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

What's the Forecast: A Look at the Future of Weather Research

Tuesday, June 14, 2022
10:00 AM EDT
2318 Rayburn House Office Building and Online via Zoom

Purpose

This hearing will provide an opportunity to discuss the highest priority investments needed for weather research and development over the next decade, as described in the National Oceanic and Atmospheric Administration (NOAA) Science Advisory Board (SAB)'s "Priorities for Weather Research" report. This discussion will include perspectives from the U.S. Weather Enterprise, comprised of public, private, and academic partners. This hearing will also examine how investments in weather research and development can protect critical infrastructure, life, property, and enhance equity in the provision of weather services, while supporting the national economy.

Witnesses

- **Dr. Scott Glenn,** Board of Governors Professor, Center for Ocean Observing Leadership of the Department of Marine and Coastal Sciences, Rutgers University
- **Dr. Bradley Colman,** President-Elect of the American Meteorological Society; Director of Weather-Strategy, Bayer & The Climate Corporation
- **Dr. Fred Carr,** Professor Emeritus, School of Meteorology, University of Oklahoma
- **Dr. Kevin R. Petty,** VP, Weather and Earth Intelligence, Spire Global, Inc.

Overarching Questions

- How can investments in weather research and development support the economy, protect life and property, and protect critical infrastructure investments?
- What federal investments in weather research and forecasting are most needed to improve U.S. weather forecasting?
- How can the federal government leverage the U.S. Weather Enterprise to accelerate implementation of weather research priorities over the next decade?
- What are the workforce needs to meet the weather priorities for the next decade?
- How can the Weather Enterprise ensure that weather forecast products and services are disseminated in an equitable manner?
- What types of weather infrastructure (dissemination networks, Earth observing networks, high-performance computing, etc.) is needed to meet the growing needs of a nation experiencing increasingly frequent and intense extreme weather events?

Background

The Weather Research and Forecasting Innovation Act of 2017, [1] and its 2019 reauthorization,[2] directed NOAA to improve its weather forecasting capabilities by advancing observations, modeling, and computing. In additional to overall improvements in forecasting capabilities, the implementation of the Weather Act has resulted in the development of NOAA's Earth Prediction Innovation Center (EPIC), and the codification of the Environmental Information Services Working Group (EISWG) and of NOAA's Impact-Based Decision Support Services (IDSS).

Since 2017, the U.S. has experienced weather and climate disasters that exceed $740 billion, with 2021 in second place for the most billion-dollar disasters in a calendar year, and the deadliest in terms of disaster-related fatalities in the contiguous U.S. since 2011.[3] This evidence shows a clear need to continue improving weather forecasting capabilities to protect life and property.

Priorities for Weather Research Report

In the Fiscal Year 2021 Omnibus Consolidated Appropriations Act,[4] Congress charged the NOAA SAB to publish a report to inform the necessary federal investments needed in weather research and forecasting over the next decade. The NOAA SAB published the Priorities for Weather Research (PWR) report which took into consideration the input of over 150 subject matter experts across the Weather Enterprise in development of its recommendations. The report recommends accelerated and increased investments in priority areas that are both balanced and constructive to the weather information value chain.[5]

The PWR report highlights five narrative themes to convey the importance of the scientific and technical recommendations in the report: Mission Critical Mile; Highly Reliable, Fully Accessible Weather Information; Improve Predictions of Water Cycle Extremes and Their Cascading Impacts; High-Impact Weather; and Global Leadership in Weather Prediction as a Pathway to Higher Quality Products and Services. These five themes underscore the importance of the recommendations identified under four core areas—Research and Development; Infrastructure; Actions and Impacts; NOAA Prioritization and Investment—of the PWR report.[6,7] The cornerstone of the narrative themes identified by the PWR report is the development and implementation of a fully-coupled Earth System Model.

Earth System Model

The Earth System Model (ESM) is a mathematical model of the physical, chemical and biological processes that affect weather and climate. The relevant systems include the atmosphere, oceans, land surface, cryosphere, biosphere and hydrologic and biogeochemical cycles, and the interactions (coupling) among them. Collectively improving the observations,

[1] P.L. 115-25
[2] P.L. 115-423
[3] https://www.climate.gov/news-features/blogs/beyond-data/2021-us-billion-dollar-weather-and-climate-disasters-historical
[4] P.L. 116-260
[5] NOAA Science Advisory Board, 2021: A Report on Priorities for Weather Research. NOAA Science Advisory Board Report, 119 pp. https://sab.noaa.gov/wp-content/uploads/2021/12/PWR-Report_Final_12-9-21.pdf
[6] Ibid
[7] Ibid

understanding, and data assimilation of the connected systems and interactions will advance the scope of knowledge of the Weather Enterprise, and the lay public. NOAA currently employs an operational weather forecast model known as the Global Forecast System (GFS).[8] The PWR report notes that in the current forecasting system, observation gaps exist in the planetary boundary layer observations, as well as high-impact weather and water cycle extreme observations. The comprehensive scale of the ESM would fill the gaps that are currently present.

Federal investments support the U.S. Weather Enterprise

The U.S. Weather Enterprise is comprised of the public, private, and academic sectors that work collaboratively to provide timely and accurate weather products and services. The Science Committee held a hearing on the U.S. Weather Enterprise in May 2019.[9] The private sector has seen significant advancement in their research and forecasting capabilities. The foundation of the Weather Enterprise continues to be the public sector, primarily through federal investments for NOAA's National Weather Service (NWS); the civilian agency responsible for issuing terrestrial and space weather watches, warnings, and advisories. The NWS provides the critical underlying data, resources, and information that is essential to the Weather Enterprise.

While the recommendations in the PWR report are focused on needed federal investments, the outcome of these investments will support the broader Weather Enterprise's efforts to improve U.S. weather forecasting. The development and integration of a fully coupled ESM will benefit from federal investments in high-performance computing outlined in the report; investments that academia and the private sector cannot make on their own.

NOAA uses numerical weather prediction (NWP) to develop forecasts by utilizing data from space-and ground-based observation platforms that feed into high-performance computer models that make predictions about weather conditions.[10] Additionally, NOAA's ongoing efforts through EPIC, has transitioned the code for the Unified Forecasting System (UFS) to Github, where it can be publicly accessed. The UFS is EPIC's solution to a community-based, coupled, comprehensive Earth modeling system used for various NWP applications. The ESM recommended in the PWR report will require regular, publicly accessible, updates to NOAA's weather model code to ensure continued collaboration with academia and the private sector, who often utilize more recently developed coding languages.

Commercial weather providers have developed add-on weather products and services, and in some cases, augmented federal weather data. However, the necessity of federally procured weather data remains indisputable. Most foundational weather observations that serve as the backbone of all weather forecasts are dependent upon federal investments that support both data collection and assimilation. Federal investments in the provision of weather data, development of forecast models, and accessibility of high-performance computing resources allows the private and academic sectors the ability to drive innovation in the development and dissemination of cutting-edge weather products and services to the public.

An important aspect of the Weather Enterprise is the weather information value chain, a concept in which hydrological-meteorological systems are observed and modeled resulting in forecasts and warnings. The information is then disseminated through channels and potentially altered by

[8] https://www.ncei.noaa.gov/products/weather-climate-models/global-forecast
[9] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=109467
[10] https://www.weather.gov/rah/virtualtourforecast

secondary information providers such as private weather services, media channels, and mobile platforms to be communicated.[11] There are still significant investments needed in information dissemination to reduce the impacts of extreme weather, water, and climate events. The PWR report recommends investing in artificial intelligence, cloud technologies, and assimilating social and behavioral data to anticipate user needs.[12] Investing in information dissemination can increase the present value of capabilities that already exist.

NOAA's short term forecasting capabilities to disseminate weather forecasts days to weeks in advance is robust. These forecasts are utilized daily for decision making by the public as well as public and private industry professionals such as fire responders and grid operators. However, the need to improve forecasting on the subseasonal to seasonal (S2S) timescale (two weeks to two years) remains a key priority for NOAA and many of the PWR report recommendations would support these efforts. Improving S2S forecasts has become increasingly important to determine seasonal drought and precipitation forecasts, and temperature outlooks. Improved forecast accuracy at greater timescales provides decision-makers additional time to prepare and communicate the weather threats they are facing to the public.[13] Supporting assimilation of existing observations and data in conjunction with developing novel assimilation methods of boundary layer observations and data is essential to improving S2S forecasts.[14]

Behavioral and Social Sciences

The PWR report detailed the importance of the "Mission Critical Mile," which is defined as the combination of understanding audiences (the "first mile") and the delivery of weather information to those audiences (the "last mile").[15] The behavioral and social sciences must be fully engaged to maximize the return on meteorological research and weather prediction. Investments in leadership to build awareness, and capacity throughout the Weather Enterprise, especially to identify critical knowledge gaps within weather forecasting and communication, will support better engagement with end-users of weather information. Increasing the integration of behavioral and social sciences into the development of weather services is a key component in addressing issues of weather information inequity. Community-centered communication approaches that are accessible and tailored, including issuing warnings in alternative languages in non-English-speaking communities are an example of such approaches that close the gap in information inequities.[16]

[11] https://www.ametsoc.org/ams/assets/File/policy/WWC_Value_Chain_Economic_Benefits.pdf
[12] https://sab.noaa.gov/wp-content/uploads/2021/12/PWR-Report_Final_12-9-21.pdf
[13] https://www.nerc.com/pa/RAPA/ra/Reliability Assessments DL/NERC_SRA_2022.pdf
[14] https://sab.noaa.gov/wp-content/uploads/2021/12/PWR-Report_Final_12-9-21.pdf
[15] https://sab.noaa.gov/wp-content/uploads/2021/12/PWR-Report_Final_12-9-21.pdf
[16] https://sab.noaa.gov/wp-content/uploads/2021/12/PWR-Report_Final_12-9-21.pdf

Additional Resources

- World Meteorological Association's 2021 Future of Weather and Climate Forecasting[17]
- National Academies 2003 Fair Weather: Effective Partnerships in Weather and Climate Services[18]
- National Academies 2018 Integrating Social and Behavioral Sciences Within the Weather Enterprise[19]
- NOAA Hurricane Forecast Improvement Program (HFIP) R&D Activities Summary: Recent Results and Operational Implementation[20]

Relevant Recent Science Committee Hearings

- May 16, 2019 – The Future of Forecasting: Building a Stronger U.S. Weather Enterprise[21]
- July 22, 2019 – Weathering the Storm: Improving Hurricane Resiliency through Research[22]
- September 26, 2019 – Understanding, Forecasting, and Communicating Extreme Weather in a Changing Climate[23]
- November 20, 2019 – A Task of EPIC Proportions: Reclaiming U.S. Leadership in Weather Modeling and Prediction[24]
- September 30, 2020 – Coping with Compound Crises: Extreme Weather, Social Injustice, and a Global Pandemic[25]
- October 14, 2021 – The Future of Forecasting: Building a Weather-Ready Nation on All Fronts[26]

[17] https://library.wmo.int/doc_num.php?explnum_id=10611
[18] https://nap.nationalacademies.org/catalog/10610/fair-weather-effective-partnership-in-weather-and-climate-services
[19] https://nap.nationalacademies.org/catalog/24865/integrating-social-and-behavioral-sciences-within-the-weather-enterprise
[20] https://hfip.org/sites/default/files/documents/hfip-annual-report-2020-final_0.pdf
[21] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=109467
[22] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=109575
[23] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=109982
[24] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=110243
[25] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=111061
[26] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=114122