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As Chairs of the Advisory Boards for several NSF NCAR laboratories, and as members of the university and industry communities that NSF NCAR's critical infrastructure serves, we write to urge the National Science Foundation to continue its strong support for the integrated research facilities provided by NSF NCAR.

The **integrated structure of NSF NCAR has proven extraordinarily effective in protecting lives and property, strengthening the national economy, and advancing US leadership in atmospheric and Earth system science.** Below, we highlight the unique value of this integrated national facility, followed by several recommendations that could further increase its societal and economic benefit.

Value as an Integrated National Research Facility

A coordinated national research structure is highly efficient.

NSF NCAR's integrated approach links models, observations, high-performance supercomputing, and emerging AI capabilities. This integration creates scientific synergies that no single institution could achieve alone. Through this national facility, researchers across the country, including those at smaller universities and rural institutions, gain access to advanced technologies, research aircraft, and supercomputing resources that would otherwise be unattainable. Education about and access to state-of-the-art tools and proven methods in space weather and earth system science coordinated through a centralized entity greatly increases the efficiency with which the academic, public and private sector research communities are able to make scientific advances. This centralized model has proven to be both cost-effective and highly competitive, delivering scientific results and operational benefits at a national scale.

Improving our nation's ability to predict makes us safe and requires national coordination.

The atmosphere does not respect geographic boundaries. A nationally integrated research infrastructure ensures a coordinated response to challenges affecting public safety and the economy. NSF NCAR research has provided foundational knowledge for predicting and preparing for severe storms, hurricanes, wildfires, and floods, directly reducing loss of life and property damage. The research products of its scientists and their collaborators also support innovation and resilience in weather-sensitive sectors such as energy, agriculture, insurance, and aviation. Technologies developed at NSF NCAR, like wind shear detection systems, have transformed aviation safety, while NSF NCAR's observational capabilities remain at the forefront of boundary-layer measurement technologies. Further, NSF NCAR's work in space

weather and Earth system modeling protects the electric grid, satellite infrastructure, and national security interests.

Atmospheric science modeling and innovation requires global leadership.

NSF investment in NSF NCAR has enabled the development of world-leading atmospheric models such as the Weather Research and Forecasting (WRF) model, the Community Earth System Model (CESM), and the Model for Prediction Across Scales (MPAS). These community models underpin both academic research and operational forecasting across the United States and internationally. The coordinated leadership provided by NSF NCAR is essential as the scientific community transitions towards AI-enabled forecasting systems and new forms of hybrid modeling. Few organizations are positioned as effectively as NSF NCAR to coordinate this transition while ensuring scientific rigor, accessibility of these new technologies for academic and industry research, and education in best practices for their use.

Fragmentation undermines efficiency and training.

NSF NCAR serves as a premier training environment for graduate students, postdoctoral scholars, and early-career faculty. Fragmenting this infrastructure across individual universities, many of which lack comparable computing and observational resources, would weaken the nation's research capacity and reduce the efficiency of workforce development. Additionally, the unique concentration of world-leading experts in multiple scientific and technological disciplines at NSF NCAR provides an educational environment that encourages systematic thinking and consideration of alternative approaches to research. At a time when international competitors are significantly increasing their investments in weather prediction and Earth system science, dispersing NSF NCAR's capabilities would erode the US scientific talent pipeline and forfeit global scientific leadership.

Opportunities to Further Strengthen NSF NCAR's Impact

The authors would like to highlight several areas where targeted investment in NSF NCAR's unique capabilities would deliver immediately-relevant and high-impact enhancements to the American academic, public and private scientific enterprise.

Expand observational platforms and regional hubs to improve forecasts.

Advances in forecasting, especially for extreme weather and storm-scale processes, depend on high-quality observations used to initialize and train both numerical and AI-based models. Ever more observations of unique and underobserved aspects of the earth system are necessary to advance the predictive skill of our forecast models, including for training the next generation of AI-based predictive models. The novel observation platforms will require coordinated research and engineering to develop, which NSF NCAR is uniquely positioned to facilitate. NSF NCAR's observational platforms have long provided gold-standard datasets for the community. However, these assets are typically deployed in campaign mode and therefore do not provide continuous

observations across all U.S. climate regimes. NSF could consider expanding toward a network of regionally distributed observational platforms operated in partnership with universities. Such regional hubs would provide continuous high-quality datasets across diverse environments while simultaneously strengthening workforce training and community engagement. Wildfire monitoring and science, air pollution, and stratospheric ozone, on scales from molecular (models, inventories) to regional and global (aircraft measurements, satellite analysis), require a continuous and regionally coordinated observation capabilities.

Expand support for computational and information infrastructure

For weather modeling and forecasting to continue to advance in forecast accuracy, NSF NCAR's research on models must continue to move forward. As an example, researchers are experimenting with integrating aspects of Artificial Intelligence (AI), especially machine learning (ML), into numerical models ("physical ML"). In order to study the effectiveness of these approaches and measure their performance impacts, advanced computational and cyberinfrastructure must be available, particularly new hardware specifically optimized for AI. The research phases of this experimentation are separate from the day-to-day operational execution of prediction and forecast models. In support of research development, facilities must maintain multiple development platforms for porting and testing models using hardware from a variety of hardware vendors (NVIDIA, AMD, Intel). These platforms are made up of highly advanced state-of-the-art chips and storage systems.

Porting weather and space models to new chips and architectures takes skilled research scientists who frequently bring decades of experience to the task. This human expertise is sometimes overlooked. Leading edge experimental cyberinfrastructure and the research staff who have deep understanding of new hardware architectures' impact on models, are essential for retaining the country's edge in weather modeling and forecasting in this era of rapid hardware development and AI. The human capital in advanced research cyberinfrastructure, which takes decades to develop, has been developed over time within NCAR, and represents a critical asset to the weather community.

Existing resources for community weather models such as WRF and MPAS are increasingly insufficient to meet the growing demands of high-resolution simulations, ensemble forecasting, data assimilation, and emerging AI-based prediction systems. Advances in these areas require sustained access to cutting-edge computing systems and coordinated software development environments.

Centralized computational resources specifically optimized for weather and earth system modeling and prediction is a cost-effective way to satisfy the needs of the academic research community. Having centralized computational resources contributes as a nexus for academic

research, allowing the sharing of new approaches which contributes to maintaining US leadership in environmental prediction.

This training is increasingly valuable to industry partners developing their own forecasting capabilities. These capabilities are not replicated elsewhere in the US research ecosystem. To maintain and enhance national competitiveness in weather and climate prediction, NSF NCAR should expand investment in state-of-the-art computational systems at NSF NCAR that are dedicated to the unique computational and data management needs of community weather and Earth system modeling, data assimilation and AI-driven forecasting, while also expanding training opportunities for the next generation of atmospheric scientists.

Expand work force and institutional expertise to strengthen US scientific leadership.

The dedicated scientists and technical staff at NSF NCAR have played a central role in advancing atmospheric science and Earth system research. Their expertise in instrumentation, modeling, and interdisciplinary collaboration is a national asset. Significant reductions in staff or sustained funding instability risk the loss of critical institutional knowledge that has taken decades to develop. Top scientific talent requires stability and commitment to meeting their requirements for doing world-leading research in exchange for delivering foundational advancements in science. Other nations have developed programs to attract and promote top-tier weather and earth system scientists by offering this stability and support, while also developing frameworks for scientific progress and accountability. NSF NCAR should develop its own competitive plan to ensure that top scientific talent remains in the United States and accessible to its researchers in academia and industry. Further, it should provide critical domain-specific training in the use of high-performance computing and GPU-accelerated architectures for weather and climate models.

Strengthen partnerships and community engagement to grow interdisciplinary research.

NSF NCAR already plays an important convening role by hosting visiting scientists and coordinating major research initiatives. Expanding these interactions, including partnerships with universities, the private sector, and other stakeholders, could further accelerate scientific innovation. Programs that support visiting scientists for extended collaborations could help seed new interdisciplinary research directions while ensuring that NSF NCAR remains closely connected to evolving community needs.

Conclusion

As we have argued above, the most efficient and cost effective way to advance atmospheric science, protect public safety, and strengthen national competitiveness is through a coordinated national infrastructure. NSF NCAR is a proven, central pillar of that infrastructure in the United States and therefore should not be dismantled. Rather, NSF NCAR's research, training programs, and computational resources should be rededicated to promoting American scientific leadership

in weather and earth system sciences. This rededication does mean that NSF NCAR's should evolve, but this should be with guidance of the entire research community—academic, government, and industry—who are best equipped to determine the directions that will allow American science to remain cutting-edge. Continued support for this integrated approach will ensure that the United States maintains its leadership in weather prediction, climate science, and Earth system research while sustaining the training pipeline for the next generation of scientists.

Sincerely,

William Collins (Lawrence Berkeley National Laboratory) – Chair, CGD (Climate and Global Dynamics) Advisory Panel

Bart Croes – Chair, ACOM (Atmospheric Chemistry Observations & Modeling) Scientific Advisory Board

Belay Demoz (University of Maryland Baltimore County) – Chair, UCAR Community Programs (UCP) External Advisory Committee and Chair EOL (Earth Observing Laboratory) External Advisory Committee

Julie K. Lundquist (John Hopkins University) – Chair, MMM (Mesoscale & Microscale Meteorology) Advisory Board

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