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

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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 constrains 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.