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M E M O R A N D U M

To: Bob Corell, Mike Hall, Charles Kennel and Ari Patrinos

From: Tim Barnett, David Randall, Bert Semtner and Richard Somerville

Subject: Strengthening the United States National Climate Modeling Effort

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1. THE CRISIS IN U. S. CLIMATE MODELING

Many climate researchers in the United States and abroad realize that the U.S. is no longer the world leader in climate modeling. Today, Germany appears to be in first place, with the United Kingdom in second. The U. S. is at best third and may well be lower. By any measure, the American effort is falling seriously behind that of Europe and, perhaps, Japan. The current crop of U.S. models is technically less sophisticated, observationally less well verified, and physically less complete than the best foreign models.

This need not be so. American scientists are as talented and as well educated as those abroad. We enjoy generally adequate funding in the modeling area, and except for a few years in the 1990s we have had the world's most powerful computers at our disposal. General circulation models of both the atmosphere and the ocean were first developed in the United States. Today, however, as the generation of American scientists who pioneered climate modeling approaches retirement age, there is a crisis in the field. Unless the U. S. moves quickly and decisively to reinvigorate its effort, it may be relegated to permanent second-class status in this critical area of Earth science research.

Our purpose in this memo is first to briefly outline three strategic options for regaining the lead in global climate modeling that the U.S. enjoyed as recently as the early 1980s. Then, we argue for adopting one of these three options.

2. THREE OPTIONS FOR PROGRESS

Option I: Further increase funding at existing modeling centers

The government might simply increase the funding and thus the level of effort at one or more of the existing climate modeling centers. Indeed, much excellent research has already come from these centers, which developed some of the first modern climate models. Additional funding would

surely have some positive effect.

In our view, however, it is not money which has been the primary rate-limiting factor in the progress made recently at these centers. Instead, we think that organizational and managerial factors, together with personnel issues, have kept these centers from maintaining the lead they once held. Too often, relevant research by outstanding scientists, at a variety of U.S. institutions, has not been well-integrated into the modeling efforts. In particular, the centers have not benefited optimally from scientific advances made elsewhere, especially in academia, despite the fact that the U.S. has a proud history of climate model development in academia, dating back to the 1960s, and including some very important work.

In sum, we think that the option of accelerating progress by simply adding funding will fail without also making major changes in the management and institutional cultures of the existing centers.

Option II: A new center for climate modeling

A new modeling center could be created. This would be a hard sell politically in these austere times, given that several modeling centers already exist. In addition, it is unlikely that many of the best scientists would willingly leave their present positions to staff the new center.

Option III: A distributed national climate modeling program

We believe that creating a Distributed National Climate Modeling Program is the most promising strategy for the U.S. to regain international preeminence in global climate modeling. A prototype distributed program already exists in the form of DOE's CHAMMP program. CHAMMP, which is distributed over multiple laboratories and universities, has successfully brought together specialists in ocean/atmosphere processes, numerical methods, and computer applications. Under the auspices of CHAMMP, we have seen the development of a close collaboration involving NCAR, GFDL and several university groups with the Los Alamos National Laboratory to implement two different oceanic general circulation models and an atmospheric general circulation model on massively parallel computers. A Distributed National Climate Modeling Program could be built on the CHAMMP framework. Such an effort would require multi-agency funding and management. It would also require a focusing of effort and a directed management approach to the science and engineering aspects of the program. One key is good management of people and existing resources. Good management will not suffice, however, without good scientific ideas.

3. A THREE-TIER STRUCTURE FOR THE DISTRIBUTED PROGRAM

We envision a Distributed National Climate Modeling Program with three elements, or tiers.

Tier I: The U. S. National Climate Model

Tier I would maintain and make available to a community of users a single U. S. National Climate Model, initially encompassing the atmosphere, oceans, sea ice, and land surface, and eventually extending to the full climate system, including biogeochemical aspects. The National Climate Model need not be centralized at a single institution, however, particularly now that we have entered the era of the network. Computing, model development, and even consultation can be spatially distributed.

We emphatically do not advocate that the U.S. have only one climate model, both because model development can benefit from competition, and also because groups dedicated to model development need to maintain control of their own research strategies. We do believe, however, that it is important that the U.S. have a single formally designated National Climate Model, and that the climate modeling expertise that is distributed throughout the U.S. flow effectively and continuously into this model, in order to keep it at the very forefront of the state of the art.

We also consider it essential that the National Climate Model support a large community of users, in order to ensure thorough testing and evaluation. A significant level of infrastructure would be needed to support this user community. A history of strong feedback from a large and active user community is one reason that the Europeans dominate today. We advocate, therefore, that groups in U.S. universities and national laboratories which are performing climate simulations but are not focused on model development should be strongly encouraged to use the U.S. National Climate Model.

Tier 2: Model development research

Tier 2 would provide a solid foundation of climate model development research, to feed into the National Climate Model. This model development research should not be centralized or regimented and need not be based directly on use of the National Climate Model itself, because the best new ideas can come from anyone, anywhere. In particular, model development research should continue to occur both in national laboratories and in universities.

The academic community is especially well positioned to produce new discoveries and innovation. As already mentioned, the U.S. has a proud tradition of such work. University-based model development groups are needed to train the next generation of modelers. Students do not learn the art of climate modeling simply by running a community model developed in a distant laboratory by people with whom they have little interaction. Aspiring young modelers can learn best through close, student-advisor interactions with those who are actually developing the next generation of models.

We advocate that model-development research in academia consist of two categories of efforts. The first would consist of a few Academic Model Development Centers set up at sites chosen via proposal, and funded for perhaps five years at a time, each at levels of up to several million dollars per year. The Academic Model Development Centers would operate in a manner similar to the NSF Science and Technology Centers. Much of the funding needed to support the Academic Model Development Centers could come from judiciously identifying and eliminating existing sub-critical modeling efforts.

The Academic Model Development Centers would not be responsible for providing community modeling services. The responsibilities of the Academic Model Development Centers would be to create new ideas that would be funneled into the National Climate Model, and to train students. It is essential to set up and maintain a well-defined mechanism to ensure that ideas are in fact effectively transferred from the Academic Model Development Centers to the U.S. National Climate Model. The lack of such a mechanism today is a major reason for the weakness of the U. S. modeling effort.

There should also be a larger number of smaller university-based climate modeling projects, each

of which might focus on one particular aspect of model development. These smaller efforts would be arranged more informally, essentially through the standard proposal and peer review procedure, but we think that it is important to acknowledge explicitly that such small projects can and should make important contributions to the overall national effort.

Tier 3: Research on climate variability

Tier 3 would consist of a strong program to explore climate variability systematically, based on a hierarchy of models and statistical methods, and centered around model applications and understanding of the basic physics of climate processes as represented through the development of simplified models, rather than numerical model development. Tier 3 activities should occur in both universities and laboratories. It is important that the Tier 3 research involving climate model applications be based on use of the National Climate Model, rather than on a hodgepodge of models from a variety of sources, so as to maximize feedback on the performance of the National Climate Model.

4. IMPLEMENTATION

It is our view that through the three-tier, Distributed National Climate Modeling Program described above, the United States can regain world leadership in climate modeling. We suggest that these concepts be set down and developed further in a concise National Climate Modeling Plan, which should be focused on the production of practical results. The National Climate Modeling Plan would be revisited once per year.

Implementation of our suggestion would bring about several key changes from the current situation. First, the U.S. would soon have an officially sanctioned, world-class National Climate Model, supporting a large user community and producing results needed by policy makers and others. Second, a system of designated Academic Model Development Centers would be put into place, and a formal mechanism would be set up to ensure that high-quality new ideas are promptly implemented in the National Climate Model. Third, the U.S. would have a clearly defined, inter-agency National Climate Modeling Plan that would spell out how the contributions of the various participants in the U.S. climate modeling effort fit together to make a coherent but decentralized national climate modeling research enterprise.

We think that the participation of the scientific community is essential for putting such a program in place. We advocate a high-level review of the current status of the U. S. climate modeling effort.

We would welcome the opportunity to discuss this proposal with you and to help in implementing the program.