NCAR weather modeling and atmospheric observing capabilities

The excellence of NCAR is advanced by its integration of observations and modeling of the atmosphere, and integration of scientific research and training. This structure facilitates knowledge transfer throughout the community, including people working at NCAR, members of the scientific community that attend meetings, visit or collaborate with NCAR, and trainees in the field. Importantly, NCAR has grown from an atmosphere-focused lab to an integrated Earth system lab, including research on hydrology, vegetation, climate, oceanography, cryosphere, wildfire, etc. Each of these subdisciplines benefits from the fact that they are all in the same place and exchange ideas and expertise. NCAR is a world leader in interdisciplinary and integrative Earth system science. One of the largest labs within NCAR is the Research Applications Lab (RAL), which hosts scientists from all subdisciplines, translating fundamental research into applied science. Any restructure that seeks to isolate these subdisciplines will weaken them individually and collectively, as they would need to overcome new institutional and physical barriers to obtain the same interdisciplinary exposure as they now have at NCAR. Again, the look towards other, more stand-alone centers provides clarity: they rarely outperform NCAR even in their respective focus area, despite their “stand-alone” activity approach. ECMWF, a world-leading weather forecasting center and often seen as superior to US modeling centers, explicitly embraces the need for coupled modeling to improve long-range prediction. As part of this vision, they broadened - not distilled - the number of experts and disciplines they include in their approach. It would thus be counter to current wisdom to separate the weather modeling and observing capacities from other research activities at NCAR.

NCAR Mesa Lab (located in Boulder, Colorado)

NCAR’s Mesa Lab was designed for the explicit purpose of facilitating collaboration among scientists and with the public. In addition to serving as the work site for some of NCAR’s staff, it serves as a meeting location for scientific meetings. Having a location relatively centrally to the US, with staff representing all sub-disciplines of the field, facilitates dissemination of knowledge and practice throughout the discipline. The Mesa Lab also serves the public through the museum that occupies a large area of the first two floors. This museum hosts individuals, families, and school classes.

NCAR serves as an essential hub for scientific exchange. Hosting meetings at NCAR in Boulder is significantly more efficient than hosting them in Ithaca; the proximity to a major international airport like Denver, combined with robust public transit and shuttle services, ensures higher attendance and better engagement. These gatherings keep students, faculty, and other

researchers at Cornell deeply integrated into the field. This collaboration is made possible by NCAR's unique relationship with the academic community through UCAR. By operating as a shared facility for the entire U.S. atmospheric science community rather than a single university, the Mesa Lab provides a neutral, accessible space that simply could not be replicated elsewhere.

The proximity of NCAR and the Mesa Lab to numerous engineering industries and federal agencies reliant on accurate atmospheric forecasts and modeling, such as the Bureau of Reclamation or USGS, allows for NCAR's expertise to flow back to the government and industry. This also attracts the best international scientists, as they can further their education and research while developing partnerships and collaborations with these entities.

Because the land was donated to NSF for the purpose of building NCAR, it would be inappropriate to transfer the property to private ownership. The buildings should continue to be used for their current purpose.

Are there any areas in which NCAR activities or capabilities duplicate those of other government agencies, universities, or the private sector?

No. NCAR's work does not duplicate other U.S. efforts; rather, its capabilities in atmospheric modeling, observation, and training are unparalleled globally. NCAR's open-source, community-driven models—headlined by WRF, CESM, and MPAS—are used extensively throughout the U.S. and around the world.

A core strength of NCAR's atmospheric modeling is its community-based approach. What this means in practice is that the code is both open source and support is actively provided for using the code as well as contributing to its development, and output from many model simulations is made publicly and freely available. The community engagement and support through mechanisms like Working Groups that involve both NCAR scientific staff as well as other members of the scientific community, and also liaisons that support community members in contributing to and using the models, are crucial for the models to be usable and useful by the community. Finally, NCAR provides tutorials on using their models, at NCAR as well as at scientific meetings, with materials that are openly, publicly, and freely available at any time afterwards. This accessibility creates immense value for the private sector as well; private companies indeed pull NCAR models 'off the shelf' and adapt them to specific commercial needs. Maintaining this level of usability requires a concentration of expertise and a mission-driven focus that neither a single university nor a private firm could replicate. By providing these open-source tools alongside dedicated support and training, NCAR ensures its

models remain both highly functional and indispensable to the global scientific and commercial communities.

There are other atmospheric models in the US, however, no others are community-based, and no others are truly open source. It is doubtful that any other entity asked to take this on would be able to match NCAR in these successes, with the institutional knowledge, established networks, and experience around community modeling that has been developed there over the course of decades. For example, NOAA's GFDL modeling center develops atmospheric models. However, they do not have a history of making the code publicly available, nor of providing training for using their models. DOE has an earth system model that includes the atmosphere; this model started not long ago from a checked-out version of CESM. While their model is nominally open source in that the code is available online, they do not provide meaningful support or training for using the computer. The training aspect of NCAR's community structure cannot be overstated. The pipeline of scientists going to GFDL and DOE, as well as the private sector, is filled with people having used NCAR models during their education.

Are there other concepts for management and operations of NCAR activities that differ from the current model that NSF should consider?

No, the current structure whereby NCAR as an entity integrating observing and modeling the atmosphere, with deep involvement and collaboration with the academic and broader community, serves the community to an excellent degree and should be maintained.

One aspect of excellence that is enabled by NCAR's integrated structure is training. NCAR's training programs include tutorials on modeling and observing platforms, summer programs on various topics, internship programs for undergraduate students, visiting programs for graduate students and for faculty, and postdoctoral programs including a centralized fellowship as well as a large number of postdoctoral positions organized within individual projects.

Many of us carried out postdoctoral training at NCAR, including three through the Advanced Studies Postdoctoral Fellowship program. The ASP program's activities involve engagement across NCAR, providing a broad base of experience to build on in the future. More generally, postdoctoral training at NCAR is envisioned to and succeeds at integrating NCAR and its activities with other parts of the scientific community, including universities. In addition, NCAR hosts many graduate students with its official Graduate Visitor Program, as well as unofficial visits by graduate students. By developing relationships at NCAR and gaining experience working with the models there, and then starting a research group at a university, former NCAR

trainees are poised to continue collaborating efficiently and effectively, contributing to the advancement of atmospheric science and also to NCAR's activities. For example, Angie Pendergrass's ongoing research projects continue to advance model evaluation. Another example of a recent project leverage advances in physics to understand parameter sensitivity of atmosphere models; this project brings together her deep experience from NCAR with university collaborators. The project made use of model tutorial materials shared online by NCAR to train an undergraduate student and a physics postdoc to use the model, and doing so efficiently since they were able to have computing accounts on NCAR's supercomputer to learn about and then actually run the model on a system supported by NCAR. This is emblematic of the advantages of NCAR integrated approach to modeling and computing, and to research and training.

NCAR was created to take on modeling and observational challenges that were too big for one university to take on; this need is very much still present to this day, and we think the best way to continue to meet it is by continuing to support NCAR.

Another aspect of integration that has enabled NCAR's excellent community modeling is its integration with advancing computing, specifically the NWSC. For that reason, it is essential that moving forward access to computing that can be used by model developers as well as members of the scientific community continues, and that it keeps being supported by the robust expertise developed at NCAR over the years.

What should the performance objectives and metrics be for a restructured atmospheric research center?

- Excellence in modeling and observing the atmosphere to advance our knowledge and understanding of it
- Continuing to support the research community - including the university community - in atmospheric science research, through modeling that is open-source, freely available, and supported, at a scale that makes it feasible for individual research groups to continue to use models for mechanistic experiments
- Continuing to integrate research and applications, in order to translate basic research into applications, as well as inform basic research questions with needs of users, decisionmakers, and society. Note that this integration arises naturally from NCAR's current structure, and is one of the reasons it has been so successful.
- Full participation in model intercomparison, evaluation, and verification activities in order to document, maintain, and improve upon the current state of the art
- Documentation of research progress through publications in the scientific literature

- Providing freely available data (including observations, models, and model output) for noncommercial research and educational purposes
- Shared governance with the research community, including universities (for example, through working groups)

By a lot of measures, NCAR models and its community working group structure are the best-performing ones - because and not despite NCAR's structure. For example, WRF-Hydro was selected as the basis for the National Water Model, CESM regularly ranks at the top of global model intercomparisons, and MPAS was just selected as the dynamical core for the NWS efforts. If the performance objective is to develop the best models and aid in training the best scientists and the metric is the world-wide uptake of those models and scientists, then NCAR is likely the most successful atmospheric modeling center in the world. Breaking up this structure is inconsistent with the ambition to improve its performance, and would greatly harm the pipeline from atmospheric science research to the applications that benefit the US public and economy. In fact, there is no other institutional structure one could point to as inspiration to do this better. Thus, it will be very challenging to prove if a restructure was successful and very easy to prove if it was unsuccessful - with the latter being much more likely.

Signed[1],

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