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

"The Future of Forecasting: Building a Stronger U.S. Weather Enterprise"

Thursday, May 16, 2019
2:00 p.m.
2318 Rayburn House Office Building

PURPOSE

This hearing will provide an opportunity for a discussion on the state of the U.S. Weather Enterprise, which is comprised of public, private, and academic partners. The overarching goal of this hearing is to determine what next steps need to be taken to not only develop U.S. leadership in weather modeling and forecasting, but also to encourage coordination and collaboration between the three sectors to ensure a robust U.S. Weather Enterprise that can provide the most timely and accurate weather products and services.

WITNESSES

- **The Honorable Neil Jacobs, Ph.D**., Assistant Secretary of Commerce for Environmental Observation and Prediction, performing the duties of Under Secretary of Commerce for Oceans and Atmosphere, National Oceanic and Atmospheric Administration (NOAA)
- **Dr. Louis Uccellini (Ooh-che-LEE-knee),** Assistant Administrator for Weather Services and Director of the National Weather Service, NOAA
- **Dr. Shuyi Chen**, Professor, Department of Atmospheric Sciences, University of Washington
- **Dr. Christopher Fiebrich (Fee-brick)**, Associate Director of the Oklahoma Climatological Survey and Executive Director of the Oklahoma Mesonet
- **Mr. Rich Sorkin**, CEO, Jupiter Intelligence

OVERARCHING QUESTIONS

- What is the current state of the U.S. Weather Enterprise, and how do we determine its future priorities?
- How do we improve the U.S.'s weather models and forecasting capabilities?
- What are the priorities, initiatives, and current weather infrastructure needs of the National Weather Service (NWS)?
- What are the workforce concerns for NOAA and NWS, as well as the broader Enterprise?
- How is the implementation of the Weather Research and Forecasting Innovation Act of 2017 progressing?
- What are the concerns surrounding the auction of 5G Spectrum in the 24 GHz band for weather forecasting capabilities?

BACKGROUND

In 2018, the U.S. experienced 14 separate billion-dollar weather and climate disasters, which is the fourth highest total number of events since 1980, only behind years 2017, 2011, and 2016. So far in 2019, the U.S. has already experienced two weather and climate disasters exceeding $1 billion each.[1] The need for accurate weather and climate predictions will continue to grow as we see more frequent and intense severe weather events across the country. However, accurate forecasts on their own have no value; forecasts gain value through their ability to influence decision-making. Fostering dialogue between all the sectors of the U.S. Weather Enterprise – public, private, and academic – will help us meet this challenge head-on.

U.S. Weather Enterprise

The U.S. Weather Enterprise (Enterprise) is an entity comprised of the public, private, and academic sectors that work collaboratively to provide timely and accurate weather products and services. The total value of weather data across all industries is approximately $13 billion.[2] A large part of the success of the Enterprise is due to open communication and collaboration between the three sectors, as each sector has a distinct and complementary role to play. The Enterprise is not static, but rather a dynamic entity where the roles of each sector continue to evolve and change. The Enterprise stands at a critical juncture as it is not considered the global leader in weather modeling and forecasting.

Nearly 30 years ago, weather data primarily came from public sector sources, but with the advancement of science and technology within the commercial sector of the Enterprise, non-federal sources of weather data have grown tremendously in recent years. While public sector sources of data continue to remain free and open to the public, some commercial data sources are proprietary. Given the rapid pace of technological advancement, the roles of each sector of the Enterprise have continued to advance as new user needs have emerged. Continued coordination and collaboration between the sectors is necessary to ensure that the entire Enterprise is working towards one common goal; improving the state of weather forecasting in the U.S. Instead of defining rigid roles for each sector, the key to successful partnerships thus far has been allowing flexibility in the interaction between the sectors with some delineation of core responsibilities for each.[3]

Public Sector NOAA's National Weather Service (NWS) is the operational face of weather forecasting in the U.S. The NWS provides long and short term terrestrial weather forecasts, operational forecasts and warnings for space weather, and issues warnings, watches, and advisories. The mission of the NWS is to "Provide weather, water, and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy."[4] NWS operations are made up of: NWS Headquarters, six Regional Headquarters, nine National

[1] https://www.ncdc.noaa.gov/billions/
[2] National Weather Service. 2017. *National Weather Service Enterprise Analysis Report: Findings on changes in the private weather industry*. https://www.weather.gov/media/about/Final_NWS%20Enterprise%20Analysis%20Report_June%202017.pdf
[3] National Research Council. 2003. *Fair Weather: Effective Partnership in Weather and Climate Services*. Washington, DC: The National Academies Press. https://doi.org/10.17226/10610.
[4] https://www.weather.gov/about/

Centers for Environmental Prediction (NCEP), 13 River Forecast Centers, 122 Weather Forecast Offices (WFOs), 21 Center Weather Service Units, 18 Weather Service Offices, two Tsunami Warning Centers, two Data Collection Offices, eight other National Centers, and the National Water Center. The WFOs provide specialized forecasts for their regions.

In April 2011, a tornado outbreak in Mississippi and Alabama resulted in significant loss of life and property damage, despite the NWS providing accurate forecasts with above average lead time for evacuation.[5] Following this event, NWS focused on its efforts to *Evolve* into a Weather-Ready Nation (WRN) to build "community resiliency in the face of increasing vulnerability to extreme weather, water, and climate events."[6] A key component of becoming a WRN is providing Impact-based Decision Support Services (IDSS) to local communities. The NWS works to provide forecasts and warnings to their partner decision-makers in state and local government, and the emergency management (EM) community through the WFOs. The partnership with the NWS has allowed the EM community to move from reacting to extreme weather events, to proactively preparing for weather events. NWS conducted an Operations and Workforce Analysis (OWA) from 2015-2016 to generate findings and recommendations to help the NWS move toward its vision to provide IDSS for a WRN. The OWA found that "the demand for IDSS [outstripped NWS's] ability to provide it across every county of the United States, and that [NWS's] current structure, workflow, and operational processes may not be ideally suited for providing the level of IDSS [NWS] partners need."[7]

The OWA made recommendations to help NWS make IDSS more widely available to its partners by freeing up forecaster time through the implementation of a Collaborative Forecast Process that would utilize the National Blend of Models (NBM). The NBM is a blend of NWS and non-NWS numerical weather prediction guidance that provides a nationally consistent starting point for forecasters in WFOs.[8] Additionally, the OWA recommended a General Schedule (GS) 5-12 career progression for meteorologists, which would put the field meteorologists onto a single career track and let them progress non-competitively from the GS-5 to GS-12 level based on the completion of certain core competencies. The NWS engages with the National Weather Service Employees Organization (NWSEO) on issues related to labor and staffing.

Other line offices within NOAA that support the mission of the NWS include the Office of Oceanic and Atmospheric Research (OAR) and the National Environmental Satellite, Data, and Information Service (NESDIS). OAR serves as the primary research arm of NOAA that provides the science needed for NOAA to achieve its strategic goals to: understand climate variability and change; serve society's needs for weather and water information; protect, restore and manage the use of coastal and ocean resources; and support the Nation's commerce with information for safe transportation. OAR administers collaborative long-term partnerships between NOAA and participating universities and other non-profit institutions. These partnerships include 16

[5] https://www.weather.gov/about/wrn
[6] https://www.weather.gov/wrn/force
[7] National Weather Service. 2017. *Operations and Workforce Analysis Catalog.* https://www.weather.gov/media/nws/OWA_Catalog_09072017.pdf
[8] https://www.weather.gov/mdl/nbm_home

Cooperative Research Institutes affiliated with NOAA Research Laboratories[9] and 33 Sea Grant Programs coordinated under the National Sea Grant College Program.[10]

NESDIS is responsible for providing observational data from NOAA's satellite constellation that feed into the NWS forecast models. The observations from polar and geostationary satellites is the backbone of numerical weather prediction at NWS. This satellite data is complemented through other observational technologies including radars, Argo buoys (free-drifting profiling floats that measure temperature and salinity in the oceans), and mesoscale data and networks. The National Academies found in a 2012 study that the NWS needs to leverage existing partnerships with the broader Enterprise to meet its mission and achieve the "greatest national good" beyond what the NWS budget alone would allow.[11] This hearing provides an opportunity to hear from all three sectors on how the NWS is doing to strengthen those partnerships.

Private Sector The private sector arm of the Enterprise is diverse and varied, with each individual business entity tailoring their unique products to their specific end-users. Due to fewer restraints, and the ability to take on more risk, than the federal government, the private sector of the Enterprise is on the cutting-edge of innovation and technology development. Much of the foundational data used by the private weather industry comes from NOAA and other federal agencies, and is used as a base to create new weather products and services for various end-users. This has developed into a lucrative secondary forecast market, with the U.S. private weather industry valued at approximately $7 billion.[12] However, private industry is also developing emerging space-based and ground-based observation technologies that could play a bigger role in providing observational weather data. Despite this potential paradigm shift in data collection, most private sector companies see the NWS as the authoritative voice for disseminating watches, warnings, and advisories to ensure public safety, [13] and work with the NWS to ensure the widest possible dissemination of these watches, warnings, and advisories.

Academia OAR research is supported by many outside academic entities such as research universities, cooperative institutes, and private research organizations. The University Corporation for Atmospheric Research and the National Center for Atmospheric Research (UCAR and NCAR) are two of the most visible manifestations of university-based weather research. Much of the research conducted by academic partners goes into the operational activities at the NWS. Many academic researchers conducting weather related research are funded by federal grants from the National Science Foundation (NSF), NOAA, and other federal agencies. In addition to conducting weather research, the academic sector is also responsible for training the next generation of meteorologists, scientists, and engineers that will make up the future Enterprise-wide workforce. The skills needed to be a successful part of the Enterprise have changed over time due to advances in science and technology, and emerging user needs.

[9] https://ci.noaa.gov/Locations.aspx
[10] https://seagrant.noaa.gov/About
[11] National Research Council. 2012. *Weather Services for the Nation: Becoming Second to None*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13429.
[12] National Weather Service Enterprise Analysis Report. 2017
[13] National Weather Service Enterprise Analysis Report. 2017

Research to Operations (R2O) and Operations to Research (O2R)

New innovations in science and technology can bring about significant improvement in operations and improve the effectiveness of an organization, but NOAA, and the federal government broadly, have not always been quick to adopt new technology. The National Academy of Public Administration noted that the NWS "does not have an efficient and effective means for identifying science and technology requirements, researching and developing them to maturity… and introducing them into operations." [14] NOAA's own Scientific Advisory Board (SAB) noted in 2013 that science is the foundation of NOAA's mission, but unless that science is successfully transitioned into operations, NOAA will fail in its mission.[15] The NOAA SAB recommended that an emphasis should be placed on a seamless transition in both Research to Operations (R2O) and Operations to Research (O2R) activities by developing strong partnerships between researchers and operational users at the beginning of a project to ensure the research conducted would meet operational needs.

Data Sharing

NOAA follows a free and open data policy by making all of its weather data available to the public. This freely available data has allowed academia access to thousands of data sets for meteorological research and has allowed the private weather industry to create value-added products and services that build upon NWS data. As more commercial entities develop the capability to collect their own proprietary environmental observations and weather data, the availability of these unique data sets to the public could potentially jeopardize not only academic research, but also the market for specialized weather products and services developed by the private sector.

NOAA Forecasting

The NWS uses numerical weather prediction (NWP) to develop forecasts by utilizing current data from space and ground based observation platforms. Ensemble predictions combine multiple runs of NWP models with different initial conditions or parameters, to better include information on the uncertainty of forecasts.[16] NOAA has been using the current NCEP Global Forecast System (GFS) weather forecast model for over 30 years as the basis of its weather models. NOAA is currently developing its next generation global prediction system which is based on the Finite Volume Cubed-Sphere dynamical core (FV3). The FV3 model was developed by NOAA's Geophysical Fluid Dynamics Laboratory, an OAR laboratory located in Princeton, NJ.[17] NOAA's phasing in of the GFS with the FV3 was delayed by the 35-day government shutdown and currently plans to make the FV3 operational sometime in 2019.

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[14] National Academy of Public Administration. 2013. *Forecast for the Future: Assuring the Capacity of the National Weather Service*. https://www.napawash.org/studies/academy-studies/forecast-for-the-future-assuring-the-capacity-of-the-national-weather-servi

[15] NOAA Science Advisory Board. 2013. *In the Nation's Best Interest: Making the Most of NOAA's Science Enterprise. A Report from the NOAA Science Advisory Board.* file:///C:/Users/pkh/Downloads/SAB%20R&D%20Portfolio%20Review%20Report%20to%20NOAA%20FINAL.pdf

[16] https://www.weather.gov/media/ajk/brochures/NumericalWeatherPrediction.pdf

[17] https://www.weather.gov/news/fv3

Congressional Activity

The Weather Forecasting and Innovation Act of 2017[18] (Weather Act) authorized research and development efforts at NOAA, primarily within OAR. It also prioritized the development of subseasonal (forecasts of two weeks to three months) to seasonal (forecasts of three months to two years) forecasts, and provided weather satellite and commercial weather data innovation and federal weather coordination. This legislation is currently being implemented by NOAA with a number of reports still due to Congress to track implementation. The reauthorization of the National Integrated Drought Information System (NIDIS) Act of 2018,[19] included the reauthorization of Title II of the Weather Act, and also authorized the Earth Prediction Innovation Center (EPIC), within OAR, to improve numerical weather prediction by creating a community global weather research modeling system.

Potential Impacts to Forecasting Due to 5G Spectrum Auctions

The Federal Communication Commission's (FCC) plans to have 5G operations share radiofrequency spectrum with Earth-observing satellites at the 24 GHz band would cause significant interference with federal weather data and forecasts. The 24 GHz band is adjacent to the band that is used by satellite-borne microwave sensors to measure water vapor, including NOAA's Joint Polar Satellite System (JPSS) Advanced Microwave Sounder (ATMS). Water vapor measurements are essential to numerical prediction of nearly every type of weather prediction, including rainfall, drought, sea surface temperature, soil moisture, and hurricane tracking. According to NOAA, water vapor data accounts for 85% of data that is used for weather forecast models. Due to the physical properties of water, water vapor can only be measured at the frequency bands currently allocated. The FCC's proposed radio frequency protection levels at 24 GHz (-20 dBW) would fail to safeguard water vapor measurements against interference. In a recent briefing to House Science Committee staff, NOAA said that this will cause an estimated 30% degradation in forecast error to operational numerical weather prediction models.

The FCC initiated an auction on March 14, 2019 for the 24 GHz band for commercial 5G services and applications, despite a bipartisan call from Chairwoman Johnson and Ranking Member Lucas to delay the auction until interagency concerns regarding weather data degradation were addressed.[20] On April 3, Chairwoman Johnson and Ranking Member Lucas sent a document request letter[21] to NOAA Acting Administrator Jacobs requesting the release of any studies NOAA has conducted that calculate a radio frequency protection level that would prevent interference with microwave sensor data. As of the time this hearing charter was sent, the Committee has not received a response from NOAA. On April 29, FCC Commissioner Ajit Pai responded to Chairwoman Johnson and Ranking Member Lucas's request to delay the 24 GHz Spectrum auction and said that the FCC had "not been presented with any evidence of harmful interference from these existing service nor a validated study suggesting operations in

[18] P.L. 115-25
[19] P.L. 115-423
[20] March 13, 2019. https://science.house.gov/letters-to-fcc-chairman-and-commissioners-arequesting-the-delay-of-5g-spectrum-auction
[21] April 3, 2019. https://science.house.gov/imo/media/doc/4.3.19%20Jacobs%20NOAA%20impacts%20of%205G%20letter.pdf

accordance with these rules would adversely affect use of the 23.6-24 GHz allocation, including for weather forecasting."[22]

When asked about spectrum concerns at this Committee's Fiscal Year 2020 budget hearing for NASA earlier this year, Administrator Bridenstine said that the 24 GHz auction "could have an impact on NASA's missions" and bring the United States back to the 1970s when it comes to weather forecasting.[23] Similarly, NOAA Acting Administrator Jacobs expressed concern about interference with NOAA and NASA satellite-borne weather data at this Committee's Fiscal Year 2020 NOAA budget hearing on April 30, 2019.[24]

ADDITIONAL READING

Government Accountability Office. 2017. *National Weather Service – Actions Have Been Taken to Fill Increasing Vacancies but Opportunities Exist to Improve and Evaluate Hiring*. https://www.gao.gov/products/GAO-17-364

National Research Council. 2006. *Completing the Forecast: Characterizing and Communicating Uncertainty for Better Decisions Using Weather and Climate Forecasts*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11699.

National Academies of Sciences, Engineering, and Medicine. 2018. *Integrating Social and Behavioral Sciences Within the Weather Enterprise*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24865.

National Weather Service. 2013. *Weather-Ready Nation Roadmap*. https://www.weather.gov/media/wrn/nws_wrn_roadmap_final_april17.pdf

[22] April 29, 2019. https://science.house.gov/imo/media/doc/4.29.19%20Ajit%20Pai%20letter%20to%20EBJ.pdf
[23] House Committee on Science, Space, and Technology. April 2, 2019. *A Review of the NASA FY2020 Budget Request*. https://science.house.gov/hearings/a-review-of-the-nasa-fy2020-budget-request
[24] House Committee on Science, Space, and Technology. April 30, 2019. *A Review of the NOAA Fiscal Year 2020 Budget Request*. https://science.house.gov/hearings/a-review-of-the-noaa-fiscal-year-2020-budget-request