White Paper: Federal Climate Services and Academic Institutions

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Summary

We recommend that NOAA base its strategic direction on the development of climate services as federated centers of activity; that is, to turn the current fragmented assets into distributed coordinated assets. This strategy recognizes the cultural and mission diversity of the existing units. Expenditures would be made at the interfaces between organizations to achieve strategic goals. Such a federated approach recognizes the rapid evolution of scientific investigation, information technology, technological development, policy evolution, and adaptation requirements. When taken as a whole, such an organization has the ability to adapt and the risk of organizational failure is mitigated as the probability of all performing units underperforming is small.

Academic institutions, both individually and in consortia, are an essential element of these federated services because they represent far more than research and education. They reach into regions, states, and localities to answer real-world problems; they are critical to economic success, and are natural places where individuals, organizations, governments, and corporations converge for problem analysis and development of solution paths. Academic institutions permeate society and are pre-existing conduits that link research, applications, and operations to accelerate the development and to increase the benefit of federal climate services.

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Background

This white paper is in response to the Request for Information from the National Oceanographic and Atmospheric Administration's (NOAA's) Climate Program Office. The Request for Information focuses on "developing priorities for a limited set of academic/research centers that work with NOAA to improve its capabilities in aspects of climate, climate prediction and efforts to bring climate science and information into policy and decision making."

The challenge of organizing the nation's assets in climate change research to best serve our ability to address the impacts of climate change is enormous. Recent recommendations highlighted the need to restructure the organization of federal funding of climate change research for better integration and coordination across the physical, environmental and social sciences and especially across problems of policy and science.[2] Federal assets are distributed both within agencies such as NOAA and across many agencies.[3] As concern expands beyond the physical science of climate change to the impacts of, and adaptation to, climate change, agencies such Departments of Agriculture, Interior, and Transportation emerge as important players, and data sources from agencies such as the United States Geological Survey (USGS), National Aeronautics and Space Administration (NASA), and the Environmental Protection Agency (EPA) become critical. Fundamental research of the climate at the National Center for Atmospheric Research (NCAR), and more extensive research programs in Earth science, social science, and cyberinfrastructure supported by the National Science Foundation (NSF), provide unique information which needs to be integrated into the climate services. Regions, states, and municipalities are developing plans and policies to address climate change. Corporations are actively responding to the conclusions of climate change science; non-governmental organizations are developing positions on climate change and energy policy. Academic institutions are building broad-based capabilities in climate change and sustainability.

The fact that the impacts of climate change affect all aspects of society is expressed in the activities that are evolving in the organizations listed above. The conflation of issues in the near-term and long-term, both local and global, requires the diligence of both sustained management and the flexibility to respond to new knowledge and changing, competing priorities. The complexity faced in addressing climate change means that no single entity, agency or centralized service can scale to "own" climate change. The intellectual resources in existing and emerging climate-interested communities are broad and deep. These communities provide opportunity for integration and the acceleration of our nation's ability to address the challenges of climate change. Therefore, NOAA's climate services need to function with and contribute to a federated community of organizations and institutions in the spirit of the open innovation communities that have evolved in the past decade.[4] Such communities have proven effective in addressing complex problems ranging from the development of the Linux

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[2] National Research Council, 2009: *Restructuring Federal Climate Research to Meet the Challenges of Climate Change*, National Academy Press, Washington, DC (pre-publication edition).

[3] Historically, the agencies most strongly associated with scientific investigation of the physical climate of the Earth and climate prediction are: National Oceanographic and Atmospheric Administration, National Aeronautics and Space Administration, Department of Energy, and the National Science Foundation.

[4] See, for example, Kogut, B. and A. Metiu, 2001 and other references provided at the end.

operating system and geographical information systems to the *Encyclopedia of Life* focused on organizing biodiversity.[5] Within NOAA, an analogous philosophy needs to be nurtured to allow existing NOAA assets to function in concert with each other to accelerate the development and use of state-of-the-art climate information in problem solving.

We envision the academic/research community to be a key component of this federation of organizations, which are distributed units with focused functionality. These units do not sit in a hierarchical organization with centralized management. Rather they sit in relation to each other in a way that might be viewed as biological; the units and the relationships among units change as new problems emerge and old problems are solved. Functional units range from modeling centers such as the Geophysical Fluid Dynamical Laboratory (GFDL) and the National Centers for Environmental Prediction (NCEP), to the federation of data centers that comprise national and international climatic data services (e.g. National Climatic Data Center (NCDC), the National Aeronautic and Space Administration's (NASA's) network of Distributed Active Archive Centers, the Department of Energy's (DOE's) Program for Climate Model Diagnosis and Intercomparison (PCMDI)), to NOAA Regional Integrated Sciences and Assessments (RISA) centers, to governmental, non-governmental, academic, commercial and personal actors on regional, state, urban, and local scales.

The academic/research community naturally resides in this spectrum of actors. We feel, strongly, that to identify the academic community as a community engaged only in research describes the role of the academic community too narrowly. Academic institutions come in many forms. There is, to be sure, fundamental research on, for example, the physical climate, hydrology and the roles of and impacts to social and ecological systems. The academic community also provides, uniquely, other pieces essential to national climate services. Academic institutions run programs to train first responders in public health, a group of people already concerned about how to incorporate climate change into their strategic plans. Business schools at universities engage corporations directly in analysis and development of solution paths for problems such as carbon management. Economists work to help quantify the value of carbon dioxide emissions and ecological services, which sit at the very basis of climate change policy. Many academic institutions work in partnership with their regions, states, and cities to help solve specific problems that are faced by the constituencies that support them. Academic institutions are often a successful way to reach into decision support communities through, for instance, agricultural field stations and extension programs. Research at academic communities involves not only scientific investigations, but also ways to build sustainable structures and ways to improve the interface between the results of scientific investigation and the use of that information in society as a whole (*e.g.* integrated assessments). ***It is this full range of the activities at academic institutions that needs to become part of the climate services of the nation.***

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[5] Linux: http://www.linux.org/
Geographical Information System: http://www.opengeospatial.org/
Encyclopedia of Life: http://www.eol.org/index

The remainder of this white paper outlines the scope and role of the academic institution in a national climate service. This is followed by a general description of a putative climate service and how, specifically, academic institutions might fit into the federated community of functional units that might comprise a National Climate Service.

The Scope of the Academic Institution in the Climate Service

Academic institutions in the United States cross the entire gamut of training, research, and assessment needed by society. For example, community colleges train emergency health technicians; professional schools train project managers, resource managers, lawyers, business and management specialists, policy analysts, and practitioners; universities train both pure and applied researchers and educators. The role of the academic institution, however, extends beyond the boundaries of research and education. For example, state schools are often directly tasked with improving the economic foundation of the state or contributing to research that supports the management and conservation of resources. This requires reaching into commercial sectors and government agencies to address both near-term and long-term problems.

The activities of academic institutions and the challenges posed by climate change intersect in a way that uniquely position academic institutions as an essential part of the nation's climate change services. The following examples make this point:

> Research universities provide an ideal setting for the multidisciplinary research required to understand the causes, evolution, and consequences of climate change. The answers to these questions, and therefore a path towards climate change mitigation and adaptation, lie at the interface of earth system science, economics, public policy, and other fields. Universities are a critical nexus for interaction among these communities.
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> Global warming will increase the occurrence of heat waves that threaten human health. A first line of response is with emergency medical providers, who if alerted to heat-related illness can provide appropriate therapy. Mitigation of urban heat extremes is carried out through urban planning and landscape architecture. Academic institutions provide access to both practical solutions and abstract analyses that require the use of information about climate change.
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> Global warming is linked to the burning of fossil fuels for energy. Universities are at the leading edge of developing alternative forms of energy and analyzing, for instance, the relation of water resources to energy generation. The problems of energy generation, energy security, and climate change are entangled. Academic institutions pioneer the prototyping of real-world systems and both use and inform knowledge of the climate system.
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> Ultimately, much of our energy consumption is used in building and maintaining structures ranging from highways to skyscrapers. Tying together architecture and engineering to conserve resources, to anticipate changing environmental conditions, and to accommodate evolving technology is essential for a sustainable future. This integration will be led through research and education.

Public policy and environmental professional schools train policy makers that go into federal, state, and local governments as well as non-governmental organizations. Environmental law and environmental economics will be key elements of the policies developed to address climate change. The knowledge generated by the scientific investigation of climate change is part of base which generates this policy, and the policy impacts climate change.

Business schools perform case studies for existing and emerging businesses; they are often directly associated with new startups. Both the predictions of climate change and evolution of policy affect the infrastructure investments of businesses (*e.g.* power plants, factories, *etc.*). Strategies for participating in future carbon markets and carbon management will be required for going forward.

Nongovernmental organizations and regional governments bring to universities projects such as forest management, land reclamation, freshwater protection and conservation, and ecosystem restoration. These projects will be key elements of climate adaptation and contribute directly to action by these organizations.

Research communities in many fields are interested in the impacts of global warming and changes in the water budget on their disciplines. These communities are largely self-organizing and cross academic and federal institutions. They range from hydrological research, to water resource management, to public health, to agricultural productivity, to faith communities concerned with environmental stewardship. Universities are a center of activity for these groups.

Academic institutions are, therefore, far more than research and educational institutions. Academic institutions are where governments, non-governmental organizations, corporations, and individuals come to for neutral-ground, real-world problem solving. Self-organizing communities develop around critical mass centers of expertise and interest. Academic institutions will provide the climate service with research, education, assessment, problem solving, and direct access to local-to-regional decision makers that are representative of regional and national priorities. They will accelerate the evolution and benefit that NOAA's climate services will have. Climate change will impact all of society, and academic institutions offer an effective pathway into society - and those who will be responsible for the future of society's success.

Towards a National Climate Service

The call for a National Climate Service has been stated in different ways, explicitly and implicitly, for more than 15 years. The imperative motivated by the 2007 Intergovernmental Panel on Climate Change[6] and the Obama Administration's policies on science make it likely that federal climate assets will be inventoried and organized into a strategic set of services. Currently, these assets are spread both within and across several agencies, and other agencies have an increasing interest in the results of the scientific investigation of the Earth's climate and the impacts of global warming.

[6] Intergovernmental Panel on Climate Change: http://www.ipcc.ch/

There have been formal and informal efforts to better integrate federal assets in climate change activities. Two notable activities are the U.S. Global Change Research Program, formed by Congress in 1990, and the U.S. Climate Change Science Program (CCSP), which followed from an Executive Branch initiative in 2001.[7] The Climate Change Science Program strives to integrate climate information derived from the full range of U.S. agencies. Still, though, there remain formidable barriers between agencies, disciplines, research, and applications. In order to break down these impeding barriers, new approaches to organization, management, and governance are needed.

NOAA holds a substantial fraction of the federal assets in the investigation of climate change. NOAA has also traditionally provided weather products, assuring the delivery of forecasts, providing environmental warnings, and taking weather observations. There is a history of service to society. It is natural to anticipate that climate services would be provided by the Federal government, and it is natural to anticipate that NOAA would be the leading provider of climate services. Climate and climate change will be of increasing importance to federal, state, and local governments. Likewise, businesses, resource managers, non-governmental organizations, and others will all need climate information for decadal planning and assessing the impact of near-term decisions on the long-term. Many of the issues that motivate the need for climate information are not, first and foremost, issues of climate change; however, they are related to climate change. That is, climate change typically exacerbates the problems decision makers already deal with. Therefore, it is critical that a climate service provide the current best, science-derived climate information in the context of that myriad of existing issues.

There is both opportunity and risk in the development of a NOAA-based Climate Service. Simply realigning and repackaging existing capabilities as a Climate Service would not provide the best the United States could offer. Coordinated strategic behavior is required both within NOAA, and for NOAA within the Federal and non-Federal community of those interested in climate information. The development of strategic capabilities using current NOAA assets requires transformational activities at all levels of the organization. This calls for a fundamental transformation at the Agency level – not simply reorganization.

Centralized organizations are a conventional response in the Federal government. However, we are wary of the development of a centralized Climate Service at the federal level, because centralized organizations are contraindicated for organizations that rely upon the uncertain outcomes of continuous research to provide the best products and services at any particular time. Centralized organizations rarely achieve their goal of changing institutional cultures and eliminating the competition for budgetary, bureaucratic, and mission turf.

Rather than trying to eliminate or manage this historical and natural fragmentation through the power of the centralized institution, we assert that there is opportunity in the rich environment of intellectual capabilities spread across NOAA, the government, and the nation as a whole. More than opportunity, there are both creative and productive tensions that need to exist to support the best research and to provide the best service. For example, the impacts community in the Department of Agriculture should be a

[7] US Global Change Research Program: http://www.usgcrp.gov/usgcrp/default.php
US Climate Change Science Program: http://www.climatescience.gov/

customer of the climate service. The customers should have numerous paths to possible solutions. The customers should not be collected into a single organization with the service providers on the assumption that climate information for one is climate information for all.

We recommend that NOAA base its strategic direction on the development of federated centers of activity; that is, to turn the current fragmented assets into distributed coordinated assets. This strategy recognizes the cultural and mission diversity of the existing units. Expenditures would then be made at the interfaces between organizations to achieve strategic goals. Such a federated approach recognizes the rapid evolution of scientific investigation, information technology, technological development, policy evolution, and adaptation requirements. When taken as a whole, the organization has the ability to adapt, and risk of organizational failure is mitigated as the probability of all performing units underperforming is small.

Likewise, at the Federal level, NOAA needs to view its participation in a federated service made up of assets of multiple agencies. No single agency or laboratory holds all of the assets required to meet the mission of providing climate information. Existing services exist both inside and outside government. The functioning of the climate service involves directing customers to the resource that is required to provide science-based information to meet the customer's need. Hence, the climate service has an element which is that of a portal or a gateway. The leadership of the Climate Service, which should include members from multiple agencies and the community as a whole, then identifies services that require development and direct resources towards developing those needed capabilities.

We suggest that NOAA develop a strategy that is consistent with modern concepts of open innovation or open communities – a generalization of the open source software culture.[8] Such communities have proven effective in addressing complex problems, ranging from the development of the Linux operating system and geographical information systems to the *Encyclopedia of Life* focused on organizing biodiversity.[9] Success will require the development of community governance models, which include, at times, the definition of process for building and modifying capabilities. We emphasize that governance and attention focused, directly, on definition and accomplishment of strategic goals is mandatory. This requires both bottom-up and top-down development of strategic capabilities. This is far different from the current situation.

Recognizing the successful attributes of the Climate Process Teams, the Regional Integrated Science and Assessment Centers, and the Applied Research Centers,[10] we propose that NOAA develop an Agency-wide strategy which incorporates these middle-sized activities as key strategic elements. Specifically, focused, integrating activities and projects should be defined at the interface between organizations to realize strategic goals. Specific goals help to make decisions in a complex system. Well chosen projects

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[8] See, for example, Kogut, B. and A. Metiu, 2001 and other references provided at the end.

[9] Linux: http://www.linux.org/
Geographical Information System: http://www.opengeospatial.org/
Encyclopedia of Life: http://www.eol.org/index

[10] Climate Process Teams: http://www.usclivar.org/CPT/CPT_Concept.pdf
Regional Integrated Science and Assessment Centers: http://www.climate.noaa.gov/cpo_pa/risa/
Applied Research Centers:
http://www.climate.noaa.gov/cpo_pa/cdep/index.jsp?pg=./cpo_pa/cpo_pa_index.jsp&pa=cdep&sub=arcs.jsp

will have short-term benefit and contribute to long-term development. Some of these activities should be chosen in a competitive way that assures innovative potential. This effectively leads to a strategy with activities executed in units ranging from small (e.g. research group) to middle (e.g. single organization) to large (e.g. multi-agency) scales. There is direct attention by management to assure the transfer of knowledge and technology across these units, hence, across scales. These will, by their very nature, link research with applications and with operations – the loop will go both ways. With this vision, a major role of the Climate Service is the integration of climate knowledge.

NOAA must recognize the importance of the information technology infrastructure necessary to support its science-based generation of products and services. While several U.S. agencies support research into cyberinfrastructure, the implementation of effective cyberinfrastructure is a difficult and troubled enterprise. An evaluation of the scale of the information technology infrastructure needed would likely reveal that the cost scales with the cost of personnel. Such expenditures demand sustained strategic planning and implementation. Such an infrastructure is a necessary ingredient for improving the research-to-applications-to-operations-to-research integration. NOAA will have to assume a lead role in the development of this infrastructure. Again, we recommend building on successful, dispersed developments with federated organizations, focused on specific goals defined by a series of strategically selected projects.

Specifics of Academic Institutions in the Climate Service

NOAA currently supports activities ranging from individual research grants to national labs containing thousands of people. Examples of existing, intermediate size assets that accumulate expertise for specific purposes are the Regional Integrated Science and Assessment (RISA) Program and Applied Research Centers. The NOAA Cooperative Institute programs provide a vehicle for aligning university activities with NOAA laboratories and, potentially, climate service goals.[11] These programs are a natural place to include academic institutions into the federated climate service described above. We will explore some of the differences that might distinguish, for example, a RISA from our vision of an organization composed of the same scale of entities in a new National Climate Service.

The following paragraph is from NOAA's web page describing the RISA program:

> *The Regional Integrated Sciences and Assessments (RISA) program supports research that addresses complex climate sensitive issues of concern to decision-makers and policy planners at a regional level. The RISA research team members are primarily based at universities though some of the team members are based at government research facilities, non-profit organizations or private sector entities. Traditionally the research has focused on the fisheries, water, wildfire, and agriculture sectors. The program also supports research into climate sensitive public health issues. Recently, coastal restoration has also become an important research focus for some of the teams.* (from: http://www.climate.noaa.gov/index.jsp?pg=./cpo_pa/cpo_pa_index.jsp&pa=risa&sub=5)

[11] NOAA Cooperative Institutes: http://www.nrc.noaa.gov/ci/

We envision that one set of assets that make up the climate service are regional in focus. That is, we recognize the regional and local attributes that distinguish one region from another. We also recognize that a region focused on agricultural interests, for example, might differ from a region focused on energy interests. That is, there are many facets that define how climate services might be organized. We assert that functional organizations should form around those interests that benefit from a critical mass of intellectual and financial resources being focused on a problem. There needs to be a reason for bringing small pieces together to provide something different than the simple sum of the individual parts. There is a need for analysis and assessment. The current RISAs recognize many of these attributes.

The description of the current RISAs focuses on research, and primarily on research on the impacts of environmental change on natural resources and humans. This is important. However, far more is needed when looking towards climate services. The climate service needs to recognize that the customers, those interested in climate knowledge, extend far beyond the research community. There is substantial, evolved intellectual capital outside of the community of scientists. In our vision of the academic institution in the National Climate Service, their role extends beyond simply applied and basic research by scientists. It extends into states and localities, based on their natural relationships; it includes the full range of activities that exist in academic institutions. The role is, also, altered by having the academic institution participate in the governance of the climate service; they are not simply recipients of federal funds. These are fundamental differences from the current RISA program. More generally, our vision of participation of the academic institution in Federal Climate Services is far different from the current culture of grants and contracts; it is far more strategic and participatory.

Compared with the current RISAs, this new role of the university expands beyond research on the environment and how climate change might impact the world of the decision makers. There are, today, many problems being brought forth by concerned and informed organizations, corporations, governments, and individuals, and academic institutions that are key to connecting climate information and problem solving for these organizations. Academic institutions are imbedded in society and address both practical and fundamental problems. Businesses and new ventures bring case studies to universities for solutions. Resource managers work with universities to develop new techniques for environmental stewardship. Policy makers ask for studies of the impact of policy options. Economists study the efficacy of environmental markets to control pollutants.

More is needed, however, than the exposition of knowledge. In order to be effective, what to do with that knowledge must be developed - action paths are required. Then the skills to pursue those paths must be taught. As these problems are addressed, the solutions or paths towards solution and the successes and failures of actions need to be accumulated into an open knowledge base. It is only once this entire end-to-end system is developed that we will optimize our ability to meet the challenges of climate change. Universities are uniquely positioned to make these links. NOAA’s strategy should include academic institutions as strategic assets, and NOAA should strive to accumulate the results of these activities to the benefit of the United States and the planet as a whole.

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