THE WHITE HOUSE
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AI ASPIRATIONS

An AI Aspiration for Weather Prediction

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IMAGINE IF…

… you had more confidence about the path, intensity, and impacts of a hurricane approaching you. Imagine if airlines could rebook passengers and reroute aircraft a full week ahead to avoid severe weather. Imagine if you could plan a picnic with your family and friends, knowing that you could count on the weather forecast two weeks out.

Today

Over the last several decades, the success of operational weather prediction has increased the public's expectation of reliably accurate forecasts up to seven days. The lack of certainty at the local scale and the increase in weather extremes make advances in weather prediction even more urgent and challenging. The intensity and frequency of extreme weather events—heat waves, drought, wildfires, floods, and severe thunderstorms—are worsening as the climate changes. In 2023, the United States experienced 28 separate weather and climate disasters that cost $1 billion or more, the highest number of such disasters on record. More accurate forecast guidance is essential for families, companies, and emergency responders as they manage risks to safety, property, and business operations.

Numerical weather prediction has long relied on physics-based models to generate operational weather forecasts. Recent advances in weather prediction, such as data assimilation, ensemble forecast generation, and earth system approaches to environmental prediction, have provided decision-makers with great value. These advances have led to increasingly longer-range, more skillful forecasts; however, these improvements come at significant computational costs that limit the issuance of timely warnings, the ability to quantify forecast uncertainty, and the pace of weather prediction model improvement.

AI opens the door

New artificial intelligence (AI) approaches use data rather than equations representing the physical evolution of the atmosphere to create weather prediction forecasts. Over the last few years, AI weather prediction models, initially developed within the private sector, have shown great promise, matching or exceeding the predictive capabilities of traditional physics-based models. Deep learning approaches using modern neural network architectures have shown increases in efficiency and efficacy at increasingly local scale compared to current operational, physics-based models. Improvements include decreasing processing time to a minute vs. hours (for a 10 day forecast); higher quality tracks for cyclones and hurricanes; improved characterization and prediction of challenging forecasts such as atmospheric rivers; lower forecast error rates; and improved forecasting of phenomena such as intense mid-latitude cyclones, extreme precipitation, flash flooding, winter weather, and heat waves. Lower costs and rapid testing with AI-driven models provide an opportunity for accelerating innovation and transitioning this promising research to operational weather prediction workflows.

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Major hurdles and societal risks

Despite the early successes of emerging AI-driven weather forecast models relative to physics-based models, the fitness of AI-driven models for operational weather forecasting remains to be demonstrated. Important challenges still exist:

- What key model output variables are needed to provide the guidance necessary for forecasters to provide impact-based decision support?
- Ensembling techniques are not fully mature. How do we best represent initial conditions and model uncertainties in an AI system?
- What are the best training data sets to create, update, and validate these models?
- How is trust established in the use of these models?

There are critical societal risks to public safety and health as well as risks to property if these models are not carefully evaluated. Incorrect forecasts of the intensity or track of an extreme weather event would pose a significant risk to life and property. Additionally, missed forecasts of extreme weather could irreparably erode the trust the public has in the forecasts and forecasters they have relied on to provide actionable information.

The work ahead

Building on today's promising AI advances, our objective is the creation and implementation of operational, end-to-end, data-driven, ensemble weather prediction modeling systems capable of providing timely, reliable, and trustworthy forecast guidance for decision makers on several hour to 3-month (sub-seasonal) timescales. That will require:

- Building open-science infrastructure for NOAA data-driven model development
- Executing available, open-source versions of AI models for testing and evaluation
- Research and development of data-driven models for both local and global coupled ensembles at a range of forecast horizons from hours to months, as well as for high-impact weather at sub-kilometer-scale that incorporates feedback from NOAA forecasters and testbed participants
- Development of data-driven techniques that can significantly enhance our data assimilation and can enable us to include previously underutilized observations into forecast guidance and climate reconstruction
- Validation and integration of the data-driven models in NOAA testbeds and National Weather Service (NWS) forecaster practice

A transformative national capability

Operational AI-driven weather forecasts hold the potential to transform how both the public and private sectors respond to and manage weather-related risks. Individuals, communities, and weather-dependent industries would have earlier access to higher quality weather information for decision-making, enabling them to more accurately assess their weather-dependent risks on timescales ranging from hours to months. The benefits of AI-driven weather forecast modeling span across multiple sectors, enhancing public safety and health, optimizing business operations, and contributing to more effective disaster management and environmental protection.