

To: NSF Office of the Director

From: Anjali S. Bamzai, Ph.D., retd.

Subject: Feedback to NSF 26-203 Dear Colleague Letter [NSF Intent to Restructure Critical Weather Infrastructure | NSF - U.S. National Science Foundation](#)

I retired from NSF in December 2024. My federal service included working at NSF, DOE Office of Science, NOAA, and two details as Embassy Science Fellow at the Department of State. For the period 1998-2001, I was a rotator at NSF on an Intergovernmental Personnel Assignment from Rutgers University; my cumulative experience at NSF is 19 years, of which around 15 years were in the erstwhile Division of Atmospheric and Geospace Sciences (AGS). At NSF, I also worked in the Arctic Natural Sciences program in the Office of Polar Programs and, most recently, on NSF cross-directorate and interagency efforts across the federal government. I have in-depth knowledge on how programs at NCAR have contributed both to scientific discoveries in meteorology, atmospheric and climate sciences as well as applications ensuing from those discoveries for the public good, economic and national security.

Based on my experience at NSF, I can affirm that all along there was stringent oversight of NCAR as well as UCAR via the following mechanisms: (i) oversight by the [National Science Board](#); (ii) rigorous peer review of UCAR in securing the management of NCAR through a competitive process; (iii) and numerous periodic site visits by subject matter experts who scrutinized both scientific activities and management practices at NCAR. Furthermore, the UCAR Board of Trustees and the representatives of the 129-member institutions comprising UCAR met regularly to shape priorities and provide feedback in UCAR's management of NCAR on behalf of NSF. In short, NCAR's track record has been exemplary, and based on its numerous contributions, it is nothing short of a national treasure.

The basis for NSF's intent to restructure critical weather infrastructure is thus perplexing and entirely unclear to me. Has any site visit team recommended that NCAR be restructured? It is tantamount to standing down an FFRDC that is of vital importance to our economic, national and human security. Demolishing an FFRDC with a stroke of a pen is easy enough; creating new institutional structures that work better than what existed is well-nigh impossible without foresight, sound judgement, institutional knowledge, and careful deliberation between all relevant stakeholders. In the case of NCAR, the stakeholders are the following: academic researchers, federal scientists from other agencies, other governmental agencies (e.g., NOAA, NASA, DOE, DOW) the private sector, and the tax-paying public. Each of the above stakeholders benefits through leveraging the innovative research and applications conducted at NCAR in unique context-dependent ways.

It is my sincere hope that all options relating to restructuring NCAR will be assessed for their potential to contribute to scientific discovery and ensuing societal benefits. Political consideration and other narrow interests must not be factors of consideration, instead, consideration of efficiencies, public good, and ensuring R&D global competitiveness in the atmospheric and related sciences must be kept paramount in the decision-making. At the outset

of any plan to restructure NCAR, there must be a clear understanding of what challenges are being addressed; a careful deliberation of the pros and cons of each option being considered; and the necessary inclusion of input from stakeholders. Else there will be unintended consequences and impacts.

The rationale for the change is not alluded to in the second DCL of January 23, 2026. Dismantling and/or restructuring of institutions, particularly those (e.g., NCAR) that have demonstrated a high impact on their community and society-at-large, is not something to be done in a cavalier manner. Decision impacts fall under the following three categories: large (1), moderate (2), and low (3). There are also associated risks and rewards with decisions: large (1), moderate (2) and low (3). As described in my feedback below, I cannot identify any (1,1) decisions in terms of (high impact, high reward). NSF should be very aware of the (low/high impact, high risk) decisions because, as my feedback indicates, these are the most prevalent. The absence of an integrated FFRDC such as NCAR does not bode well for our Nation's future competitiveness in atmospheric and related sciences.

Below I offer perspectives on the following topics: (1) NSF Personnel and organizational change in oversight of NCAR; (2) Restructuring contrary to enhanced Efforts that address the Administrations FY 27 R&D priorities; (3) Atmospheric Sciences to Earth System Science: Towards an Integrated Earth System perspective; (4) Crosscutting Education and Training programs at NCAR and (5) Unsolicited input on NWSC and two Aircraft. These are under subheadings 1.1, 1.2, 1.3, 1.4, and 1.5, respectively.

Next, I provide input on specific issues/questions in the DCL: (1) Input sought on space weather, weather research infrastructure, and Mesa Lab; and (2) Response to questions at the end of the DCL. These are under subheadings 2.1 and 2.2, respectively.

1.1 NSF Personnel and Organizational change in oversight of NCAR

Even the harshest critics of NSF acknowledge that the agency is run with a level of efficiency that rivals the private sector. The overhead is ~6%, and the expertise program directors is top-notch. Having said that, I submit there has been considerable disruption in oversight of NCAR on the part of NSF over the past couple of years. Over the past several decades, a member of the career Senior Executive Service provided oversight of NCAR. Contrary to this, in the past two years, there has been substantial turnover in personnel change in terms of program officers with responsibility for the management and oversight for the NCAR; as many as three program managers in the short space of a couple of years! This personnel change at NSF has occurred under the backdrop of a major reorganization at NSF itself, with oversight of NCAR moving under the Chief Officer Research Facilities (CORF) in the Office of the Director (O/D)

When NCAR was founded, its budget was reported under a separate line along with all other NSF facilities. Over the years, there was a realization that a facility needs to be in proximity to the scientists who utilize the facility. This optimized scientific outcomes from both the smaller

bottom-up PI-funded grants and the larger research infrastructure. I have studied and described this in the article [The role of NSF in climate science](#). Thus, ships were moved to GEO/OCE, NCAR was moved to GEO/AGS, and so on. That way, the synergies between facilities and the scientists using the facilities were optimized. Program directors with oversight responsibility of facilities/infrastructure maintained close interactions with those overseeing science programs. This is particularly important for an FFRDC with an institution with a broad integrated portfolio as NCAR. With the recent transfer of facilities to O/D CORF, the program officers with deep scientific expertise on NCAR are in the directorates, while NCAR itself is under O/D CORF. We are back to the future!

A long-term stable relationship between the NSF program officer and the leadership team at UCAR is absolutely crucial to achieve the deliverables under the UCAR Cooperative Agreement. I reiterate that the NSF reorganization has resulted in distancing the facilities from the users of the facilities, as well as Program Officers with subject matter expertise and institutional knowledge from the erstwhile Division of Atmospheric and Geospace Sciences in the Geosciences directorate. The intent to restructure NCAR should be made deliberately. The applications of the research NCAR conducts result in tremendous economic growth in diverse sectors such as agriculture, energy, transportation (particularly but not exclusively aviation), insurance, environment, recreation and tourism, human health, and national security. The research ecosystem NCAR fosters is like no other institution in the US or abroad: it enables businesses to utilize the latest technologies, thereby ensuring US global competitiveness.

1.2 Restructuring contrary to Enhanced Efforts on Administration's FY 27 R&D priorities

NCAR has a wide array of topics in its portfolio, including substantial efforts addressing FY 27 Administration priorities enunciated in [Memorandum M-25-34/NSTM-2 to Heads of Executive Departments and Agencies](#). The NSF's intent to restructure does not acknowledge that dismantling parts of NCAR runs contrary to the fact that some efforts at NCAR that are well-aligned with the priorities laid out in the memo will face adverse impacts.

There are five R&D budgetary priorities; including Artificial Intelligence and Quantum S&T. Polar regions research is also called out; the rapidly changing conditions in the Arctic have national security, commerce, infrastructure, and transportation implications. In Antarctica, leadership is expressed through a world-leading science program. Under Preparedness and Resilience, agencies need to improve the Nation's safety and resilience by *'anticipating, preventing, responding to, and recovering from threats and natural disasters. Such R&D priorities should be risk-informed and encompass, as appropriate, integrative approaches across threat and hazard domains, including cyber and electromagnetic attacks on critical infrastructure, supply chain weaknesses, power grid vulnerabilities, resiliency, airspace threats, biological threats, severe terrestrial and space weather, and other geophysical hazards.'*

The Administration's FY 27 R&D memo calls for *'a focus on high-value research efforts.'* In this regard, the rate of return for investments in the R&D efforts at NCAR is tremendous. Progress

in Earth System Science ensures the nation remains environmentally intelligent. Given the Administration's focus on polar research, I note the [Polar Climate Working Group \(PCWG\)](#) is a consortium of scientists from universities and national labs who are interested in modeling and understanding the climate in the Arctic and the Antarctic, and how polar climate processes interact with and influence climate at lower latitudes. In addition to conducting scientific modeling experiments, the Polar Working Group develops and maintains the sea ice model component. ([CICE](#)) used in [CESM](#), a fully coupled state-of-the-science global Earth system model.

Harvesting predictability towards the development of early warning systems of severe weather, sub-seasonal to seasonal predictions, and longer time scales ensures sound risk management. E.g., the insurance and reinsurance sector can leverage the transformative potential of AI and data analytics to ensure it is resilient in the face of a crisis and prepared for the challenges it may face.

Any potential restructuring needs to be undertaken with foresight as deleterious impacts may very well lead to a diminished enterprise: e.g., will sectors (e.g., agriculture, defense, reinsurance, financial services) be reduced to relying on Punxsutawney Phil for guidance on risk management of assets? A hasty restructuring impacts not only the next-generation of STEM researchers in the field but also jeopardizes the innovation pipeline that drives our economy, national security, and global competitiveness.

Recognizing that today's most urgent challenges require not only new knowledge but also new pathways to accelerate advances to impact, in 2022, Congress passed the CHIPS and Science Act to create the Technology Innovation and Partnership (TIP) Directorate. TIP represents the most significant structural evolution at NSF in decades, designed to accelerate technology to the market and society, prepare a competition-ready workforce, harness the full geography of innovation across the nation, and strengthen U.S. competitiveness. Through programs such as the NSF Regional Innovation Engines, Translation to Practice (TTP), and NSF Tech Labs, TIP fosters collaboration across universities, industry, government, and philanthropy to turn ideas into impact.

The success of these partnerships being fostered within TIP pertains directly to the Earth System Science conducted at NCAR. Society will need to confront and address weather extremes via resilient infrastructure and planning. It would be a mistake on the part of NSF to downplay the potential impacts of global environmental change and not provide research and application communities the research infrastructure required to make advances in those areas as well.

1.3 Atmospheric Sciences to Earth System Science: Towards an Integrated Earth System perspective

Over the years, NCAR has evolved to cover major components of Earth System Science, keeping abreast of how observing/understanding/modeling/predicting the coupled Earth System. Starting

with individual components such as atmosphere, ocean, land, etc. that represent with fidelity processes, an enormous effort has gone into coupling the components. It is the predictive capability of the Community Earth System Model that gives our Nation its competitive edge across time scales, be it on the battlefield through environmental intelligence and situational awareness, or be it the economic sector through spurring innovation and stimulating business growth.

Scientific discovery depends on a combination of distributed (i.e., PI-led) and top-down (e.g., community-driven and societally determined) efforts. NCAR contributes to both of these and is particularly important for its role in bringing researchers from different disciplines together to learn from and provide leverage for each other's efforts. Let's not miss the next big discovery in Earth System Science by placing our research facilities in silos of the components of the Earth System rather than studying the coupled Earth System Science. It would be a travesty to the public good if the research infrastructure at NCAR is geared solely towards weather research, just as we are poised to make advances in the fully coupled Earth System.

NCAR's eight labs and programs collectively cover a breadth of research topics in Earth System science, from the effects of the Sun on Earth's atmosphere to the role of the ocean in weather and climate prediction, as well as supporting and training the next-generation of Earth system scientists. The laboratories and programs (Atmospheric Chemistry Observations and Modeling (ACOM), Climate and Global Dynamics (CGD), Computer Information and Systems Laboratory (CISL), Education, Engagement and Early Career Development (EdEC), Earth Observing Laboratory (EOL), High Altitude Observatory (HAO), Mesoscale and Microscale Meteorology (MMM) and Research Applications Laboratory (RAL) have niche areas of team science, spanning phenomenological understanding on a host of space-temporal scales.

Co-location of these labs in one Center enables lateral collaborations between the labs and programs, that produce synergies in team science that are not possible at other academic institutions, in part because NCAR is expected to work at developing tools and large instruments through sustained, stable funding on behalf of the broader community it serves. This has resulted in the whole being greater than the sum of the parts. It has also resulted in positive amplification of the dissemination of scientific outcomes and U.S. global scientific leadership in the field. The scientific endeavor is greatly diminished by the restructuring and siloed approach.

A strong integrated NCAR will ensure continued advances in Earth System Science for the public good. Recent examples of such scientific discoveries are the following: [new computer simulations that reveal the Earth system in unprecedented detail](#); insights on [ozone photochemistry in fresh biomass burning smoke over the United States](#); research to [advance warnings of space weather events](#) that, if successful, allow agencies and industries to mitigate impacts to GPS, power grids, astronaut safety; and [air pollution from wildfires that burn buildings](#).

1.4 Impact of Crosscutting Education and Training Programs at NCAR

The EdEC program engages, trains, and provides educational development opportunities for the next generation of scientists and engineers, the broader Earth system science community, and the general public. It prepares students and early-career scientists for careers to work in cutting-edge fields such as severe weather observation and modeling, space weather prediction, and new technologies like artificial intelligence and machine learning. The Advanced Study Program has an excellent track record in terms of mentoring scientists and engineers as they prepare to enter the field. EdEC collaborates with the university community by training mentors, providing teaching tools, and funding faculty to do research with NCAR.

The Computational & Information Systems Laboratory (CISL) creates public exhibits at the NCAR-Wyoming Supercomputing Center (NWSC) and runs a summer internship. The Earth Observing Laboratory (EOL) runs a variety of activities, including online resources and open houses for local communities during field campaigns. The High Altitude Observatory (HAO) maintains resources about our Sun and eminent solar scientists.

1.5 Unsolicited input on NYSC and Two Research Aircraft:

The atmospheric and related sciences community has been unnerved by the pace at which changes are being made to the NCAR research ecosystem through the issuances in the past couple of months. The decision on NWSC and two research aircraft is being communicated with little information input that was taken in the NSF decision-making process. [NSF News of December 17, 2025](#) stated *Specifically, NSF will explore options to transfer stewardship of the NCAR-Wyoming Supercomputer to an appropriate operator; divest of or transfer the two NSF aircraft that NCAR manages and operates; and redefine the scope of modeling and forecasting research and operations to concentrate on needs such as seasonal weather prediction, severe storms, and space weather.* [NSF DCL of January 23, 2026](#) stated *The NCAR-Wyoming Supercomputing Center (NWSC), located in Cheyenne, Wyoming, and two research aircraft (a Gulfstream V and an EC-130) are being considered separately from this DCL.* Language in [NSF News of February 12, 2026](#) stated *The U.S. National Science Foundation has informed the NSF National Center for Atmospheric Research (NCAR) that management and operations of the NCAR-Wyoming Supercomputing Center are expected to transition to a third-party operator consistent with the terms of NSF's cooperative agreement with the University Corporation for Atmospheric Research.*

Finally on February 20, 2026, NSF personnel acknowledged that NSF is in conversations with the University of Wyoming to manage NWSC. I also read in press articles that a ‘comprehensive review’ of NCAR is underway. What would be the process and timeline for this review? In the meantime, would the ~ 2000 scientists who use the supercomputing systems be able to undertake their R&D without disruption? The American Academy of Actuaries has expressed [concerns](#) that reinsurers currently face uncertainty regarding access to foundational data that helps measure and model extreme weather losses. Did NSF conduct an analysis on the impact of the proposed changes in the M&O of NWSC on the economy or interact on this with stakeholders such as the American Academy of Actuaries?

Did program officer(s) or senior managers at NSF, or the NSB, with oversight of critical weather infrastructure, identify any inefficiencies at CISL that necessitate this transfer? In the past, as/when issues came up in the management of specific facilities at an NSF FFRDC (e.g., NWSC at NCAR), the institution managing the FFRDC for NSF (e.g., UCAR in this case) typically worked with NSF to address issues successfully in close discussions with program officers and senior management. I see the process being followed for dismantling as vital an institution as NCAR as a departure from the merit review and oversight processes set in place at NSF.

Regarding the two aircraft, they can be moved to either NOAA, NASA, or the private sector. Moving to NOAA would potentially result in increased capacity for operational-related missions; this would be at the expense of no longer meeting the research needs of the atmospheric and Earth System Sciences community that NCAR was set up to serve in the first place. On the other hand, moving the aircraft to an agency like NASA ensures, to a certain extent, that researchers funded by NSF (be it the atmosphere cluster in the Geosciences directorate or Office of Polar Programs) can continue to pursue scientific investigations that may not have immediate benefits in operational prediction but rather enable operational advancements in due course of time. My recommendation thus is to move the aircraft to NASA so they are available to the research community for future field campaigns. The interactions and synergies with the atmosphere cluster in Geosciences and development of airborne instrumentation (through funding streams such as Major Research Instrumentation (MRI), Midscale Research Infrastructure (Ms-RI-1, MsRI-2), and Small Business Innovation Research (SBIR)) would be greatly weakened in the long run if NSF divests itself of the aircraft.

2.1 Input on Specific Feedback Sought on space weather, weather research infrastructure, and Mesa Lab:

While not submitting an expression of interest in M&O for observing capabilities described in the DCL, I stand ready to provide my scientific and programmatic expertise in atmospheric and related sciences. Furthermore, as Past-President of the American Meteorological Society (AMS), and current member of the Executive Committee as well as Council, I am committed to working with my colleagues in AMS leadership to enable any discussions that NSF may need to bring together the public, academic, and public sectors in addressing the issues at hand.

Below, I offer my perspectives on what is beneficial for the public good in terms of R&D, applications, and services.

The NSF is eliciting expressions of interest for the M&O of various observing facilities in space weather and weather research infrastructure at NCAR through the DCL. Restructuring and dismantling parts weakens overall integrated team science that the community conducts in all three sectors...federal, academic, and private sector. It also weakens the understanding of the phenomena across spatial and temporal scales. For example, research infrastructure in observational capability (e.g., EOL) is enhanced by the presence of research infrastructure in modeling/simulation (e.g., MMM, ACOM, and CGD) and vice versa.

The fragmented nature of data sources, heterogeneous formats, and steep technical requirements have long limited who can participate in research, slowing the pace of scientific discovery. NCAR has fostered a vibrant and connected research ecosystem. There is no mention of the research infrastructure that NCAR provides in several areas, including atmospheric chemistry and climate. Will that remain intact as NSF restructures the weather research infrastructure? Generally speaking, an FFRDC is mission-driven to achieve what cannot be achieved through grants to individual researchers. With the dismantling, there is a loss of connective tissue that NCAR has effectively provided to the R&D community, and through the scientific outcomes and their applications, to the Nation.

1. NCAR Space Weather Activities:

- **Management and operations of space weather-related observational platforms, modeling, and science as a stand-alone activity.** Space weather science should not be a stand-alone activity from the science of the lower atmosphere. The whole Sun-Earth System should be studied to make sure scientific advances are accelerated in terms of feedbacks, forcing, and coupling of elements of the Earth System. Separating space weather platforms, modeling, and science as a stand-alone activity is not in the best interests of either the space weather community or the lower atmosphere community. The nation needs interdisciplinary and system-wide efforts that exceed the perspective and abilities of any individual scientist. As currently structured, NCAR offers a unique research ecosystem to do precisely this.
- **Management and operations of space weather-related observational platforms, modeling, and science, combined with other NSF investments/facilities.** In terms of science, there are already synergies between researchers who use the data from the Daniel K Inouye Solar Telescope (DKIST) facility and those who rely on space weather data provided by Geospace Facilities. The two communities meet regularly at workshops, e.g., Geospace Environment Modeling (GEM), Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR). I have attended these workshops that bring together scientists from NOAA and NASA as well. The Whole Atmosphere Community Climate Model (WACCM) is a comprehensive numerical model, spanning the range of altitude from the Earth's surface to the thermosphere. The development of WACCM is an inter-

divisional collaboration that unifies certain aspects of the upper atmospheric modeling of HAO, the middle atmosphere modeling of ACOM, and the tropospheric modeling of CGD, using the NCAR Community Earth System Model (CESM) as a common numerical framework. Furthermore, WACCM-X extends WACCM to the upper thermosphere and includes processes important to the ionosphere. All this has been possible only through the existence of a center such as NCAR. An initial reductionistic approach of lower and upper atmosphere is good for a start, however as the field has evolved, one absolutely needs to consider the coupling between the two. Combining the geospace with facilities such as those that were formerly in the Mathematics and Physical Sciences directorate at NSF may achieve economies of scale, however space weather is a niche field with a small community of experimental scientists and modelers. It may very well get neglected in a merger with the larger community of space scientists. Furthermore, other agencies e.g., NASA, have leveraged the HAO lab to accomplish their agency needs.

2. NCAR weather modeling and atmospheric observing capabilities:

- **Management and operations of weather-related observational platforms, modeling, and science as a stand-alone activity.** I do not believe a stand-alone activity is desirable or warranted. Interactions and coupling take place on a host of spatial and temporal time scales. Weather is an initial value problem, longer time scales, e.g., climate, the coupling between the atmosphere, ocean, and other components of the Earth System becomes crucial. The coupled Earth System needs to be considered via an Earth System Science framework. E.g., on the topic of wildfires, consideration of wildfire urban interface, strength of materials of buildings to ensure resilience against wildfires, etc., need to be addressed. Ironically, the intent to restructure NCAR is being considered just as one of NCAR's most noteworthy modeling projects (i.e., Model Prediction across Scales, MPAS) has gotten the nod to become the core of NOAA's next-generation unified model, a framework used for day-to-day weather forecasting as well as other applications in both operations and research. To make the weather predictions by the National Weather Service at par, if not better than predictions by ECMWF, a concerted effort is needed to utilize emerging technologies, e.g., AI, to harvest predictability and eventually predictions. NCAR's role in this is integral in terms of scale interactions between the shorter, i.e., weather, and longer, i.e., sub-seasonal to seasonal, and climate. Early lead times to phenomena such as drought, heat, and cold waves provide the U.S. a competitive edge in terms of planning, be it the closing of operations on an oil rig in the Gulf, or be it moving assets to a region dealing with wildfires.
- **Management and operations of weather-related observational platforms, modeling, and science, combined with other NSF investments/facilities.** Additional synergies between NSF investments/facilities, the M&O, the weather-related observational platforms, modeling, and science can be explored with the operational prediction at NOAA and DOD.

3. The NCAR Mesa Lab (located in Boulder, Colorado)

- **Ownership of the NSF NCAR Mesa Lab building for private use.** The state of Colorado donated the land on which the Mesa lab exists. As described by Joseph Bassi in his 2015 book entitled [A Scientific Peak: How Boulder Became a World Center for Space and Atmospheric Science](#), the once Wild West city of Boulder rose to become a leader in space and atmospheric sciences. The local residents supported raising money via bonds for the land that was donated to the federal government. Through the decades, the Mesa Lab has become a ‘scientific Mecca’ for generations of scientists. Given the history and the iconic nature of the building, it should not be used for private purposes. Additionally, if the NSF passed on ownership of Mesa Laboratory in Boulder for private use, it risks hitting an [unexpected obstacle](#): a 65-year-old city ordinance that could cut off city water to the building if it changes hands. In 1961, a measure was placed on Boulder’s ballot to make an exception to the rule and extend city water to the Mesa Lab — and only NCAR. It passed with nearly 80% of the vote. The measure amended the city charter to extend city water to specific tracts of land, on the condition that the land was “used to carry out the purposes and functions of the University Corporation for Atmospheric Research [UCAR], the National Center for Atmospheric Research [NCAR], or the National Science Foundation [NSF].”
- **Ownership of the NSF NCAR Mesa Lab building for public use.** I strongly recommend that the Mesa Lab be retained by NSF for use by NCAR researchers. The building is iconic, and thus it would be consistent with Section 3 (g) of Executive Order 14344, [Federal Register: Making Federal Architecture Beautiful Again](#). This building was designed by the renowned architect I.M. Pei, who was inspired by the Anasazi-inspired cliff dwellings of Mesa Verde in the American West. Despite NSF-imposed budget constraints, Pei managed to incorporate features such as bush-hammering of the concrete finish to blend with the surrounding area. It is a globally recognized icon of American architectural excellence. Space needs and usage can be optimized by working with UCAR. Any shortcomings or inefficiencies that have been identified during the oversight of NCAR should be addressed.

2. 2 Response to Questions at the end of the DCL

1. Are there any areas in which NCAR activities or capabilities duplicate those of other government agencies, universities, or the private sector? There have been periodic site visits of experts who address questions such as this. I suggest NSF program officers read past reports to check if, indeed, there is any major redundancy in NCAR activity or capabilities. Having said that, some level of duplication is necessary and desirable in science to ensure reproducibility and thus credibility. Different scientists and groups have different perspectives and abilities. They collaborate; compete, learn from one another, challenge one another, and drive one another forward. This is the foundational nature of the scientific enterprise.

When resources are limited, it is challenging to allocate those resources across the scientific enterprise. Two approaches are crucial and complementary: a) to avoid sub-critical investments and provide sufficient resources for scientific advancement, and b) to ensure the effective use of those resources. Rather than trying to assess duplication, per se, the emphasis should be on contribution to scientific advancement and resulting societal benefits. This might be assessed through a combination of: a) past successes, and b) future potential.

Past successes are relatively easy to quantify, and using that as a measure, [NCAR's past successes and impact on the daily lives of citizens](#) are extraordinary and compelling. The challenge is projecting into the future. Are there ways we can anticipate ROI? This is a more challenging area for all science and innovation, not just the case for NCAR. It is (likely) worth considerable effort to develop, but also requires enormous humility due to the likelihood of getting it wrong. It's been my experience that the converse is true. Agencies such as NOAA and NASA find it cost-effective and beneficial to their missions to provide \$s to take the R&D at NCAR to the next Technical Readiness Level (TRL). Similarly, the private sector works with NCAR scientists, primarily at RAL, to develop customized products crucial for their businesses. Having an institution like NCAR fosters the interdisciplinary science needed to meet today's challenges. In my discussions with colleagues in the insurance and reinsurance sector, they have stated that they rely on long-term data and model simulation outputs for the problems they are addressing. The small to mid-size companies do not have the wherewithal or incentives to maintain this kind of research infrastructure.

2. Are there transformative prospects for observational platforms and the resulting data that are currently unexplored or underutilized? NSF puts out calls such as MRI, MsRI-1, MsRI-2 for transformative approaches to observing, be it innovative instrumentation or observational platforms. Recently, funding was terminated for the Airborne Phased Array Radar (APAR) project. NCAR has been leading its development in partnership with other institutions. If successful, the APAR observations would enable huge advances in our observational capability of severe storms through a glimpse of 3-D structures at an unprecedented level. This observational capability would be of tremendous benefit to both the research and operational communities. It would also improve our forecasting of severe storms in the operational realm.

3. Are there other concepts for management and operations of NCAR activities that differ from the current model that NSF should consider? Typically, we look to alternate models to improve M&O of an existing institution where issues have been identified. Unfortunately, I can't think of another institution that NCAR could emulate, be it within the U.S., or overseas. UCAR's management of NCAR is a tried-and-true approach of enhancing innovation from individuals, PI-led curiosity-driven research through access to community tools, and a team-oriented approach of developing/building what the community needs in terms of state-of-the-science facilities. To these, we might add some innovation-enabling approaches. Can we use prizes? Or funding models to emphasize graduate students and postdocs, but less resources elsewhere?

It has been my experience that managers from other institutions, including those from other countries, look to emulate what NCAR is doing! Having said that, I'd like to add the following: over the past six decades of its existence, NCAR scientists have contributed to and enabled some of the greatest discoveries in the atmospheric sciences. Initially, the focus was the atmosphere, as the science progressed, we realized that the coupling of the atmosphere with the ocean (indeed, it is this element of the Earth system that provides the long-term memory and hence predictability beyond weather time scales), biosphere, and cryosphere are needed for a deeper understanding and improved weather and seasonal forecasts.

4. What should the performance objectives and metrics be for a restructured atmospheric research center? As I allude in my response to Question 3 above, a restructured atmospheric research center needs to evolve to embrace a fully coupled Earth System Science Center. This would be in keeping with the National Academies of Science, Engineering, and Medicine (NASEM) report that NSF commissioned a couple of years ago. Key aspects of the 2022 report entitled [Next Generation Earth Systems Science at the National Science Foundation](#) include taking an Integrated Systems Approach, moving beyond traditional, siloed research to examine the Earth as a system of interacting components, including human activities. It recommended advancing both curiosity-driven and use-inspired research and fostering convergence across disciplines. It also recommended building a capable workforce with the goal of producing actionable knowledge that aids in managing natural resources, mitigating disasters, and enhancing societal resilience. Indeed, NCAR has already embarked on this work, including through the development of convergence science approaches that are directly related to achieving the outcomes in that report; it is something that only an integrated center like NCAR can accomplish for the Nation.

In principle, performance objectives and metrics for an enterprise such as NSF NCAR need to assess across several dimensions, including the following: (i) contribution to the advancement of science and technology; (ii) usage of tools developed by the community of researchers in the field and beyond; and (iii) benefits of research outcomes to the broader public. Many measures and indices offer focus on one piece of the puzzle without taking a holistic view of metrics that reflect both scientific and technological advances as well as the public good. A revitalization of NCAR would need to be done in the absence of such 'fog of metrics'. Rather new quality metrics need to be developed, e.g. discarding growth at any cost versus quality productive measures in the public-private-academic partnership for sustained use of natural resources.

Thank you for the opportunity to provide this input.

Respectfully submitted by
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