I yield back Mr. Chairman.

Chairman MILLER. Let me introduce our witnesses. Our first witness today is Dr. Neil Jacobs. He is the Chief Science Advisor for the Community Unified Forecast System (UFS), part of the University Corporation for Atmospheric Research's Cooperative Programs for the Advancement of Earth System Science and hosted at North Carolina State University. Dr. Jacobs previously served as both Acting Under Secretary of Commerce for Oceans and Atmosphere and Assistant Secretary of Commerce for Environmental Observation and Prediction. Dr. Jacobs holds bachelor's degrees in mathematics and physics from the University of South Carolina and master's and doctoral degrees in air and sea interaction and numerical weather prediction from the North Carolina State University. Man, that is a lot. I could barely get that out, Doctor.

Our second witness is Dr. Kevin Petty. He is the Chief Executive Officer of Aeris LLC. He has also worked as a Project Scientist and Scientific Program Manager with the National Center for Atmospheric Research and as an Accident Investigator and Senior Meteorologist for the National Transportation Safety Board. Dr. Petty graduated with an M.S. and Ph.D. in atmospheric sciences from the Ohio State University, OH—there it is—and a B.S. in mathematics/secondary education from Illinois College.

Our third witness is Dr. Scott Weaver. He is Founder and Principal Scientist of CLIMET Consulting—or CLIMET Consulting LLC and brings over 20 years of experience as a scientist and executive, leading climate and weather scientific research and advancing interagency science policy across the Federal Government, most recently, serving as the National Director for Windstorm Impact Reduction at NIST (National Institute of Standards and Technology) and Executive Director of the Interagency Council for Ad-

vancing Meteorological Services at the White House Office of Science and Technology Policy. Dr. Weaver has also held scientific research and leadership positions in NASA, NOAA, NIST, and the private sector focused on weather, climate variability, climate change, and disaster impact reduction.

Welcome. And a warm welcome to all of our witnesses, and truly, thank you for being here today. It's much appreciated.

I now recognize Dr. Neil Jacobs for 5 minutes to present his testimony.

**TESTIMONY OF THE HONORABLE DR. NEIL JACOBS,
ACTING NOAA ADMINISTRATOR, 2019–2021**

Dr. JACOBS. Chairman Miller, Ranking Member Ross, and Members of the Subcommittee, thank you for the opportunity to testify at this hearing on a topic that is extremely important for the future of our country's scientific leadership. Over the last few years, there have been several major successes owed to the *Weather Research and Forecasting Innovation Act of 2017*. Considerable progress has been made toward developing a community-friendly Unified Forecast System, which streamlines the software architecture, while embracing an open innovation approach that is mutually beneficial to the public, private, and academic sectors. This is a major paradigm shift because previous versions of the code would only work on NOAA's internal supercomputers. Engaging the broader community will not only result in greater access to innovative solutions, but it'll simultaneously train the future workforce.

The Earth Prediction Innovation Center (EPIC) is a program charged with supporting this effort. The goal of EPIC is to empower the scientific community to develop, test, and contribute their own innovations to the UFS through a transparent and objective evaluation process. This transformation is underway, but there was a lot more work that needs to be done. The UFS, which is a community model, still needs to finalize its governance that is by the community for the community in which NOAA is a critical stakeholder.

Numerical weather prediction is an initial value problem. Correctly predicting the future state of any Earth system requires observations with greater resolution and accuracy. Many of these new observations are being produced by private industry. Commercial data buy programs such as GPSRO (Global Positioning System Radio Occultation), commercial aircraft data, and the National Mesonet Program are cost-effective ways to greatly improve model accuracy.

While acquiring data for more advanced observing systems is a critical step to improving forecasts, we cannot lose sight of an equally attainable opportunity, which is extracting more value from the data that we already collect. The process of data assimilation such as the JEDI (Joint Effort for Data Assimilation Integration) framework is often overlooked, yet it is one of the most important aspects of numerical weather prediction where significant returns on investment are easily attainable.

Another challenge we are facing is how to manage the new data when those file sizes are growing exponentially. As files get larger, transfer speeds get slower. The mission of the National Weather

Service is to protect life and property where often seconds matter. Increasing the latency of data availability, even if it is more accurate, is counterproductive.

Whether the satellite data forecast models or processing and visualization tools like AWIPS (Advanced Weather Interactive Processing System), cloud is the answer. We must evolve beyond a process that relies on moving data. Not only does cloud computing eliminate the latency problem, the elasticity of on-demand commercial cloud also eliminates the bottleneck of limited access to compute research for research and development.

Efficiencies throughout the value chain of forecasting can also be gained from artificial intelligence (AI). I am encouraged by NOAA's rapid adoption of various AI and deep-learning techniques and would like to thank the Committee for supporting this emerging capability in the *Weather Act Reauthorization*.

While these are a few technical gaps that need to be addressed, there's broader overarching aspects that are essential to accelerating progress. Workforce recruitment, retention, and development is a growing challenge. There are very few opportunities for the current workforce to upskill or reskill to adapt to rapidly evolving technological advancements. While software engineering is a common field at most universities, finding engineers with a solid understanding of atmospheric physics and dynamics is not easy.

Additionally, the programming skills needed for model development are similar to those required in other job markets where the starting salaries are far more competitive. There's a growing number of Earth system science degree programs within the U.S. universities, but many are limited in their ability to introduce students to model code.

Versions of the UFS through support of NOAA and the National Science Foundation are being developed for use in the classroom as a teaching tool. Being able to run a global model without access to large supercomputers was unimaginable just a few years ago. However, we now have versions of the UFS that can run on public cloud, as well as a laptop. While this is a game-changing capability to train the future workforce, we are now just approaching the start line for this race.

Chairman Miller, Ranking Member Ross, and Members of the Subcommittee, thank you again for inviting me to participate today. I would be pleased to answer any questions you may have.

[The prepared statement of Dr. Jacobs follows:]

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT
U.S. HOUSE OF REPRESENTATIVES

“Winning in Weather: U.S. Competitiveness in Forecasting and Modeling”
Written Statement of Dr. Neil Jacobs

Chairman Miller, Ranking Member Ross, and Members of the Subcommittee, thank you for the opportunity to testify at this hearing on a topic that is extremely important for the future of our country’s scientific leadership.

Over the last few years, there have been several major successes owed to the Weather Research and Forecasting Innovation Act of 2017. Considerable progress has been made towards developing a community-friendly Unified Forecast System (UFS), which streamlines the software architecture, while embracing an open innovation approach that is mutually beneficial to the public, private, and academic sectors. This is a major paradigm shift because previous versions of code would only work on NOAA's internal supercomputers. Supporting the broader scientific community through public-private-academic engagement that grows the user base will not only result in greater access to innovative solutions that improve forecast skill, but it simultaneously trains the future workforce.

The Earth Prediction Innovation Center (EPIC) is the program charged with supporting this effort. The goal of EPIC is to empower the scientific community to develop, test and contribute their own innovations to the UFS through a transparent and objective evaluation process. This transformation is underway, but there is a lot more work that needs to be done. The UFS, which is a community model, still needs to finalize its governance that is by the community, for the community, in which NOAA is a critical stakeholder.

At its core, numerical weather prediction is an initial value problem. Correctly predicting the future behavior of any earth system requires high quality observations of its current state. Acquiring higher resolution observations with greater accuracy is essential. Many of these new observations are being produced by private industry. Commercial data buy programs, such as those used for GPS-RO, commercial aircraft data, or the National Mesonet Program, are a cost-effective way to greatly improve forecast model accuracy. While developing or acquiring data from more advanced observing systems is a critical step to improving forecasts, we cannot lose sight of an equally attainable opportunity, which is extracting more value from the data we already collect.

The process of data assimilation, such as the Joint Effort for Data assimilation Integration (JEDI) developed by the Joint Center for Satellite Data Assimilation, is often overlooked, yet it is one of the most important aspects of numerical weather prediction, where significant returns on investment are easily attainable.

One challenge we are facing is how to manage new data when those file sizes are growing exponentially. As files get larger, the transfer speeds get slower. The mission of the National Weather Service is to protect life and property, where often seconds matter. Increasing the latency of data availability, even if it is more accurate, is counterproductive. Whether it is satellite data, forecast models, or processing and visualization tools like AWIPS, cloud is the answer. We must evolve beyond a process that relies on moving data. Not only does cloud computing eliminate the latency problem, the elasticity of on-demand commercial cloud also eliminates the bottleneck of limited access to compute for research and development.

Efficiencies throughout the value chain of forecasting can also be gained from Artificial Intelligence. I am encouraged by NOAA's rapid adoption of various AI and deep learning techniques and would like to thank the Committee for supporting this emerging capability in the Weather Act Reauthorization.

While these are a few technical gaps that need to be addressed, there are broader overarching aspects that are essential to accelerating progress. Workforce recruitment, retention, and development is a growing challenge. There are very few opportunities for the current workforce to upskill or reskill to adapt to rapidly evolving technological advancements. While software engineering is a common field at most universities, finding engineers with a solid understanding of atmospheric physics and dynamics is not easy. Additionally, the programming skills needed for model development are similar to those required in other job markets where the starting salaries are far more competitive. There are a growing number of earth system science degree programs within U.S. universities, but many are limited in their ability to introduce student to model code. Versions of the UFS, through support of NOAA and the National Science Foundation, are being developed for use in the classroom as a teaching tool. Being able to run a global model without access to a large supercomputer was unimaginable just a few years ago; however, we now have versions of the UFS that can run on the public cloud as well as a laptop. While this is a game-changing capability to train the future workforce, we are just now approaching the start line of this race.

Chairman Miller, Ranking Member Ross, and Members of the Subcommittee, thank you again for inviting me to participate today. I would be pleased to answer any questions you may have.

Dr. Neil Jacobs is the Chief Science Advisor for the community Unified Forecast System, part of the University Corporation for Atmospheric Research's Cooperative Programs for the Advancement of Earth System Science and hosted at North Carolina State University.

He is also a Visiting Senior Policy Fellow at the American Meteorology Society and the recipient of the Society's 2023 Kenneth C. Spengler Award for leadership in fostering community collaboration across the weather, water, and climate enterprise.

Dr. Jacobs previously served as both Acting Under Secretary of Commerce for Oceans and Atmosphere and Assistant Secretary of Commerce for Environmental Observation and Prediction, where he was responsible for the strategic direction and oversight of over \$5.6 billion in annual spending, including key investments in space innovation, remotely-piloted autonomous systems, and the development of a community modeling framework to advance U.S. weather and climate prediction, while unlocking the partnership potential of non-governmental and private organizations to study the oceans and promote a blue economy.

Dr. Jacobs holds bachelor degrees in mathematics and physics from the University of South Carolina and masters and doctoral degrees in air-sea interaction and numerical weather prediction from North Carolina State University.

Chairman MILLER. Thank you very much, sir.

I now would like to recognize Dr. Kevin Petty for 5 minutes to present the testimony.

**TESTIMONY OF DR. KEVIN PETTY,
CHIEF EXECUTIVE OFFICER, AERIS LLC**

Dr. PETTY. Chairman Miller, Ranking Member Ross, and Members of the Subcommittee, I want to thank you for the opportunity to share some thoughts and perspectives related to the weather enterprise, particularly from the standpoint of U.S. competitiveness and weather forecasting and modeling now and into the future. I've had a long career working in the weather enterprise. I've been fortunate enough to work in the public, private, and academic sectors. Most recently, I joined the leadership team at Aeris LLC, a small, Colorado-based team that is focused on the development and application of environmental modeling at meter-scale resolutions.

These diverse positions and experiences have helped to shape my perspective on the weather enterprise, particularly what has worked well and what has not. Here in the United States, we face distinctive weather-related challenges that are not seen in other parts of the world. Factors such as a changing climate, population growth, increased complexities associated with a built environment are all shaping the need for accurate, timely weather data and information.

The ability to achieve significant measurable improvements in weather analysis and forecasting is rooted in four fundamental areas: in observations, in computing, and modeling and information delivery. Unfortunately, no single entity or sector of the enterprise has the capacity to meet the depth and breadth of the demands associated with each of these domains. That said, our country has successfully developed something that no other country has been able to replicate, and that is a strong, robust weather enterprise where public, private, academic, nongovernmental organizations have the ability to support the common goal of protecting life and property and ensuring a strong, vibrant economy. The U.S. competitiveness in weather forecasting and modeling is highly dependent upon our ability to effectively leverage the strengths of each segment of the weather enterprise.

Now, it goes without saying that the U.S. weather enterprise would not be what it is today without NOAA. NOAA is and will remain a central component of the weather data and information value chain. Many companies like my own depend on NOAA to produce very high-quality data, including weather forecasts. Nonetheless, like other segments of the enterprise, NOAA must continue to use rapidly evolve if it's going to be a driving force in terms of being a preeminent leader in weather forecasting globally.

We've seen other components of the enterprise quickly hasten the pace of innovation, and this is particularly true from the private sector's perspective. There—the private sector has made significant investments and advancements in the development of new observing systems, in the use of artificial intelligence, in pushing the boundaries of modeling from the standpoint of spatial and temporal resolution.

The *Weather Research and Forecasting Innovation Act of 2017* has helped to guide recent NOAA activities in several positive ways, including from the standpoint of encouraging commercial weather data buys, highlighting the importance of expanding and upgrading computational resources, and providing concrete direction on weather research and forecasting priorities. However, there's more work to be done. If we're going to be the leader in weather forecasting and modeling, it is imperative that NOAA have the continued support and direction it needs. With these elements in place, NOAA should formulate a clear, concise weather forecast improvement strategy with defined tradeoffs. This should also include well-defined agreed-upon metrics for improvement. NOAA should also carefully consider whether its current structure can foster the desired level of innovation. And finally, NOAA should build deeper, more collaborative research and development partnerships with industry.

In conjunction with NOAA's efforts, Congress should support NOAA by not overtaxing NOAA with new responsibilities that do not deliver targeted value, particularly if they don't come with a supporting budget. Congress should also adhere to the established timeline for the budgeting process. Federal agencies such as NOAA can't be expected to be innovative forces in terms of improved forecasting without the capacity to effectively plan. The lack of budgets also has a cascade effect on NOAA's partners.

I want to thank you for this opportunity to present this testimony, and I welcome any questions or comments you may have.

[The prepared statement of Dr. Petty follows:]

Testimony of Dr. Kevin R. Petty, Chief Executive Officer, Aeris LLC.
Winning in Weather: U.S. Competitiveness in Forecasting and Modeling
Submitted to the
Subcommittee on Environment
Committee on Science, Space and Technology
United States House of Representatives
6 March 2024

Chairman Miller and Ranking Member Ross, and members of the Subcommittee, I want to thank you for the opportunity to provide a few thoughts, perspectives, and insights related to the Weather, Water, and Climate Enterprise (hereafter Weather Enterprise or the Enterprise), particularly in terms of U.S. competitiveness in weather and forecasting, now and in the future.

My name is Dr. Kevin Petty, and I am the Chief Executive Officer at Aeris, LLC. Aeris is a Colorado-based small business dedicated to fostering safety and national security through advanced microscale atmospheric modeling and related decision support tools.

As part of my comments, I would like to highlight some of the benefits of the Weather Research and Forecasting Innovation Act of 2017. I would also like to comment on how the private sector is rapidly reshaping the Weather Enterprise from the perspective of weather and forecasting improvements. For additional context, I will start off by sharing some background information on Aeris and its relevance to today's discussion.

Aeris was founded in 2015 by scientists from the National Center for Atmospheric Research (NCAR). Its mission is to (1) conduct world-class environmental research, with a focus on atmospheric modeling, (2) develop novel software solutions that translate data into enhanced decision making, and (3) provide industry-leading technical services built on creative minds and distinctive core competencies. This mission has been fundamental to Aeris' ability to address complex needs and requirements across a diverse array of environmentally sensitive domains including, but not limited to, defense, homeland security, intelligence, and aviation. Aeris' demonstrated ability to work closely with its customers to solve challenging, multifaceted atmospheric-related problems has garnered the attention and trust of some of the most demanding organizations in the United States, including the Department of Defense (DoD).

Aeris has shown the capacity to develop and deliver novel science-based offerings designed to enhance operational elements related to national security, particularly from the perspective of protecting and enabling warfighters. Aeris has developed a broad range of chemical, biological, radiological, and nuclear (CBRN) and combatting weapons of mass destruction (CWMD) defense modeling and information systems for the Defense Threat Reduction Agency (DTRA). Aeris has also worked with the United States Air Force (USAF) on the construction of data analysis methodologies and numerical weather prediction uncertainty research. In addition to supporting DoD efforts, Aeris has supported other governmental agencies such as the Department of Homeland Security (DHS), National Aeronautics and Space Administration (NASA), and the Federal Aviation Administration (FAA).

At its core, Aeris is working in concert with its partners to develop cutting-edge microscale atmospheric modeling capability that enables weather and environmental analysis and prediction at meter-scale spatial resolutions. This capability leverages general purpose Graphics Processing Unit (GPU) computing technologies along with what's known as a Large Eddy Simulation (LES) model that has been implemented to run resident on GPU computing hardware. Aeris' LES modeling framework, which is referred to as the Joint Outdoor-indoor Urban Large Eddy Simulation (JOULES), provides the ability to simulate, reconstruct, and predict critical data such as winds and turbulence at urban "building-aware" scales down to approximately 1 m horizontal and vertical resolutions. To do this, JOULES is designed to incorporate full atmospheric physics (e.g., clouds, precipitation, radiative transfer of energy, etc.). Moreover, it can be coupled to larger scale operational numerical weather prediction (NWP) models such as the National Oceanic and Atmospheric Administration's (NOAA) High Resolution Rapid Refresh Model (HRRR) or the Global Forecast System (GFS). This emerging technology, along with Aeris' scientific expertise in NWP and transport and dispersion, is fueling a range of current and potential applications that include detailed airborne hazard prediction, Uncrewed Aircraft Systems (UAS) operations safety and air traffic management, renewable energy, and current and future climate resiliency for urban city planning, to name just a few.

I say all this because Aeris is an example of how the U.S. Weather Enterprise has and will continue to evolve. Factors such as a changing climate, population growth, and increased complexities associated with the built environment are deepening the need for accurate, timely weather data and information at temporal and spatial scales that effectively support stakeholder action and response. Aeris, along with other private sector companies, has recognized this need, as well as the associated challenges and gaps. Over the last several decades, there has been significant growth in the private sector as companies have been established to address deficiencies ranging from meteorological observations to decision support systems. In the case of Aeris, we are working closely with environmentally sensitive customers to solve extremely complicated and challenging problems that require microscale data and information. Such engagement is often centered on understanding an end user's unique requirements to provide user-tailored products, services, and solutions. It should be noted that like other sectors of the U.S. Weather Enterprise, the private sector is fully committed to protecting life and property, enhancing operational productivity and efficiency, and securing our nation.

The ability to achieve significant, measurable improvements in weather analysis and forecasting is rooted in four fundamental areas: observations, computing, modeling, and information delivery. Unfortunately, no single entity or sector in the Enterprise has the capacity to meet the depth and breadth of demands associated with each of these domains. The U.S. competitiveness in weather forecasting and modeling is highly dependent on its ability to effectively leverage the strengths of each segment of the Weather Enterprise. Furthermore, the U.S. must carefully consider how to effectively gauge whether actions and activities associated with these areas truly improve weather-related forecasts and U.S. competitiveness. In other words, are the right metrics being employed?

For years, critics have argued that NOAA's National Weather Service (NWS) trails the Europeans (i.e. the European Center for Medium-Range Weather Forecasts – ECMWF) in terms of forecast accuracy. The claims are largely based on assessments of 500 millibar height (roughly 18,000 feet) anomaly correlation, a single measure of model forecast accuracy. While this has long been an accepted metric in the scientific community, it is a single metric that does not directly capture model performance within the boundary layer – where humans live. Nor does it capture the quality of weather forecasts from the perspective of impact. It is imperative to recognize that the missions of NOAA's NWS and ECMWF are very different. The NWS mission of protecting life and property is very different than that of the ECMWF, which is dedicated

to global medium-range forecasting. It is vital that NOAA's NWS, along with the broader U.S. Weather Enterprise, meet the common goal of protecting life and property and fostering an economy that is productive and resilient in the face of extreme weather. The ability to properly measure and track progress towards this goal is going to need to extend well beyond assessments of 500 mb height anomaly correlation coefficient scores. In other words, the U.S. should develop and institute meaningful metrics that are in line with its goals and objectives. The U.S. faces distinctive weather-related challenges that are not seen in other parts of the world; however, it has been successful in cultivating a potential solution that no other country has been able to replicate – a strong, robust weather enterprise where public, private, academic, and non-governmental organizations have together been able to effectively contribute to a common goal.

It goes without saying that the U.S. Weather Enterprise would not be what it is today without NOAA. NOAA is and will remain a central component of the weather data and information value chain (i.e., observations, computing, modeling, and data/information delivery). However, like other segments of the enterprise, NOAA must continue to evolve rapidly if it is to remain a driving force behind enabling the U.S. to be the preeminent leader in weather forecasting globally. The Weather Research and Forecasting Innovation Act of 2017 has helped to guide recent NOAA activities in several positive ways including, but not limited to, the following:

1. **Commercial Weather Data:** The Act encourages significant interaction with industry. One element of this interaction is from the standpoint of commercial weather data. In the past, NOAA has generally used the approach of procuring, operating, and maintaining weather stations, radars, satellites and other sensor platforms. However, in recent years, industry has introduced new business models in which companies operate the sensing platform and sell data. This business model is being demonstrated for terrestrial, airborne, and space-based observations. Such a model can allow NOAA to reduce risks and costs, while obtaining observations central to forecast improvements. Identifying opportunities associated with commercial weather data buys should continue, with a focus on weather analysis and forecast improvement, as well as return-on-investment.
2. **Computing:** The Act highlights the importance of computing by directing NOAA to determine computing requirements that will facilitate and support weather forecasting. From a stakeholder perspective, the desire is that NOAA will ultimately expand and upgrade its computational resources to support improvements in weather analysis and forecasting, as well as ensure uninterrupted, timely dissemination of data and information to meet mission requirements and promote a healthy, vibrant enterprise. Work to ensure NOAA possesses or has access to a modern, robust infrastructure should be a priority.
3. **Environmental Information Services Working Group (EISWG):** The Act codified the existence of EISWG. This group, composed of individuals from across the Enterprise, has worked tirelessly to provide advice and guidance to NOAA regarding weather research priorities, emerging technologies, and partnership opportunities. For example, members of EISWG were instrumental in the development of the NOAA Science Advisory Board's (SAB) report on weather research priorities for the United States. With proper leadership, this working group is well-positioned to continue to assist and advise NOAA on a diverse set of topics ranging from forecast improvement to workforce development to effective partnerships.

The Weather Research and Forecasting Innovation Act has provided NOAA with direction related to advancing weather research and forecast capabilities in the United States. However, it is worth noting that the pace at which NOAA is able to innovate will need to match that of the broader Enterprise. This is going to require a nimbler organization that is open to change.

In the last decade, the private sector has emerged as a key player in the development and operation of numerical weather prediction models at both regional and global scales, catering to the diverse needs of weather-sensitive industries. Notably, companies have actively engaged in advancing these models to support clients in industries such as transportation, agriculture, energy, construction, and mining. Additionally, a substantial number of companies have been able to close gaps associated with the general public's appetite for weather data and information. What sets some of these companies apart is their incorporation of proprietary observations in the data assimilation process. By leveraging their unique data sources, these companies not only enhance the accuracy of their predictions but also establish a distinctive edge in the market. This additional layer of differentiation allows them to provide tailored and precise weather forecasts, crucial for clients seeking optimized operational strategies and risk mitigation during high-impact weather events. The integration of proprietary observations further underscores the private sector's commitment to innovation and customer-centric solutions, reinforcing their role as essential contributors to the advancement of meteorological capabilities.

The private sector has also been at the forefront of pushing the boundaries of innovation in the application of artificial intelligence (AI) to propel advancements in weather prediction. Industry has harnessed the power of AI to analyze large and complex datasets, enabling a paradigm shift in weather forecasting. This transformative approach has been particularly successful due to the extensive use of historical data generated by institutions like the ECMWF. The large datasets have become invaluable for training AI models, allowing companies to develop algorithms that can discern intricate patterns and relationships within meteorological data. As previously noted, some companies are strategically incorporating proprietary datasets into their AI schemes, enhancing the specificity and reliability of their predictions, including designing novel impact-based forecast methodologies.

Companies such as Aeris have been introducing groundbreaking innovations in the development and enhancement of microscale weather forecasts, with a focus on meter-scale predictions for urban applications. This cutting-edge capability is particularly crucial for emerging technologies such as Unmanned Aerial Systems (UAS) and Advanced Air Mobility (AAM) operations, as well as the process of developing and designing urban spaces. By harnessing advanced GPU-enabled LES modeling techniques, Aeris is working to achieve unparalleled accuracy in environmental conditions at very fine scales. Such capabilities are instrumental for applications where small variations in weather can have significant impacts in terms of safety and operational efficiency. Additionally, urban planners can benefit from these microscale predictions, gaining insights into localized patterns (e.g., heat stress) that can influence infrastructure development and city planning. The private sector's commitment to pushing the boundaries of microscale weather predictions highlights its role in driving innovative solutions to solve complex, small-scale problems.

A common, and often overlooked, theme for many innovative science-based companies is the fact that these entities are making regular, and sometimes deep, investments in research and development. These investments span both basic and applied research. To do this, companies have worked to hire and retain a strong science and engineering workforce with the capacity to advance understanding as it relates to central components of weather analysis and forecasting, including in situ and remote sensing, modeling and algorithm development, computing, data management, and application development. Often, these competencies complement the needs of NOAA and other governmental agencies, providing potential opportunities for deeper collaboration and partnership. Unfortunately, the notion of public-private partnerships within the Weather Enterprise has remained predominately transactional in nature (e.g., buy or acquire data, a sensor, or a service). NOAA's ability to accelerate innovation would likely benefit from working more closely and collaboratively with industry beginning at the ideation stage.

To significantly bolster the United States' competitiveness in weather forecasting and modeling, it is important for:

- **NOAA to:**
 - Formulate a clear, concise weather forecast improvement strategy. A strong strategy includes outlining essential priorities and identifying and adhering to strategic tradeoffs. Moreover, the definition of "improvement" should be thoughtfully reviewed, as this can have wide-ranging meaning, leading to a lack of focus and dilution of resources. Thus, constructing targeted and meaningful metrics to measure progress is also imperative.
 - Carefully consider whether its current structure can foster the level of creativity, problem-solving, and scientific exchange that supports disruptive innovation in the weather analysis and forecasting space.
 - Determine whether accelerating weather forecasting improvements in the U.S. would be better accomplished by standing up an independent, diverse, limited-duration team whose sole focus is centered on modeling. Part of the goal would be to remove bureaucratic constraints to create an agile environment where individuals/teams embrace failure, value curiosity, and execute rapidly through an iterative research and development process.
 - Build deeper, more collaborative research and development partnerships with industry to help reduce risks and achieve its broader mission.
- **Congress to:**
 - Support NOAA by not overtaxing NOAA with new responsibilities (e.g., tasks, initiatives, projects, and programs) that do not deliver value and/or are simply too much to take on at the time. It is counterproductive to broaden what is already an extensive portfolio without including provisions that reduce accountabilities elsewhere, particularly without the budget to support such efforts. Moreover, adding unnecessary administrative burdens impacts NOAA's ability to adequately resource essential tasking that will strengthen U.S. competitiveness in forecasting and modeling.
 - Adhere to the established timetable for the budgeting process. Federal agencies such as NOAA can't be expected to be innovative forces in terms of improved forecasting without the capacity to effectively plan. Such planning requires having a budget from which to work, as well as being able to depend on timely, annual budgets. It should be noted that the lack of a timely and trusted budgeting process also has considerable cascade effects on partner organizations in the broader Enterprise.

Thank you for the opportunity to present this testimony. I welcome any questions or comments that you may have.

Short Bio for Dr. Kevin R. Petty
Chief Executive Officer, Aeris, LLC

Dr. Kevin Petty is the Chief Executive Officer of Aeris, LLC. Aeris is a Colorado-based small business dedicated to fostering safety and national security through advanced microscale atmospheric modeling and related decision support tools. In addition to leading Aeris, Dr. Petty closely interacts with members of the national and global weather enterprise including, but not limited to, government agencies, academia, and other private-sector providers.

Before joining Aeris, Dr. Petty was the Senior Vice President for Weather and Earth Intelligence at Spire. Prior to that, he served as the Director of Science and Forecast Operations at The Weather Company and as the Chief Science Officer for Vaisala, a Finland-based company that develops meteorological instrumentation. He has also worked as a Project Scientist and Scientific Program Manager with the National Center for Atmospheric Research (NCAR) and as an accident investigator and Senior Meteorologist for the National Transportation Safety Board (NTSB). Dr. Petty graduated with an M.S. and Ph.D. in Atmospheric Sciences from Ohio State University and a B.S. in Mathematics/Secondary Education from Illinois College.

Chairman MILLER. Thank you, Doctor.
I now recognize Dr. Scott Weaver for 5 minutes to present his testimony.

**TESTIMONY OF DR. SCOTT WEAVER,
CHIEF EXECUTIVE OFFICER, CLIMET CONSULTING**

Dr. WEAVER. Thank you. Chairman Miller, Ranking Member Ross, and Members of the Subcommittee, I'm Dr. Scott Weaver, Founder of CLIMET Consulting LLC, a new consultancy focused on science and policy issues and weather and climate. I've also served in several scientific leadership roles within the Federal Government, including as a Research Meteorologist for NASA and NOAA, Director of the interagency National Windstorm Impact Reduction Program led by NIST, and most recently as the inaugural Executive Director of the Interagency Council for Advancing Meteorological Services, or ICAMS, at the White House Office of Science and Technology Policy. Thank you for the opportunity to appear before you today.

The ICAMS aspirational goal, as stated in its 2020 charter, is "The United States will lead the world in meteorological services via an Earth system approach, providing societal benefits with information spanning local weather to global climate." So the question before us today is essentially what are the requirements for the United States to lead the world in meteorological science and services and ensure that all sectors of American society are prepared for the pervasive weather threats that menace our country on an increasingly frequent basis?

This is a timely question. Since 1980, the United States has experienced over \$2.5 trillion in economic losses and over 8,000 fatalities from extreme weather events, with \$1 trillion of those losses occurring in the last 7 years alone. These weather disasters highlight a somewhat uniquely American experience. No other country in the world faces such a diversity, frequency, and intensity of extreme weather events. As such, our national weather prediction efforts are challenging by comparison, and in some instances, require targeted phenomenologically based modeling approaches that may not be as necessary for other countries. Indeed, the United States experiences approximately 1,400 tornadoes per year on average, dwarfing the annual tornado count of any other nation in the world.

Despite these challenges, our Nation has made significant progress in numerical weather prediction. One shining example is the reduction in the average 3-day hurricane track forecast error from 450 miles in 1970 to just 50 miles today, an incredible achievement. Nevertheless, there still exists a critical need and an incredible opportunity for the United States to lead the world in meteorological science and services. To achieve this requires coordinating a thriving research and applications enterprise to finally begin to bend the curve in the Nation's annual weather disaster losses. Given that ICAMS agencies invest almost \$6 billion annually in the meteorological enterprise, it is critical that the Federal Government strengthen coordination of its own meteorological assets.

However, significant obstacles exist. Varying missions, budget development approaches, and legislative requirements make it challenging to effectively develop shared priorities and practices across the range of meteorologically sensitive Federal agencies. In recognition of these challenges, Congress created ICAMS to elevate Federal coordination of meteorology to the White House level.

In response, the White House and the ICAMS agencies chartered four standing committees, one on observations, one on computing, one on services and one on research and innovation. If properly resourced and supported, this structure has the potential to accelerate progress on an array of important issues in meteorological science and services, including numerical weather prediction.

Through these committees, ICAMS has achieved some success already, including advancing interagency coordination of meteorological science priorities for wildfire and initiating the development of the first ICAMS decadal strategic plan, an effort that must continue for ICAMS to achieve its goal.

Despite these bright spots, I am concerned that ICAMS may never reach its full potential. Strengthened provisions are needed in the *Weather Act Reauthorization* to ensure that ICAMS remains elevated as a top national priority so that it can effectively respond to urgent and rapidly evolving national needs.

Indeed, over the last two decades, the meteorological enterprise has undergone revolutionary changes, the most notable of which is the rapid evolution of the private sector from primarily developing end user products and services to that of a multibillion-dollar commercial enterprise that is in direct competition with the Federal Government to provide the very foundational data, modeling, and information that was once only the purview of Federal meteorological agencies. This rapidly evolving landscape requires a nimble and effective national strategy to make what amounts to an order-of-magnitude change in how the Federal Government leverages the commercial sector for mutual benefit.

In closing, I provide several recommendations for consideration by Congress and the President. These include mandating the completion of the ICAMS decadal strategic plan, reimagining the Interagency Meteorological Coordination Office, unleashing the private sector by aligning relevant Federal and commercial research and development goals, fostering engagement at the agency-head level to inform Federal agency budget development activities, and implementing mechanisms to encourage and enable the participation of non-Federal stakeholders in ICAMS.

I thank the Committee for its recognition of the need for a strong meteorological enterprise. I look forward to our discussion today, and I'm happy to answer any questions you may have.

[The prepared statement of Dr. Weaver follows:]

Testimony of

Dr. Scott Weaver
Founder and Principal Scientist
CLIMET Consulting, LLC

Before the

Committee on Science, Space, and Technology
Subcommittee on Research and Technology

U.S. House of Representatives

March, 6, 2024

Introduction

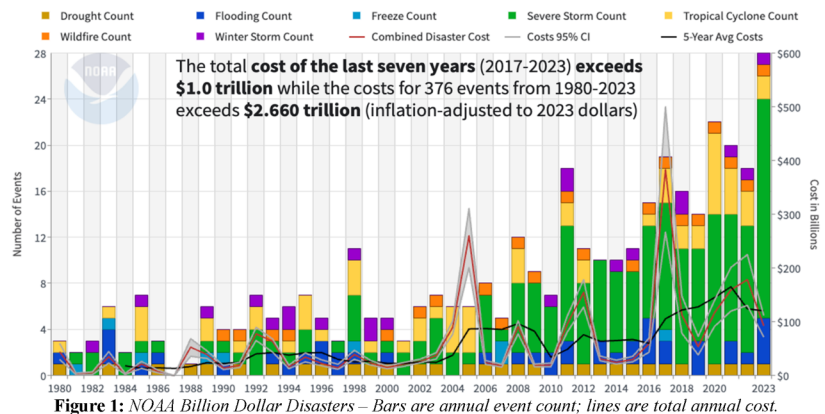
Chairman Miller, Ranking Member Ross, and members of the Subcommittee, I am Dr. Scott Weaver, Founder of CLIMET Consulting, LLC, a new consultancy focused on science and policy issues in weather and climate. I have also served in several scientific leadership roles within the federal government, including as a Research Meteorologist for NASA and NOAA, Director of the interagency National Windstorm Impact Reduction Program led by NIST, and most recently as the inaugural Executive Director of the Interagency Council for Advancing Meteorological Services, or ICAMS, at the White House Office of Science and Technology Policy. Thank you for the opportunity to appear before you today.

The ICAMS aspirational goal as stated in its 2020 Charter¹ is:

“The United States will lead the world in meteorological services via an Earth system approach, providing societal benefits with information spanning local weather to global climate”

So, the question before us today is essentially, what are the requirements for the United States to lead the world in meteorological science and services and ensure that all sectors of American society are prepared for, and able to adequately respond to the pervasive weather threats that menace our country on an increasingly frequent basis?

This is a timely question. I come before you today at a critical time for the meteorological science and services enterprise. Since 1980, the United States has experienced over \$2.5 Trillion in economic losses and over 8,000 fatalities from extreme weather events, with \$1 Trillion of those losses occurring in the last seven years alone (see figure 1). No one is immune from the effects of extreme weather. Hurricanes, tornadoes, heatwaves, wildfires, floods, and droughts are causing severe impacts across all 50 states (see figure 2), and the impacts are worsening.



¹ ICAMS Charter: https://www.icams-portal.gov/resources/signed_icams_charter.pdf

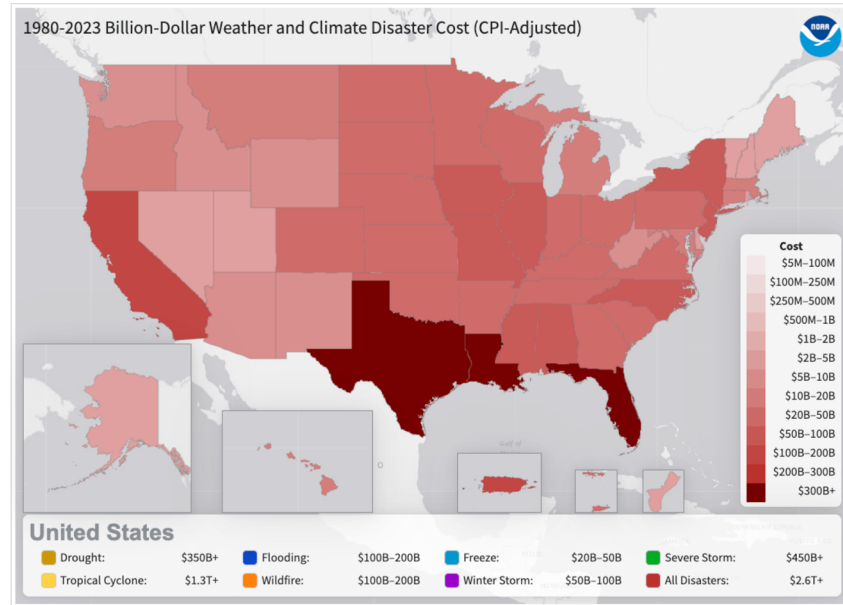


Figure 2: NOAA Billion Dollar Weather Disaster Cost by State 1980-2023 (darker shading indicates greater cost)

These weather disasters highlight a somewhat uniquely American experience. No other country in the world faces such a diversity, frequency, and intensity of extreme weather events. As such, our national weather prediction challenges are exceedingly difficult by comparison, and in some instances, require targeted phenomenologically-based modeling approaches that may not be as necessary for other countries. Indeed, the U.S. experiences approximately 1400 tornadoes per year on average², dwarfing the annual tornado count of any other Nation in the world. There is a similar situation with tropical cyclones. In 2020, there were 31 Atlantic tropical storms and hurricanes, 11 of which made landfall in the U.S., causing tens of billions of dollars in damage to the American economy, while in 2017 our nation experienced nearly \$300 billion in tropical storm and hurricane losses from three landfalling storms, and the list goes on.

Despite these sobering statistics, over the last seven decades our Nation has made significant progress in Numerical Weather Prediction (NWP) – the foundational element and first line of defense for a multi-sector enterprise focused on the provision of meteorological forecast products

² <https://www.spc.noaa.gov/wcm/ptorngraph-big.png>

and services on timescales ranging from minutes to years. One shining example of our collective progress in NWP is the role it has played in the enormous reduction in tropical storm and hurricane forecast track errors over the last 50 years. For instance, the average three-day track forecast error has been reduced from 450 miles in 1970 to just 50 miles today (see figure 2 yellow dashed line). This incredible scientific and technological achievement is the result of an international multi-decade long investment in a coordinated research to applications effort.

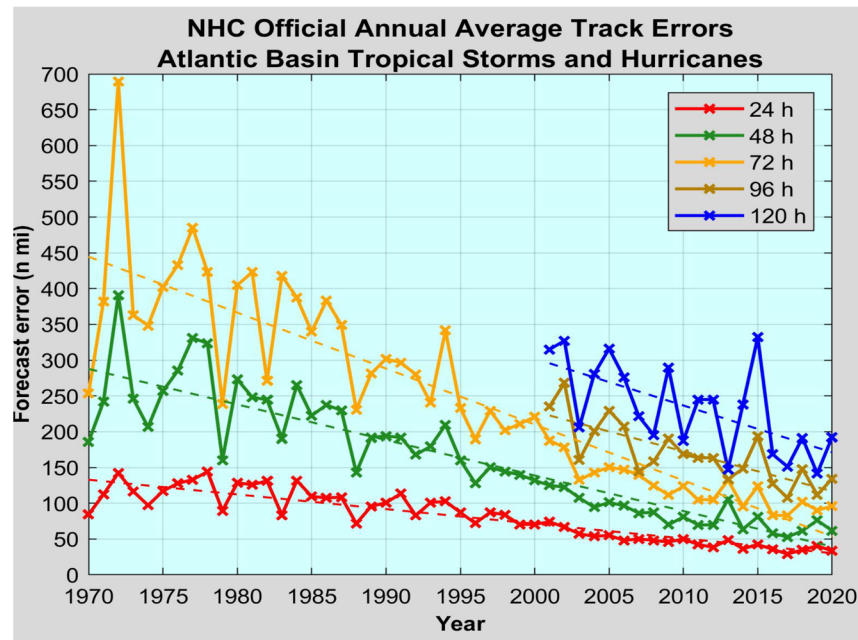


Figure 2: NOAA/NHC forecast TC track error validation for various lead times (colors).

Despite this, and other similar successes, there still exists a critical need, and an incredible opportunity, for the United States to lead the world in meteorological science and services. To achieve this requires developing, supporting, and coordinating a robust and thriving research and applications enterprise to tackle our most pressing national challenges in weather and climate prediction, and finally begin to bend the curve in the Nation's accelerating annual weather disaster losses. However, for America to lead the world in meteorological science and services requires focus on more than just the foundational scientific and technical aspects that are required to improve the skill of our Nation's Earth system prediction models. It is also essential to improve coordination of the Nation's vast meteorological assets, to ensure that we are efficiently and effectively managing our investments across the entire weather enterprise.

While the federal government is only one sector that makes up the meteorological enterprise, it serves as the de facto strategic leader, especially given that the federal meteorological science and service agencies report annual investments approaching \$6 billion in the congressionally mandated federal meteorological enterprise budget crosscut, some of which supports the academic, commercial, and non-governmental organization (NGO) sectors.

Given the significant federal investment of resources, it is critical that the federal government engage in strong coordination of its own assets, in addition to providing a leadership role in the broader meteorological enterprise. However, significant obstacles exist. Varying missions, budget development approaches, and legislative requirements make it challenging to effectively develop shared priorities and practices across the range of meteorologically sensitive federal agencies. While coalitions of the willing exist in small pockets of interagency activity (e.g., wildfire), and are commendable, these voluntary coalitions are not the most effective way to develop, coordinate, and implement a far-reaching national strategy for advancing the entire meteorological enterprise.

Towards Improved Coordination of Meteorological Science and Services

In recognition of the need to better coordinate meteorological science and services across the federal government, in the 2017 Weather Research and Forecast Innovation Act, or “Weather Act”, Congress created the Interagency Council for Advancing Meteorological Services (ICAMS) to elevate federal coordination of meteorology to the White House level, to ostensibly provide the requisite leadership to advance this critical national priority. The impetus for this 20+ federal agency³ coordination effort is further summed up quite well in a quote from a recent peer reviewed publication in the Bulletin of the American Meteorological Society⁴:

“Although the Weather Act covers a broad range of meteorological topics, the motivation for administrative restructuring was driven largely by the need for better coordination of relevant weather research and forecast innovation activities through elevated visibility and engagement among principal-level policymakers.”

To provide this improved coordination, the ICAMS agencies established four standing committees under ICAMS: The Committee on Observational Systems (COBS), the Committee on Cyber, Facilities, and Infrastructure (CyFI), the Committee on Services (CoS), and the Committee on Research and Innovation (CoRI). Each of these committees contains subordinate bodies that reflect all relevant aspects of the meteorological enterprise (see figure 3). If properly resourced and supported, this structure has massive potential to be the gold standard in scientific interagency coordination and accelerate progress on an array of important issues in meteorological science and services, including NWP.

³ A list of the 28 ICAMS federal agencies is contained within the ICAMS charter: https://www.icams-portal.gov/resources/signed_icams_charter.pdf

⁴ Droegemeier, K. K., and N. A. Jacobs, 2022: Restructuring of federal coordination to advance meteorological services. Bulletin of the American Meteorological Society.

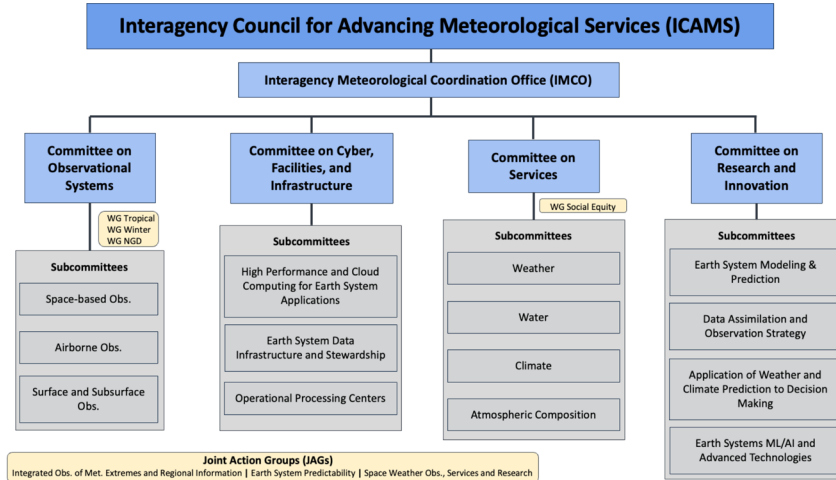


Figure 3: Organizational chart for the Interagency Council for Advancing Meteorological Services (as of July 2023)

To be sure, ICAMS has achieved some level of success already. In addition to the multi-year effort to establish the ICAMS structure and develop an initial set of near-term priorities⁵, in 2022-2023 the ICAMS agencies engaged in two efforts to advance interagency coordination of meteorological science priorities for wildfire. This included research-focused interagency workshops, and co-developing priorities for interagency research, development, and implementation of observational systems to inform various annual agency budget development processes for wildfire. Having a shared inventory of needs and requirements to address gaps in observations and modeling for one of the Nation's most pressing meteorological disaster needs can be of high value, provided it is used to inform agency budget planning, as intended.

Additionally, in late 2022, ICAMS embarked on the development of its first decadal strategic plan and provided multiple opportunities for the public and federal agencies to provide their perspective, including developing and gathering external stakeholder input via publication of a public request for information, holding multiple public listening sessions, a Town Hall event at the annual meeting of the American Meteorological Society, engagement during a federal roundtable, and an agency survey instrument. Given that ICAMS is still operating under short term priorities, it is critical that the development of the decadal strategic plan continue if ICAMS is to achieve its aspirational goal.

⁵ Mariotti, A., S. J. Weaver, N. Kanankutty, M. Paese, M. Yapur, 2023: Progress in federal coordination to advance meteorological services. Bulletin of the American Meteorological Society.

While these achievements are notable, ICAMS may never reach its full potential. The original Weather Act did not include much in the way of specifics for ICAMS, and accordingly, charged the OSTP Director with developing the details of ICAMS implementation, a mandate that was fulfilled in 2019 and 2020 with the development and release of the ICAMS Charter. However, interagency policy mechanisms like charters are subject to the whims of each administration, as opposed to more enduring legislative requirements. Therefore, strengthened provisions are needed in any Weather Act reauthorization to ensure that ICAMS remains elevated as a top national priority so that it can effectively respond to urgent national needs, such as those for NWP, and the many other important aspects of the meteorological science and services enterprise. Additionally, the Interagency Meteorological Coordination Office (IMCO) is vastly under resourced and under staffed to effectively coordinate a \$6 billion federal meteorological enterprise, and its location within a federal agency can oftentimes become a barrier to promoting robust interagency engagement.

Finally, over the last two decades, the meteorological enterprise has undergone significant changes. None of these is more impactful than the evolution of the private sector from primarily developing end user products and services, to that of a multi-billion dollar commercial enterprise that is in direct competition with the federal government to provide the very foundational data, modeling, and information that was once only the purview of federal meteorological agencies. This rapidly evolving landscape requires a nimble and effective strategy to make what amounts to an order of magnitude change in how the federal government engages with the commercial sector.

Recommendations

As the former inaugural Executive Director of ICAMS, I provide the following recommendations for consideration by Congress and the President:

- Mandate the completion and implementation of the ICAMS decadal strategic plan, which is already a required deliverable under the ICAMS charter, and necessary to guide short-, medium-, and long-term activities across the entire meteorological enterprise
- Reimagine the Interagency Meteorological Coordination Office (IMCO) by implementing an interagency resource support model similar to the U.S. Global Change Research Program
- Unleash the private sector by leading explicit coordination amongst the federal and private sectors to align Earth system research and development goals for mutual benefit, especially to enable the rapid development and implementation of emerging commercial technological advances for in situ and space-based observational systems
- Foster engagement at the agency head level to inspire interagency leadership conversations around shared priorities and opportunities in meteorological science and services to inform coordinated federal agency budget development activities

- Ensure that the ICAMS definition of meteorological science and services includes an Earth System approach to its scientific activities, similar to the World Meteorological Organization
- Implement mechanisms to encourage and enable the participation of nonfederal stakeholders in ICAMS to better reflect the diversity of perspectives across the broader meteorological enterprise, to ensure that the full slate of American meteorological scientific expertise is being thoughtfully leveraged

I thank this Committee for its recognition of the necessary role for the Federal Government and in supporting the meteorological science and services, and the resulting creation of ICAMS to provide the environment for advancing U.S. leadership in the meteorological science and services enterprise.

I look forward to our discussion today, and I am happy to answer any questions you may have.



Dr. Scott Weaver is Founder and Principal Scientist of CLIMET Consulting, LLC, and brings over 20 years of experience as a scientist and executive, leading climate and weather scientific research and advancing interagency science policy across the federal government - most recently serving as the National Director for Windstorm Impact Reduction at NIST, and Executive Director of the Interagency Council for Advancing Meteorological Services at the White House Office of Science and Technology Policy. While at the White House, Dr. Weaver led the coordination of the federal meteorological enterprise across more than 20 agencies, developing and executing strategic priorities, policies, and practices to advance the provision of meteorological science and services for the Nation. Dr. Weaver has also held scientific research and leadership positions in NASA, NOAA, NIST, and the private sector, focused on weather, climate variability, climate change, and disaster impact reduction.

While at NOAA, President Obama awarded Dr. Weaver the Presidential Early Career Award for Scientists and Engineers (PECASE) in 2012, "for innovative research at the frontiers of science and technology."

Chairman MILLER. Thank you very much. And I thank all the witnesses for their testimony.

The Chair recognizes himself for 5 minutes of questions.

Dr. Jacobs, I'd like to talk about NOAA's commercial programs because the United States is unique in having many weather startups and innovators. NOAA has been operating the Commercial Weather Data Pilot Program for a few years now with success, despite some—what some might call hiccups in organization and structure. I understand NOAA intends to offer short-term contracts for 6 months at a time and then recompetes those all over again. Do you believe that this has a chilling effect on the commercial sector or limits the full potential of a thriving commercial data market? Or even is it correct to say that the commercial weather data industry is one of the most valuable assets in—the United States has when compared to global competitors?

Dr. JACOBS. It's a hugely beneficial program. So a lot of commercial data that's available, it has a huge impact on the forecast models. It's really, really valuable. There's more out there that can be acquired. A lot of these companies are producing data at a rate faster than NOAA can acquire it.

I would say that from an investor standpoint, I hear often a lot of issues with confidence in long-term investment in developing and deploying these programs if they're faced with short-term contracts. So a lot of times there's what we call nonrecurring upfront engineering to deploy and build out these networks to sense things like weather. That's expensive. And these companies would like to have more confidence that they're going to get a long-term return on their investment before they deploy a lot of these assets.

Chairman MILLER. Thank you very much. And that all—that tracks and makes sense, and I appreciate your testimony.

My next question is going to be for all of our witnesses to chime in on so, you know, feel comfortable to go on in. One reason that I called this hearing today was to help us better understand why and how the European global model has been labeled the gold standard. I understand that the Europeans largely have the same data that we do, but they focus heavily on improving their internal model code and data assimilation. So can each of the witnesses if possible give their opinion on why has NOAA fallen behind on data assimilation, and what can we do to catch back up?

Dr. JACOBS. There's a couple different reasons. It's true the European Centre has had a more skillful global model for quite some time. I would like to point out that NOAA runs several different models on different forecast horizons, and they are by far the leader at all with the exception of the global model. The U.S. model has been anywhere between second and fourth as far as forecast skill.

And while there are some datasets that the European Centre may use that the United States doesn't, it's primarily related to data assimilation. The European Centre, as well as a couple other skillful models like the U.K. Met Office use four-dimensional variational assimilation. The United States doesn't use 4D-Var yet, although there is a system in development for 4D-Var.

The tradeoff is 4D-Var is extremely computationally expensive to run, and it requires a tremendous additional amount of compute both to run it and test it. And that was kind of the decision back

in the day was, with limited compute resources, how do we divvy up the different models based on the tradeoffs? And it turns out that, you know, 4D-Var, I think, is going to add the most value.

Chairman MILLER. Thank you.

Dr. PETTY. I would add from the standpoint of maybe organization and what the focus is. As noted in several testimonies you heard today, the U.S. itself has a number of different issues that we have to target when it comes to weather, and the timescales are really broad, everything from nowcasting to medium-range to longer-term type of forecasting. When we think about the Europeans and the ECMWF (European Centre for Medium-Range Weather Forecasts), specifically, they have a very targeted, focused mission that really helps with their efforts of advancing what they do. They do not have to spend the time really deploying resources in so many different areas because of their focused mission.

The other thing that I might add on top of that is really the aspect of being diluted is quite challenging for us in the United States. And if we can have a more focused way of targeting improvements and have the right metrics, that is key. What does it mean to have forecast improvement? We can talk about 500 millibar height, or we can talk about how have you forecasted tornadoes. And so really having focused metrics is something that we need to consider.

Chairman MILLER. Thank you.

Dr. WEAVER. Ten seconds, can't really add much except—no, that's OK—except to say that I typically view the meteorological enterprise larger than just the modeling component. Modeling is foundational, but there's a greater enterprise out there that we can also be focused on in addition to just the foundational modeling.

Chairman MILLER. Thank you all very much.

I now recognize Ranking Member Ross for 5 minutes of questions.

Ms. ROSS. Thank you again to the witnesses for joining us today.

While the discussion of our weather models' performance is highly important, at the end of the day, the goal is for there to be effective and actionable weather information that aids decisionmakers and protects lives and property. Researchers have found that in some cases, increased warning time for extreme weather can lead to a lack of action, as less urgency is perceived. There also has been research to suggest that messaging on personalized impacts can lead to significantly higher evacuation rates. But at the same time, recipients of that information found it to be more overblown.

Dr. Jacobs, if the United States were able to achieve a perfect weather model, there's still a possibility that the public would not react as intended to certain information. We certainly see that in North Carolina. How can NOAA and the U.S. weather enterprise improve the human response to the information that it puts out?

Dr. JACOBS. Thank you very much for that question. So as someone who focuses on numerical weather prediction, I'd always thought the more skillful the forecast, the more lives you would protect. And you're absolutely right, particularly with tornado warnings. More lead time doesn't always translate to more lives saved.

This is really a social science issue. It comes down to how do you translate this information into actionable decisions that result in behavior that is going to protect life and property? I think there needs to be a focus on really translating this through the social scientists that the National Weather Service is bringing on board. But additionally, one of the things that they don't have is they don't have verification data. They don't have circumstances of how lives are lost. So it's really challenging to sort of figure out how do you test and evaluate different sort of criteria of messaging? Because you may have a tornado warning, you don't know if the person got the warning, didn't get the warning, got the warning and didn't know what to do, or got the warning and knew what to do but didn't have the means to do anything. There's a lot of different variables other than just doing damage assessments that we need to actually test and validate these different metrics and prediction tools that are coming from the social science community.

Ms. ROSS. Dr. Petty, I see you nodding your head. What can the private sector add? And do you have anything to add to what Dr. Jacobs has said? And of course, we'll give Dr. Weaver an opportunity as well.

Dr. PETTY. Yes, I think Dr. Jacobs hit the nail on the head, that the social science component is so important. And from the private sector standpoint, the private sector stands poised to be a partner to NOAA when it comes to translating that information into actionable information that people can use. And so I think that's where the private sector can really provide a considerable amount of support.

Ms. ROSS. OK. Dr. Weaver, do you have anything to add?

Dr. WEAVER. Yes, I have something to add. So when I think about this from the 10,000-foot level of an organization like ICAMS and all the different Federal agencies, I've had the pleasure to work at NIST for several years, which is sort of an odd place for meteorologists to end up, but what was great about that was I really got to—I got to work with engineers and social scientists and all—a very large interdisciplinary team that even included epidemiology experts, OK, so this is very interdisciplinary. And this team would study the impacts of weather disasters, so they would go out after, after the forecast was made, after the forecast was no longer meaningful, and they do sometimes year—you know, multiple yearlong longitudinal studies of the entire disaster, the social components, how communities recovered, did they get the information, what was the meteorological science like, the entire scope. And so I bet you if I told 100 meteorologists that NIST does this, maybe a few of them would know. And so this is why something like ICAMS is so important because this is where that information trading and understanding what different agencies do can be so important.

So I'll also put a plug in and say, you know, it's time to reauthorize the National Windstorm Impact Reduction Program. That is the program that does a lot of this. And it's not in the *Weather Act*, per se, but it's a very close relative. And I think it's vitally important as these—you know, like I said in my testimony, I'd like to bend the curve in those increasing billion-dollar disasters. And inves-

tigating the different components, whether it's engineering or social science afterward, is critical to that effort.

Ms. ROSS. Well, Dr. Weaver, we're so glad that you are testifying today.

And, Mr. Chairman, I'll yield back.

Chairman MILLER. Thank you, Ms. Ross.

I now recognize Mr. Posey for 5 minutes of questions.

Mr. POSEY. Thank you, Mr. Chairman, and I thank the witnesses.

Dr. JACOBS, does NOAA weather service's Aircraft Observation Program have the ability to obtain contrail data from aircraft, commercial aircraft?

Dr. JACOBS. So they don't actually record the contrail data itself, but all commercial aircraft record wind and temperature information, and several commercial airlines also record relative humidity information through different sensors. And temperature and relative humidity are the variables in which you would be able to forecast and predict contrail conditions.

Mr. POSEY. Yes, if NOAA doesn't have the ability to do that, are there other commercial companies that can provide that data to NOAA?

Dr. JACOBS. There are. In fact, there's a lot of different commercial companies that pull down different data. All—like I said, most of the commercial airlines collect this data. It's just to manage of having a commercial data buy contract to get the data primarily to cover the cost of communications to run the data off the plane. But the data does exist, and there are commercial companies that provide it now.

Mr. POSEY. OK. So NOAA does or doesn't have the ability to model contrails and tell constituents and the people, American people when and where they will form and if they can predict them into the future?

Dr. JACOBS. They don't, to my knowledge, do a forecast specific for contrails, but they do forecast temperature and humidity at the flight levels, which the planes fly, which you can use those variables to derive conditions when you would know contrails would exist.

Mr. POSEY. OK. The three of you, yes or no, do you support NOAA improving the aircraft program so it can be able to provide more weather data, as well as contrail data from aircraft?

Dr. JACOBS. Yes.

Dr. PETTY. Yes.

Dr. WEAVER. Yes.

Mr. POSEY. Thank you. Dr. Weaver and Dr. Petty, are there current commercial data providers whose data would drastically improve the U.S. forecasting models?

Dr. PETTY. Yes, I think there are several companies out there. I slightly misspoke earlier, but what I wanted to hit on was that there is an acceleration in innovation. And you can see that innovation across these new observations, whether they be space-based or airborne observations or terrestrial. So there are opportunities out there for NOAA to acquire additional data sources.

Mr. POSEY. What do you think the role of infrared sounding plays in creating weather forecasts? You know, how can we incor-

porate more of those data into U.S. models, and what would the impact be?

Dr. WEAVER. So, I mean, there—as Dr. Petty was discussing, there’s plenty of data sources out there, right? So it’s not just about infrared. And I’m not an expert specifically on infrared, but I am aware, as I mentioned in my testimony, that there are several private sector companies that are rivaling the capabilities of the Federal Government. And this is something that we have to deal with and figure out a way that we can use all of the data, whether it’s being collected by the government or the commercial sector. So I know of several companies that are doing quite revolutionary things in terms of radars on satellites or radars on the ground, et cetera. And, you know, these are very valuable data sources that would certainly—you have to work with your government partners, though. You can’t just throw the data out there and expect them to be able to know how to assimilate it. It’s got to be a co-production as this goes along through time, right? So—because there—we have standards that we have to meet in terms of weather forecasting and the Federal Government. We can’t just throw anything at it. And so it has to be quality controlled and, you know, assured through some research that these are adequate datasets for their purpose.

Mr. POSEY. What’s the role of calibration and data continuity for both short-term weather and longer-term climate predictions?

Dr. WEAVER. OK. Yes. So, I mean, it’s very important for longer-term climate predictions. I mean, one of the things that we must do, even in the short-term climate predictions, things like seasonal, right, which is—you know, varies year to year, et cetera, those kinds of phenomena, you need to have a very consistent data base through time to understand them first and then be able to predict them. So we do have something in the climate and weather community called reanalysis, which tries to go back and collect all the observations through time and then streamline them or quality control, if you will, to make them—you know, an observation taken in 1980 would be similar to the one today. But they’re not, so you need to figure out ways to put them on an even keel.

Mr. POSEY. Got you. I see my time’s up. Mr. Chairman, I yield back. Thank you.

Chairman MILLER. Thank you, Mr. Posey.

I now recognize Ms. Lofgren for 5 minutes of questions.

Ms. LOFGREN. Well, thank you, Mr. Chairman. And thanks to each of these witnesses, very interesting, and I’ve learned some things this morning, which is always a treat in the Science Committee.

Obviously, we have challenges not only in data collection, but data assimilation and distribution. I have a question about, you know, once those challenges are addressed, which may take a while, how are we thinking about using AI if at all? I mean, NOAA had a pilot project in partnership with a company that specializes in AI language software to translate weather information more accurately and efficiently into different languages, and so that would be more accessible to non-English language speakers. But it occurs to me that there may be a greater capability with AI. I’m wondering what each of you thinks about that. And then also, how do

we deal with the persistent problem of hallucinations? So if each of you could address that, I would appreciate it.

Dr. JACOBS. I think there's a tremendous opportunity for AI all across numerical weather prediction, even down to potentially replicating the entire modeling system. So right now, the current state-of-the-art is physics-based models. AI can replicate a lot of what those algorithms do. And the advantage, I think, with AI is that you can run this on a tiny fraction of the amount of compute, but you still need the physics-based modeling systems and the observations and the data assimilation to build it—at a minimum, a training dataset to train the AI systems on. So I don't think we'll ever see a situation where we can predict the weather going forward in the future without correctly observing the atmosphere because it's an initial value problem. But I think there's huge potential benefits to gain from AI in optimizing the speed and efficiency of which the physics-based models predict the weather.

Ms. LOFGREN. Thank you. I mean, I didn't mean to suggest that we wouldn't need the actual data. Obviously, we do. But how we assimilate and crunch it could be of value.

Dr. JACOBS. It is. Well, I often hear people talk about how AI is going to replace physics-based modeling.

Ms. LOFGREN. Nope.

Dr. JACOBS. And I don't understand how that's theoretically possible because you'll always need this type of system to do the training and the air analysis on the observing systems.

Ms. LOFGREN. Correct. Dr. Petty, do you have any additional comments?

Dr. PETTY. I would just echo Dr. Jacobs, but I would add, even beyond our ability to leverage AI from the context of forecasting improvement, I think we're going to see it in other areas of the entire value chain all the way down to how do we translate data into actionable information? I would admit I was one of those individuals who is a little bit kind of standoffish, if you will, on AI, but seeing what has been done in the last couple of years, it's going to be a powerful tool.

Dr. WEAVER. Yes. So obviously, we're at a technological revolution here. I certainly agree with what my two colleagues here have just said regarding the training and, you know, where we're going with this. You know, when I was a research scientist, you know, and all day every day, you're looking at that, you're just looking at data and trying to understand things, you know, we live in a culture of doubt. I know that's surprising for some people, that we are not as always as sure as we would like to be. And that's part of the scientific process. You're always doubting your results.

So when I see these papers coming out that are like, we're beating, you know, numerical weather prediction, et cetera, it's very exciting to see that. I'd like to see more. Yes, I've only seen a few. So maybe there's more, I don't know. But that could just be the scientists and the culture of doubt. If this—if what some of these claims are making are really true, then that's fantastic because, you know, when Neil was talking about the training, once you train the system, it's over. Then you just need to run it, right? And that could be done on a laptop, whatever, right? You just—you don't need the massive amount of compute. Once you have this—

Ms. LOFGREN. Well, you need to train the system——

Dr. WEAVER. You do, yes.

Ms. LOFGREN [continuing]. But you still need data for it to crunch.

Dr. WEAVER. Hundred percent. I mean, that's—that—yes. So we need both, but the idea here is the forecast can be done much quicker because you've trained it already essentially. You don't have to wait for it to crunch out through. So very exciting time. I'd like to see a little more personally, but that's just my own opinion.

Ms. LOFGREN. Of course. I know I'm putting you on the spot, but if you have after this hearing some thoughts on how to deal with guardrails, as well as the hallucination problem that is persistent, I'd be eager to hear it after the hearing.

With that, Mr. Chairman, I yield back.

Chairman MILLER. Thank you, Ms. Lofgren.

I now recognize Mr. Collins for 5 minutes of questions.

Mr. COLLINS. Thank you, Mr. Chairman. Dr. Weaver, I kind of want to pivot off of that just a little bit, and maybe not pivot, just ask some more questions about it because there's several things here at play. Like we all have talked about for the past year about China and the threat has been one of the greatest threats to our country that there is. And I know that they do a good job of AI. And I guess first question is where do we stand in relationship to China on the AI race and maybe some quantum computing in there as well?

Dr. WEAVER. Yes, so I—I'll be honest with you, I'm not an expert on where we stand with China in terms of AI, so I wouldn't really have much to add to the hearing on that. I don't know if any——

Mr. COLLINS. Do you think that—do you think their AI modeling is pretty good? Have you seen any of their forecasting modeling?

Dr. WEAVER. I have not. Therefore, I can't really comment on it.

Mr. COLLINS. Have any of—anybody?

Dr. PETTY. I have not seen their output. I think one thing that I would maybe caution—and I think this is what Dr. Weaver was referring to—is, when we hear claims about these models, it's really important to understand, well, how are these models—AI models verified, and what were they verified against? And until we can see, you know, those data and how that was done, it's very difficult to ascertain how well maybe the Chinese or others are doing. So there really needs to be a rigorous——

Mr. COLLINS. Well, I mean, isn't it—it's easy to verify it after the fact whether or not it was true or not, right, whether or not it happened.

Dr. PETTY. But a lot of times in science when you're doing that verification, you need to know the methodology that was followed so that methodology can be replicated and make sure that that was done correctly. And I—from kind of your question about the Chinese, I don't know if they're verifying against 500 millibar height or temperature at the surface or, you know, wind speeds in New York. And really having that verification, thorough verification is helpful.

Mr. COLLINS. Right. Well, I've been in small business for over 30 years, and just seeing the accelerated advancement of AI even in the transportation industry, which I'm in, it's just amazing. And I

would like to know where—you know, where NOAA stands and where we stand from a private industry standpoint in the country because there is a race. And China's spends more money than the entire world on quantum technology and quantum computing. And that's in everything, not just defense, not just hacking, and—because they want to rule the world one day.

Dr. Jacobs, I was walking in, so I'm sorry. We've been kind of running around like crazy here this morning. You were talking about cloud computing. Is NOAA ready for artificial intelligence?

Dr. JACOBS. So right now, they're testing out a couple different AI systems to replicate a lot of what the physics-based models are using, and they're showing a lot of promise. As I was saying earlier, I think the benefit there is you save on computational resources, at least for the operational prediction system, but you still need to generate the training datasets.

When it comes to cloud, NOAA is definitely headed in that direction, as well as a lot of the private sector, most of the universities. I think a lot of—at least in the private sector—I don't really know any companies that own their own high-performance computing anymore.

Mr. COLLINS. Right.

Dr. JACOBS. Pretty much all use commercial cloud. The beauty of commercial cloud is probably more seen in the research and development than it is in the operational because you can—you buy on demand. You only buy what you need, and when your research needs fluctuate, that's an extremely cost-effective way to do it because if you have a series of experiments that you want to test with traditional on-premises high-performance computing, you only have a limited amount of resources so you run the experiments one at a time. With the commercial cloud option, you can pay for all of these experiments to be run in parallel, simultaneously. It costs the same whether you run them all at the same time or one after the other. But the beauty of running them all at the same time is you get the research done faster.

Mr. COLLINS. Good. I've got one other question. I know we're down to less than 25 seconds. Dr. Jacobs, I introduced the *Weather Information for Agricultural Act*, and I didn't know if you could take just a minute to explain the advances in drought weather modeling and how it can best be used by farmers.

Dr. JACOBS. There's a lot of advancements, and actually, there's a lot of work being done on seasonal and subseasonal prediction with AI, too, because a lot of it—there are dynamic models that run out to 9 months. But a lot of this is pattern recognition, seasonal patterns like ENSO (El Nino Southern Oscillation) and PDO (Pacific Decadal Oscillation) and things like that. That's actually a really unique spot for AI, so I think there's a lot of advancements being done on those different forecast horizons. And most of the agriculture community, they know exactly how to use the data. They just want to know both what is the prediction—

Mr. COLLINS. Right.

Dr. JACOBS [continuing]. And what is the confidence in the prediction.

Mr. COLLINS. All right. Thank you. Sorry about that, Mr. Chairman. I yield back.

Chairman MILLER. No worries. I'd like Mr. Frost for 5 minutes of questions.

Mr. FROST. Thank you, Mr. Chairman.

I represent central Florida, and in Florida, we get a lot of hurricanes. Every hurricane season, friends, family, siblings, myself, we see an increasing number of dangerous storm systems develop and make their way toward our State. Mr. Jacobs—or, Dr. Jacobs, I first off want to thank, you know, the work that you're doing and that NOAA and all the staff are doing. You know, this past hurricane season, I spent a lot of time at our county and city EOC (Emergency Operations Center) of the city of Orlando and county. When I asked them how their relationship is with NOAA, they have nothing but good things to say about your staff and the work that y'all are doing and keeping us safe in the entire State of Florida, so I appreciate that.

Dr. Jacobs, when it comes to hurricane preparedness, why is it important to understand the relationship between climate and weather?

Dr. JACOBS. Well, climate modulates the weather, and so while we have the ability to predict the weather, particularly when it comes to hurricanes, the fuel for those is the sea surface temperatures. And we also have seasonal influences. For example, this last season, the prior one, we had El Nino, which in the Atlantic, there tends to be a lot of shear, which prevents the development of storms. That's nature's way of removing heat and transporting it toward the poles. And so as we transition into a La Nina year, I think the seasons will be a good bit different.

But understanding the relationships between the changing climate, the influences that feed these storms, that I think is—there's a lot of research that needs to be done there. The exciting thing to me is we're—the capabilities and forecasting these storms, both track and intensity, are really, really improving.

But one of the areas in hurricane forecasting that I think needs additional work and focus on is rapid intensification. We always see storms that when they come into the Gulf, particularly over the loop current, there's a tremendous amount of rapid development that the models struggled to handle. And that, I think, is an area where there needs to be additional work and research above what's being done right now.

Mr. FROST. Yes, I mean, in the event of a hurricane, good forecasting and modeling can really save lives. What—where have you seen gaps in successfully communicating the severity of these storms to people?

Dr. JACOBS. I think that there's work to be done on the track forecasting. I've got to give a tremendous amount of credit to the Hurricane Center. They just rolled out a new way to sort of visualize the cone based on impacts. But there was—you know, a translating model, both the projection and the uncertainty, is tricky because a lot of people tend to focus on just the center track of the storm when the effects of the storm could be hundreds of miles away. Having people being able to visualize the impact of a storm surge, it's one thing to just say this storm surge may be 5, 10, 15 feet. It's another thing to actually be able to visualize how high 15 feet of water is. Getting this message out there, I think, it's largely

a social science problem, where even though we're improving the skill and the models, we still need to figure out better ways to message, to visualize the output in a way that solicits a proper response.

Mr. FROST. Yes, I have a bipartisan bill with Congressman Webster on this Committee, the *Fixing Gaps in Hurricane Preparedness Act*. It's actually included in this Committee, the *Weather Act*, and it would direct NOAA to study the ways that most at-risk populations, seniors, folks with disabilities, people who speak different languages, how they react to hurricane forecasts and communications that come from the government.

Dr. Jacobs, do you think focusing on these types of populations align with what you think some of the gaps are?

Dr. JACOBS. Absolutely. I think that one of the biggest challenges—and we've seen this with tornado watches and warnings, but it's the same thing with the hurricanes is we need verification data. Do the people understand the warnings? If they do understand the warnings, do they know what to do? If they do understand the warnings and they know what to do, can they take action? There's a lot of different situations where people, even though they know exactly what to do, for one reason or another don't take action. Maybe they can't take action. And this, I think—this needs both verification information from the circumstances of all these different populations, as well as tailored messaging.

Mr. FROST. Yes. Yes, the bill directs NOAA to do the study, but really will have impacts for municipal government, State government, Federal Government, and all types of nonprofits and players in this space who helped reduce the amount of lives that we've seen lost during these intensified storms that are getting—lasting longer and creating more devastation due to the climate crisis. So I appreciate your work.

You know, last hurricane season, I had a great offer from NOAA to hop on the Hurricane Hunters plane. I wasn't able to do it just because it was my first hurricane season, and I wanted to make sure I was home. But next time, I think I'll hop on. Thank you. I yield back.

Chairman MILLER. Thank you, Mr. Frost.

I just want to say I want to thank all the witnesses for their valuable testimony and the Members for their questions. The record will remain open for 10 days for additional comments and written questions for Members. Once again, thank you to our witnesses.

This hearing is adjourned.

[Whereupon, at 11:01 a.m., the Subcommittee was adjourned.]

Appendix

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by the Honorable Dr. Neil Jacobs

Congressman Sorensen Questions for the Record

Neil Jacobs

1. I have met farmers who have logs going back generations that document the changing climate. These farmers, in my district, they know that the climate is changing. Unfortunately, I don't think NOAA and Congress are doing enough to communicate with the public on climate change. NOAA does a good job of communicating to small groups but does not communicate to broad groups very often. To communicate climate change to the country, NOAA will need to develop skills to communicate effectively to wide audiences. Dr. Jacobs: Does NOAA need resources from Congress to develop this skill?

Yes. While NOAA has an extremely talented communications team, they operate under a very small budget within the Office of the Under Secretary. The lack of resources limits most of the interaction to reactive opposed to proactive. This goes well beyond climate change because NOAA has such a diverse mission from protected marine resources to forecasting weather. The recent push to make all of NOAA's data free and open creates many challenges, including how to properly interpret raw data, quantifying uncertainty, and representing data in the proper context. Effectively communicating probabilities, risk, and uncertainty is essential whether it's related to climate projections or tornado warnings.

A much greater overarching problem that NOAA is facing is a lack of recognition, branding, and promotion. NOAA touches every person in this country every single day, yet most of them do not realize it. Unlike NASA, NOAA's logo is not widely recognized. This is a function of a few things, mainly short-sighted rules regarding use of the logo, as well as lack of funding. I commend NOAA for updating their licensing policy in 2022 to allow for limited commercial use, but I do not believe this goes far enough. There needs to be a well-funded proactive marketing campaign. In my opinion, this would be the single largest return on investment across the entire mission of the agency. Not only would it serve as a force multiplier for the amazing services NOAA already provides, but it would be the greatest and most efficient way to simultaneously grow public, stakeholder, and constituent support, while doubling as a recruitment tool for the future workforce. Visibility and recognition are essential for growing the public's awareness of NOAA's science, services, and products. Communication of various hazards and risks becomes much easier when the public recognizes the agency as the trusted authoritative source.

2. Many TV meteorologists are afraid to discuss climate change too much on the air. When I started talking about climate on the air, my producers were concerned for my job security. NOAA and Congress need to fill the gap here. I have been told that NOAA is not authorized to provide services to the public directly related to climate change. Dr. Jacobs: Is this correct, and if so, what can Congress do to allow NOAA to fill this gap in services to the American public?

To my knowledge, there is no policy that explicitly prohibits NOAA from providing climate-specific services; however, this may be related to how one defines a "service". While it is generally assumed that NOAA is the agency granted the authority to provide climate information and services to the public, it lacks specific authorization which defines roles and terms. One of the challenges regarding services, whether it is climate or weather, is understanding the roles of the public and private sector, and where any boundaries may exist. Some stakeholders advocate for NOAA to provide a greater range of services, while others see this as interfering with their existing business models to provide similar services.

One thing that can be done before deciding on more specific authorizations would be to establish a recurring assessment of the roles and capabilities of both the weather and climate enterprise. This was originally done in 2003 with the Fair Weather report from the National Academies; however, that was a one-time report that is over 20 years old.¹ This type of assessment should be performed on a recurring cycle every 5, 7, or 10 years to keep up to date with the rapidly-evolving capabilities within each sector.

¹ <https://nap.nationalacademies.org/catalog/10610/fair-weather-effective-partnership-in-weather-and-climate-services>

3. Our weather radars have well documented gaps in coverage. There are companies working to fill these gaps by installing their own radars in uncovered or under covered areas. The weather Act of 2017 included a commercial weather data pilot program to allow the government to purchase data from these private companies. For the Panel: Is there wisdom in this approach? In your opinions, has the program been successful?

The commercial weather data pilot program is a huge success story for many reasons. It is a very cost-effective way to gain access to cutting edge data to test, while simultaneously incentivizing private investment for research and development. I believe acquisition of commercial radar data to fill the large near-surface gaps from overshooting beams is a very logical approach. In fact, it is likely the only option for many sites. However, it is important to note that this is only a pilot program for acquiring and testing new data. If these data are shown to add value, then a more long-term acquisition strategy with service level agreements, such as the National Mesonet Program, would be a preferred contracting vehicle.

Responses by Dr. Scott Weaver

Congressman Sorensen Statement and Questions for the Record

Good Morning,

I want to thank Chairman Miller and Ranking Member Ross for convening this hearing and our witnesses for their willingness to appear before us today.

I am so happy to be with you today to discuss the importance of weather forecasting and modeling. Truth be told, the only job I ever wanted as a kid was to be the Meteorologist on television.

I got to live my childhood dream for 22 years as a trusted source of severe weather information...working in Texas for 5 years and then the rest of my career in the Congressional District I now serve.

My job was to help neighbors make good decisions. When to stay off the roads in the winter. How to stay safe in heat waves. When to take shelter for the tornado. It was also taking the risk of communicating climate when no other Meteorologists would touch the issue. Why were some weather events happening frequently? How was climate impacting my local area?

When my Congresswoman decided to retire, I knew I had to try to be the first Meteorologist in Congress in nearly half a century. I knew I needed to be the climate communicator in Congress.

1. I have met farmers who have logs going back generations that document the changing climate. These farmers, in my district, they know that the climate is changing. Unfortunately, I don't think NOAA and Congress are doing enough to communicate with the public on climate change. NOAA does a good job of communicating to small groups but does not communicate to broad groups very often. To communicate climate change to the country, NOAA will need to develop skills to communicate effectively to wide audiences.

- a. **Dr. Jacobs:** Does NOAA need resources from Congress to develop this skill?
- b. **Dr. Weaver:** Do you have anything you would like to add?

(Dr. Weaver): I share the Congressman's enthusiasm for weather and climate science, including the communication of findings, opportunities, and threats that are important for a broad stakeholder base within our society. Scientific communication is a vital part of the scientific process. As you mention, NOAA does a stellar job at some aspects of climate communication via their Climate Program Office. Therefore, it would certainly be a benefit for the country if NOAA had increased resources to strengthen their climate communication capabilities.

2. Many TV meteorologists are afraid to discuss climate change too much on the air. When I started talking about climate on the air, my producers were concerned for my job security. NOAA and Congress need to fill the gap here. I have been told that NOAA is not authorized to provide services to the public directly related to climate change.

- a. **Dr. Jacobs:** Is this correct, and if so, what can Congress do to allow NOAA to fill this gap in services to the American public?
- b. **Dr. Weaver:** Would you like to comment?

(Dr. Weaver): NOAA already provides an enormous amount of climate services to the public through a myriad of channels. Whether it is the direct observational data and climate modeling output that they provide to the public free of charge, the establishment of the agency-wide Climate Ready Nation initiative, or their lead support for the quadrennial National Climate Assessment, NOAA is the de facto lead federal agency for climate change science and services.

NOAA also chairs the U.S. Global Change Research Program (USGCRP) – a 13 (now 14) agency coordination mechanism for climate change science research mandated by the Global Change Research Act (GCRA) of 1990. In fact, recently the USGCRP has decided to go well beyond the Congressional mandate, which explicitly targets interagency research coordination, by adding an entirely new line of interagency coordination that focuses specifically on climate services, in a sense operationalizing interagency climate science research so that it can be better used to inform climate policy, community decision making, engineering design standards, etc.

- 3. Our weather radars have well documented gaps in coverage. There are companies working to fill these gaps by installing their own radars in uncovered or under covered areas. The weather Act of 2017 included a commercial weather data pilot program to allow the government to purchase data from these private companies.

- a. **For the Panel:** Is there wisdom in this approach? In your opinions, has the program been successful?

(Dr. Weaver): My understanding from many conversations with CEO's in private industry is that the program has not worked as effectively as hoped. Despite this, there is definitely wisdom in the approach. As I mention in my written testimony, private industry is now in direct competition with the federal government to provide the foundational weather and climate observational data (e.g., via satellites, radar, etc.) and modeling. This was not the case 10-20 years ago when the federal government was the primary producer of the foundational information, while the private sector would essentially function as end user that would develop value added products for their clients. Given this new environment, it is not only wise, but absolutely essential that the federal government recognize this new reality and act accordingly to minimize unnecessary duplication of efforts within the larger weather enterprise (i.e., including the private sector, academia, and NGO's).