

Appendix B

Public-Private Provision of Weather and Climate Services: Defining the Policy Problem

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Note: The committee commissioned the following white paper from a leading expert on policy issues related to weather and climate services. Dr. Pielke's views, as expressed below, may not always reflect the views of the committee or vice versa.

INTRODUCTION

In the United States a broad and interrelated set of government, private, and academic entities provides weather and climate services. For present purposes, a weather and climate service is defined to mean information provided about the past, present, or future state of features related to the atmosphere with the intent that decision makers will use such information to their benefit. The various entities that comprise the nation's weather and climate services enterprise evolved a great deal over the twentieth century with little discussion or debate of appropriate roles and responsibilities, with a few notable exceptions. Even so, the United States is among the most advanced (if not the most advanced) nations in the world in the efficient production and effective use of weather information. Yet as science, technology, markets, and demands related to weather information evolve, lack of discussion or debate of appropriate roles and responsibilities has the potential to limit future progress of the nation's weather and climate services enterprise.

In those few cases where discussion and debate have occurred, satisfactory resolution has not. Consequently, many have arrived at differing and conflicting expectations about roles and responsibilities of the various entities that provide weather and climate services. A policy problem exists to the extent that these differing expectations impede the development and delivery of products and services that would have value to decision makers.

Roles and responsibilities for the provision of weather and climate

services differ by sector. The National Weather Service (NWS), non-NWS government agencies, academia, and the private sector each play a unique as well as shared role in the provision of services. Because of the overlap and blurring of activities among these sectors it is important not to ascribe monolithic status to any one of them. For instance, universities and government labs are involved with commercialization of research as a result of government policies that encourage technology transfer. For-profit companies routinely compete with federal labs and universities for federal research dollars. These same entities compete with each other for contracts for the provision of services to companies and foreign governments. The NWS relies on a range of contractors and purchases a number of services from the private sector to fulfill its mission. Further, the complex tapestry of sectors, institutions, and services means that to understand the proper role of any subset requires some sense of the whole. Like the blind men and the elephant, partial perspectives are likely to mislead.

The purpose of this paper is to define the policy problem associated with the present state of roles and responsibilities within the weather and climate services enterprise. Recommendation of alternative courses of action goes beyond the present focus. The paper begins with a discussion of issues centered on particular “sectors,” noting however the considerable difficulty associated with identification of clear boundaries between sectors. It needs to be emphasized that many examples are provided in the text below in order to illustrate the complexities involved in issues of roles and responsibilities. Such examples are meant to be illustrative and diagnostic, not prescriptive; no claim is made here as to the appropriateness or inappropriateness of the activities discussed. However, this is the essential point of the paper: in many cases, it is difficult if not impossible to judge which actions are appropriate and which are not, given the lack of community agreement on roles and responsibilities.

UNDERSTANDING COMPLEXITIES IN ROLES AND RESPONSIBILITIES WITHIN THE WEATHER AND CLIMATE SERVICES ENTERPRISE

The National Weather Service

The NWS and its predecessors have for more than a century had legislative authority for governmental provision of weather services. In this role, agency officials have long been sensitive to potential conflict with the private sector.

Contemporary debate is quite similar to debate on this topic that took place more than a half-century ago. Following World War II, numerous military meteorologists found themselves returning to life as civilians and

**Box B.1 Six-Point Program on Public-Private
Sector Relationships**

1. Advise all field offices that industrial meteorology is a legitimate field of endeavor and should be encouraged and aided by the Weather Bureau in the interest of the national economy.
2. Advise all organizations now served by the Weather Bureau that they are not getting an individualized and specialized service (i.e., added information and/or more service than is normally given the general public) and furnish them with a list of consulting firms approved for teletype service.
3. Advise individuals or organizations seeking specialized services that it is not a Weather Bureau function and with their consent refer the matter to the Central Office of the Weather Bureau for transmittal to the American Meteorological Society and the meteorological consultants.
4. Advise all Weather Bureau personnel that they should be alert to point out and develop cases in business where the employment of a consulting meteorologist would aid in developing applied meteorology.
5. Accept grants from individuals or organizations for research and statistical surveys only when they cannot be accomplished by or with private consulting meteorologists.
6. The service of looking after interest of private concerns and the initiating of special advice for commercial uses is the field of consulting meteorology and the Weather Bureau will make it a practice to refer to the field of consulting meteorologists requests for services of this kind.

SOURCE: American Meteorological Society, 1949, Report of the executive secretary, 1948, *Bulletin of the American Meteorological Society*, v. 30, p. 140-141.

seeking to use their expertise in weather to make a living.¹ The resulting growth of commercial weather services led the American Meteorological Society (AMS) to arrange for a conference in 1948 “to clarify the relationship between the Weather Bureau and private meteorologists.” This conference resulted in an agreement between the chief of the Weather Bureau, representatives of Industrial Weather Consulting Services, and the AMS. This agreement was titled the “Six-Point Program” and is reproduced in its entirety in Box B.1. The agreement was, however, never adopted as formal policy by the Weather Bureau.²

¹American Meteorological Society, 1949, Report of the executive secretary, 1948, *Bulletin of the American Meteorological Society*, v. 30, p. 140-141.

²Weather Bureau, 1948, Policy with respect to private practice of meteorology and instructions regarding cooperation with private meteorologists, Circular Letter 22-48, March 9.

Perhaps seeking to get out ahead of the AMS agreement, two weeks prior to the AMS conference the Weather Bureau issued a “Circular Letter” to all of its offices on “Policy with Respect to Private Practice of Meteorology and Instruction Regarding Cooperation with Private Meteorologists.”³ The letter stated, “All employees should be familiar with the policy on extension of applied meteorology and development of private meteorological services to meet commercial and industrial requirements beyond the scope of government services.” The letter cautioned, “The Weather Bureau must not permit an impression that it has ‘exclusive rights’ in the science and practice of meteorology.” The letter provided the following guidance for determining if a particular service was appropriate for the Weather Bureau:

Usually, a question on whether a private request is within the province of a government service or should be referred to private sources can be decided by comparison with similar cases in other professions, such as engineering or law. In analogous cases the matter is one for a private engineer or a lawyer, it probably falls within the province of the private meteorologist.

The guidance provided by the letter was apparently inadequate or insufficient to resolve debate for long because in 1953 the Department of Commerce (DOC) convened an Advisory Committee on Weather Services comprised of eight meteorologists—of which six worked in the private sector, one for the AMS, and one for a university—to review and evaluate “civil weather matters” with a focus on the public-private sector issue.⁴

The committee found the “Circular Letter . . . does not clearly establish the relationship between the Weather Bureau and private meteorologists” and recommended that it be “cancelled” in favor of the AMS Six-Point Program.⁵ The committee found that the ambiguity resulted, at least in part, because

the organic act under which the Weather Bureau still functions was written at a time long before present developments and applications of the science to business and industry could have been envisioned. It is necessary, therefore, that a redefinition of functions be made to recognize the changes since that time. . . . While all of the recommendations of this report can be implemented under the existing organic act, we feel it is desirable that a study be made to determine whether the basic law should be revised.⁶

³Weather Bureau, 1948, Policy with respect to private practice of meteorology and instructions regarding cooperation with private meteorologists, Circular Letter 22-48, March 9.

⁴Advisory Committee on Weather Services, 1953, *Weather is the Nation's Business*, Department of Commerce, U.S. Government Printing Office, Washington, D.C., p. 6.

⁵Advisory Committee on Weather Services, 1953, *Weather is the Nation's Business*, Department of Commerce, U.S. Government Printing Office, Washington, D.C., p. 45.

⁶Advisory Committee on Weather Services, 1953, *Weather is the Nation's Business*, Department of Commerce, U.S. Government Printing Office, Washington, D.C., p. 2.

Since the 1950s, debate has waxed and waned. In the early 1980s, the Reagan administration proposed the privatization of government weather satellite operations. A protracted and public debate ensued.⁷ Weather satellite operations were not privatized, but the debate created sufficient impetus for the NWS and the private sector to discuss codification of roles and responsibilities. One result was NWS adoption in 1991 of a statement on the public-private partnership in the provision of weather services.

According to the 1991 statement, “the primary mission of the NWS is the protection of life and property and the enhancement of the national economy.”⁸ The report introduces specific guidance on proper roles and responsibilities of the government and private sector. “The NWS will not compete with the private sector when a service is currently being provided or can be provided by commercial enterprises, unless otherwise directed by applicable law.”⁹ No guidance is provided on how the policy would be implemented, including mechanisms for dispute resolution, oversight, sanctions, and accountability to the policy. Not surprisingly, little evidence can be found to suggest that either the NWS or the private sector had interest in reconciling the ambiguities resulting from the 1991 policy. Perhaps more accurately, actors in the NWS and the private sector saw in the 1991 statement what they wanted to see and acted accordingly. Evidence for this conclusion is found in debate that occurred during the late 1990s when the Commercial Weather Services Association (CWSA) spearheaded an effort to formalize in the NWS legislative mandate the language of the 1991 statement. The NWS objected. The CWSA legislative effort did not succeed.

The 1991 policy statement, like its predecessors, was insufficient to reconcile debate about roles and responsibilities. In a 1997 review of the NWS conducted at the bequest of the Secretary of Commerce before taking over as NWS administrator, General Jack Kelly wrote:

The 1890 Organic Act contains some outdated wording and does not reflect the current capabilities of the private sector weather industry. Within the NWS, government agencies (both Federal and local) and the private sector, disagreement exists as to what is the appropriate mission for and the level of services and products required from the NWS. A review (U.S.

⁷P. Cox, 1983, Fair weather: Government weather forecasting soaks taxpayers to shower benefits on special interests, *Reason*, June, p. 23-30.

⁸National Weather Service, 1993, Policy and guidelines governing National Weather Service and private sector roles; *NWS Operations Manual* Chapter A-06, July 30, 1993, <<http://www.nws.noaa.gov/im/a06toc.htm>>.

⁹In response to a comment raised during the public comment period the NWS pointed to the fruit-frost program as an example of a service provided in competition with the private sector due to a mandate in legislation.

Congress or DOC) should be conducted to determine the NWS mission for the 21st Century and lead to an updating of the Act.¹⁰

Similar sentiments have been expressed by many members of the private sector.¹¹ So despite the existence of an NWS policy statement since 1991 on the provision of weather services by NWS, debate continues unabated on proper roles and responsibilities.

The primary reason for differing perspectives on roles and responsibilities related to the National Weather Service stems from a conflict inherent in the multiple missions that the agency is expected to serve. The frequently invoked Organic Act of 1890 gives the NWS responsibility for public safety through the provision of storm warnings *and* responsibility for enhancing economic activity. The relevant text is as follows (15 U.S.C. 9 §313):

The Secretary of Commerce shall have charge of the forecasting of weather, the issue of storm warnings, the display of weather and flood signals for the benefit of agriculture, commerce, and navigation, the gauging and reporting of rivers, the maintenance and operation of seacoast telegraph lines and the collection and transmission of marine intelligence for the benefit of commerce and navigation, the reporting of temperature and rain-fall conditions for the cotton interests, the display of frost and cold-wave signals, the distribution of meteorological information in the interests of agriculture and commerce, and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties.

If the NWS mandate were *only* to support economic activity or *only* to provide storm warnings it would be relatively straightforward to develop clear guidance for roles and responsibilities,¹² but the twin objectives can come into conflict. These twin objectives and the conflict that can result

¹⁰John "Jack" Kelly, in the Kelly Report, p. 58, <<http://www.publicaffairs.noaa.gov/nws3.html>>.

¹¹See, for example, the testimony before the House of Representatives Subcommittee on Energy and Environment by Michael S. Leavitt, on behalf of the Commercial Weather Services Association, April 9, 1997, 105th Congress, 1st Session; and by Joel Myers on behalf of AccuWeather, Inc., March 25, 1998, 105th Congress, 2nd Session.

¹²These dual objectives confound approaches to resolve public-private sector conflicts grounded in economic theory. If the NWS served only economic ends, the economic theory provides clear guidance (see, e.g., National Research Council, 2001, *Resolving Conflicts Arising from the Privatization of Environmental Data*, National Academy Press, Washington, D.C., 99 pp.). However, the public safety mandate trumps economics in many cases. Even so, economic issues lead to sources of conflict. Among these are ever lower barriers to entry for new providers of added value, technology-driven rapid obsolescence of past modes of delivering weather services, and the public-good "issues of scope" that arise when publicly funded data are used to create for-sale products.

were referred to explicitly by Jack Kelly in his 2001 address at the annual meeting of the American Meteorological Society:

The challenge for the meteorological community is to balance governmental responsibilities to provide warnings and forecasts for everyone subject to weather-related hazards with the private sector's responsibility to tailor forecasts for use by specific entities, build markets, and mitigate risk by developing more effective means to integrate weather, water and climate information into commercial business plans, strategies and decisions. While the National Weather Service and private sector entities each have distinct roles in the weather information dissemination process, we must continue working strategically as partners for the public good and the economic benefit of our country as a whole.¹³

Whatever one's views on the respective roles of government and the private sector, the existing NWS mandate necessitates reconciling missions established in law that have built-in conflicts. To date such reconciliation has not occurred, and the attempt to codify such reconciliation in the 1991 NWS policy statement is flawed according to both perceptions and practice.

Non-NWS Government

If the roles and responsibilities of the NWS can be characterized by attempts to grapple with conflicting missions established in law, non-NWS governmental roles and responsibilities might be said to have an opposite situation. Few missions are explicitly provided in law, leaving the provision of services to ad hoc implementation and oversight.¹⁴ At the outset, an important exception should be made for weather and climate services provided by the military in support of national security. Such services are beyond the scope of the present analysis, leaving for present discussion weather services provided by agencies such as the non-NWS National Oceanic and Atmospheric Administration (NOAA), Federal Aviation Administration (FAA), Department of Agriculture, and Department of Transportation.

Consider the range of issues raised by the following examples:

- The Aviation Digital Data System (ADDS) is an on-line tool that provides weather information to the aviation industry and is sponsored by the FAA, operated by the National Center for Atmospheric Research

¹³J. Kelly, 2001, Opportunities for 21st century meteorology: New markets for weather, water and climate information, American Meteorological Society Policy Forum, Albuquerque, N.M., January 17. <<http://www.ametsoc.org/AMS/atmospolicy/presforums/albq2001/kelly.pdf>>.

¹⁴Important exceptions are the Climate Services Act of 1975 and the U.S. Global Change Research Act of 1991.

(NCAR), and disseminated via the NWS Aviation Weather Center on a NOAA web site. However a disclaimer featured prominently on the ADDS web site notes that it is not a product of the NWS. The ADDS web site describes its mission as to “make available to the aviation community digital and graphical analyses, forecasts and observations of meteorological variables.”¹⁵ The FAA has plans to use ADDS as the basis for briefings provided to commercial pilots.¹⁶ In this case a “quasi-operational” product is provided essentially outside the NWS using some NWS infrastructure.

- A nonprofit corporation (University Corporation for Atmospheric Research [UCAR]), operated under the government’s Federally Funded Research and Development Center (FFRDC) program and supported by public funds, capitalized a subsidiary private company, Weather Information Technologies, Inc., or WITI.¹⁷ WITI worked closely with a publicly funded research entity also under UCAR management, the National Center for Atmospheric Research, on projects such as using National Weather Service weather forecast models to provide information to consumers by zip code¹⁸ and competed for and won a \$15 million contract to provide Hong Kong with consultative services for the design of a new airport.¹⁹ WITI was sold in 1999.

- The Forecast Systems Laboratory (FSL) of NOAA provides wind profiler systems and consulting on such systems to the U.S. Department of Defense, National Aeronautics and Space Administration, and Department of Energy, as well as the governments of Canada, Australia, New Zealand, China, Japan, and the European Union.²⁰

- The Department of Transportation, in its Intelligent Transportation Systems program, sponsors an initiative called FORETELL in partnership with several state governments and the Canadian government, and operated by a private sector contractor, Castle Rock Services.²¹ The goal of the initiative is to provide weather information to public and private sector decision makers.²² The federal government has a wide range of experience at the interface of public institutions and private entities.²³

¹⁵<<http://adds.aviationweather.noaa.gov/projects/adds/info/>>.

¹⁶T. Horne, 2002, ADDS on the move, *LOPA Pilot*, January.

¹⁷<<http://www.bcbr.com/sep96/witi2.htm>>.

¹⁸<<http://www.ucar.edu/communications/staffnotes/0009/ucarf.html>>.

¹⁹<<http://www.ucar.edu/communications/quarterly/fall93/prscorner>>.

²⁰<<http://www.fsl.noaa.gov/~vondaust/fir99/fir99c.html>>.

²¹<<http://www.foretell.com/help/Foretell/about.htm>>.

²²<<http://www.its.dot.gov/TravelManagement/fortell.htm>>.

²³See, for example, General Accounting Office, 1995, *Government Corporations: Profiles of Recent Proposals*, GAO/GGD-95-57FS, Washington, D.C., 62 pp.

Each of these examples, and these are but a few of many possible such examples, illustrates the significant degree of activities that fail to fit any “textbook” description of weather and climate services. The situation is made more complex by the various government policies encouraging the commercialization of government technology, including the role of FFRDCs. Given the complexity of governance and incentive structures in the context of the lack of formal policies or procedures, it would be extremely difficult for participants with differing perspectives to arrive at judgments of proper roles and responsibilities of non-NWS government providers of weather and climate services. Nor is it at all clear if anyone has responsibility for coming to such judgments.

Academia

If the provision of weather and climate services by non-NWS government agencies can be characterized as complex, then the provision of weather and climate services by organizations in academia is akin to the “wild wild west” where a frontier mentality reigns. As weather and climate services have demonstrated increasing value in the economy, members of the academic community have rushed to cash in. Although consulting by academics has a long and respected tradition in the atmospheric sciences and many established private sector meteorological services firms had their origins as university start-ups, the recent decade has seen explosive growth in the formation of such entities. The federal government has encouraged university-based technology transfer through legislation such as the Bayh-Dole Act of 1980.

Other reasons for this trend are the growing support among universities of commercial activities, which is itself motivated by federal policy, decreasing funding from state and federal sources, and the highly visible success of commercialization activities in other areas of technology such as biotechnology and information technology. In the atmospheric sciences there does exist a high degree of variability across institutions for the support of commercialization.²⁴

The twin influences of an environment that encourages commercialization and the fact that the atmospheric sciences have not yet gained the visibility (and thus demands for accountability) of other areas of technology mean that many activities are being initiated before the development of generally accepted criteria for proper roles and responsibilities. By way of

²⁴R.A. Pielke, Jr., 2001, *Weather Research Needs of the Private Sector: Workshop Report*, U.S. Weather Research Program, Palm Springs, Calif., December 2000. <<http://sciencepolicy.colorado.edu/pielke/workshops/private.sector/private.sector.report.pdf>>.

contrast, in other areas of technology policy such as biotechnology and information technology, there exists a history of debate and discussion of roles and responsibilities. In weather and climate services, the paucity of such discussion has set the stage for potential conflict.

Consider the complexities involved with the following examples:

- Northwest Research Associates, Inc.,²⁵ focuses primarily on performing research sponsored by the federal government. In early 2002 its web site stated that it operates an entity called Foresight Weather,²⁶ out of its Colorado-Research Associates²⁷ division subsidiary, focused on providing weather predictions to the energy industry. The Foresight Weather web site stated that it relies on scientists at the neighboring publicly funded National Center for Atmospheric Research to provide research and technology, and to serve as consultants in support of the products and services that Foresight Weather sells to its clients, primarily in the energy industry. NCAR is itself funded by the National Science Foundation (NSF) and other federal agencies to conduct research.
- Faculty at major research universities, such as Rhode Island, Oklahoma, North Dakota, Michigan, and others, operate or are otherwise associated with for-profit companies that provide weather and climate services. Many of these companies employ university graduate students working on government-provided grants and contracts focused on weather and climate research. Graduate student research can in principle serve the purpose of “killing two birds with one stone”—that is, providing knowledge in support of the government research grant obligation while at the same time contributing to a product or service sold for profit to a customer.
- The University of Oklahoma Department of Meteorology received \$10 million in support from the Williams Companies.²⁸ The department also receives considerable public support for research, including designation as one of the first NSF Science and Technology Centers. In the spring of 2002, the department announced that it would limit access to certain products because of its relationship with certain private sector partners. The department then took a step back from this announcement and announced that it was reconsidering its data access policies.²⁹

As is the case in the provision of services by non-NWS government agencies, coming to judgments of proper roles and responsibilities is

²⁵<<http://www.nwra.com/history.html>>.

²⁶<<http://www.fswx.com/home/intro.index.htm>>.

²⁷<<http://www.colorado-research.com/>>.

²⁸<<http://www.caps.ou.edu/news/williamsgrant.htm>>.

²⁹Information on the CAPS data policy is updated on-line at <<http://www.caps.ou.edu/wx/>>.

made difficult by the various federal and state policies and incentives for those in academia to foster commercialization of science and technology.³⁰ Yet, unlike that case, academia has struggled mightily over the past decade to establish general mechanisms for making such judgments in the context of biotechnology, information technology, and other areas that have shown large commercial potential. The Association of University Technology Managers has sought to collect a set of “best practices” in academia for assessing such roles and responsibilities.³¹ The application of such mechanisms to the atmospheric sciences is haphazard and unsystematic at best.³²

Private Sector

The provision of weather and climate services in the United States by the private sector occurs in a wide range of manners. Figure B.1 illustrates the terrain of private sector activities in relation to the National Weather Service “service flow.” It is important to recognize that while the NWS forms the foundation for a wide spectrum of “value-added” activities in the public and private sectors, there is a considerable (and underappreciated) set of activities also in the public and private sectors that provide weather and climate services *independent* of the NWS.

Many entities—particularly (but not limited to) television and other media—collect and report information on weather and climate independent of any government service. For example, in 2001 the American Meteorological Society presented an award to three Oklahoma television stations for their coverage of the May 3, 1999, tornado outbreak, which provided the public with details on the exact location and path of individual tornadoes unmediated by scientists or the government.³³ Many public and private organizations—ranging from the New York State Thruway Authority to State Farm Insurance to *USA Today*—collect weather and/or climate information for direct use or further dissemination to paying clients. A company called Global Atmospheric, Inc., owns the nation’s only lightning detection network and sells its products to a range of customers, including the National Weather Service, The Weather Channel, and the

³⁰R.A. Pielke, Jr., 2001, *Weather Research Needs of the Private Sector: Workshop Report*, U.S. Weather Research Program, Palm Springs, Calif., December 2000. <<http://sciencepolicy.colorado.edu/pielke/workshops/private.sector/private.sector.report.pdf>>.

³¹<http://www.autm.nct/index_n4.html>.

³²R.A. Pielke, Jr., 2001, *Weather Research Needs of the Private Sector: Workshop Report*, U.S. Weather Research Program, Palm Springs, Calif., December 2000. <<http://sciencepolicy.colorado.edu/pielke/workshops/private.sector/private.sector.report.pdf>>.

³³<http://www.nssl.noaa.gov/publicaffairs/releases/ams_group.html>.

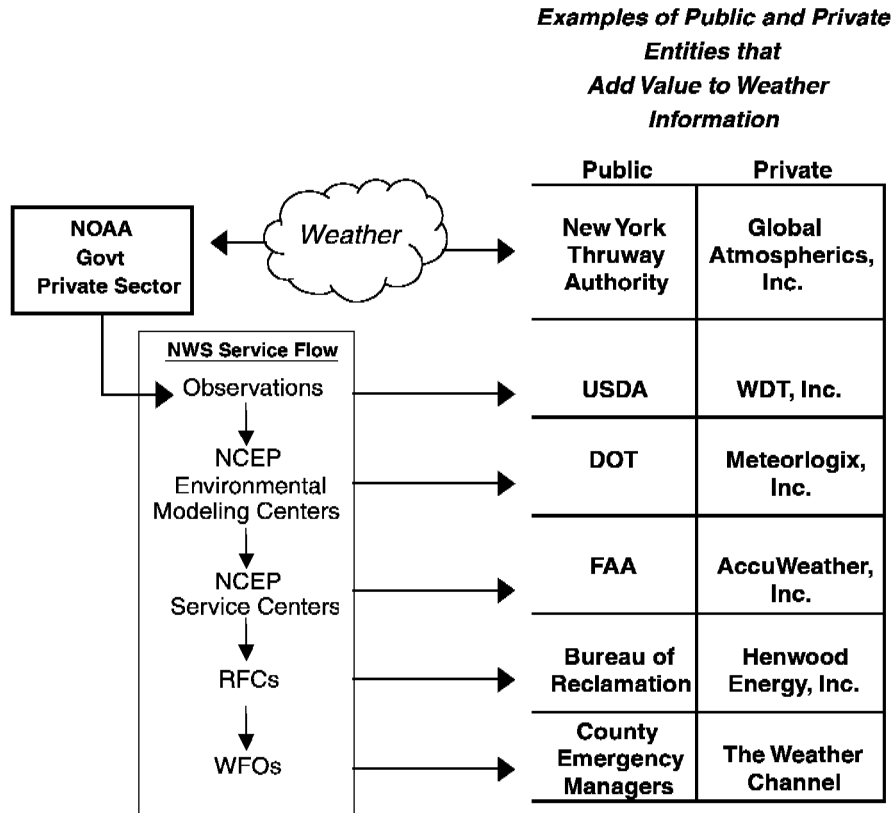


FIGURE B.1 Example of weather service providers. The notion and depiction of “NWS Service Flow” follows from D.R. Wernley and L.W. Uccellini, 2000, Storm forecasting for emergency response: A United States perspective, in *Storms*, R. Pielke, Jr., and R. Pielke, Sr., eds., Routledge, N.Y., pp. 70-97.

PGA Tour.³⁴ Another company, AWS Convergence Technologies, Inc., collects temperature data through its own private network and offers services based on those data.³⁵ The size of the market for the provision of weather and climate services independent of the NWS has not been rigorously assessed. However, an initial hypothesis (based on personal experience and nothing more) is that the size of this market is as large as and

³⁴<http://www.lightningstorm.com/ls2/discover/nldn/index.jsp>. Global Atmospherics, Inc., is an example of research transferred from an academic setting, in this case the University of Arizona, to the private sector.

³⁵<http://www.aws.com>.

likely larger than the market for products and services built upon the NWS infrastructure. The NWS encourages a view of weather and climate services constrained to those related to its products. However, a more comprehensive perspective results in a considerably more expansive view of “weather and climate services.”

Nonetheless, many entities use the services of the NWS as the basis for providing value-added services. Value is added to products and services at every stage of the NWS “service flow,” as shown in Figure B.1 and illustrated by examples. Some companies (and many for-profit entities originating in academia) use the raw data collected by the nation’s atmospheric observing systems as input to proprietary weather forecast models. One such company is Weather Decision Technologies, Inc.³⁶ Other companies focus on the direct dissemination of NWS forecasts, with The Weather Channel the most widely known example.³⁷

The NWS supports a great diversity of economic activities in the commercial meteorological industry through its products and services. The size of this market has also not been rigorously assessed, although estimates range from \$500 million to more than \$1 billion.³⁸ Given the diversity of economic activities, it should not be surprising that individual companies that create products and services based on raw observational data or that independently interpret NWS model output have suggested that the value-added products within the NWS service flow represent subsidized public competition. However, proper understanding of such claims much occur in the broad context of the diversity of organizations that rely on NWS information as input to the production of products and services.

The summarizing of cases above in each of the sectors reviewed here is provided not to implicate specific judgments, but to note that evaluation of roles and responsibilities is made difficult due to the complex and interwoven tapestry of the NWS and other government infrastructure, academia, and companies operating in the broader economy. Clearly, the perspectives

³⁶<http://www.wdtinc.com/>. Weather Decisions Technology, Inc., also has its origins as a university spinoff, from the University of Oklahoma.

³⁷<http://www.wcather.com/>. The Weather Channel (TWC) and the NWS have entered into agreements such that NWS formats its products in a manner that serves the needs of TWC (F. Batten and J.L. Cruikshank, 2002, *The Weather Channel: The Improbable Rise of a Media Phenomenon*, Harvard Business School, Boston, 304 pp.).

³⁸R. Pielke Jr., J. Abraham, E. Abrams, J. Brock, R. Carbone, D. Chang, S. Cranford, K. Drozdzemcior, K. Emanucl, E.W. Friday, Jr., R. Gall, J. Gaynor, R.R. Getz, T. Glickman, B. Hoggatt, W.II. Hlookc, E.R. Johnson, E. Kalnay, J. Kimpel, P. Kocin, B. Marler, R. Morss, R. Nathan, S. Nelson, R. Pielke Sr., M. Pirone, E. Prater, W. Qualley, K. Simmons, M. Smith, J. Thomson, and G. Wilson, 2002, Report of the U.S. Weather Research Program Workshop on the Weather Research Needs of the Private Sector, *Bulletin of the American Meteorological Society*, submitted.

of those in individual companies may differ dramatically on the issue of “government competition” depending primarily upon where each draws information from the NWS service flow. Correspondingly, it would be easy to envision *in principle* how the NWS service flow might be optimized to facilitate the market for any particular niche of companies associated with points of departure from the service flow. However, such optimization would likely have dramatic consequences for other companies in different niches, drawing from different points of departure in the service flow. This complexity (i.e., the policy and political challenge of “multiattribute optimization”) is one reason why the NWS has had difficulty achieving a successful relationship with the private sector.

None of the previous discussion should be interpreted as either to condone present practices or to imply that claims of “unfair competition” are unjustified. Rather, the complex tapestry of the NWS in relation to the myriad agencies and companies that it supports makes assessment of present practices and claims an extremely challenging task. Consequently, it is understandable that multiple views on this subject have developed over decades and have defied good-faith attempts at resolution.

DEFINING THE PROBLEM

The problem then is that participants in the national enterprise for the provision of weather and climate services lack the means to judge appropriate roles and responsibilities from the standpoint of meeting national goals and the mechanisms to reach shared expectations on roles and responsibilities. Part of the reason for the lack of means and mechanisms is that the weather and climate services enterprise is highly complex and sprawls across government, private, and academic sectors. Further, national goals related to the provision of weather and climate services are many, and in the promulgation of goals into specific policies, many conflicts among policy objectives have been introduced. Conflict is exacerbated by national science and technology policies that force integration of the public and private sectors (e.g., the Bayh-Dole Act). The identification of conflicts—much less their resolution—is hampered by the lack of a “forest”-scale perspective on weather and climate services. Instead, there are many with a view of individual “trees.” The lack of such a perspective means that debate and discussion over the decades have largely been engaged in by those with a clear stake in particular outcomes. Consequently, the provision of weather and climate services has been treated much less like a policy issue to be assessed and addressed than like a political issue to be won.³⁹

³⁹R.A. Pielke, Jr., and R.E. Carbone, 2002, Weather impacts, forecasts, and policy: An integrated perspective, *Bulletin of the American Meteorological Society*, v. 83, p. 393-403.

Why Judging Appropriate Roles and Responsibilities Matters

Coming to a stabilization of expectations regarding appropriate roles and responsibilities for the provision of weather and climate services matters for at least four reasons. These reasons are discussed in greater detail in the following subsections: (1) institutional conflict; (2) efficiency in resource use; (3) accountability, transparency, and legitimacy; and (4) conflicts of interest. Ultimately, the primary reason why this problem matters is that as long as it persists unresolved, it impedes the effective and efficient transfer of weather and climate knowledge from the science and technology community to decision makers in the form of useful products and services.⁴⁰ This impedance limits the benefits to society resulting from the nation's investments in the science and technology of weather and climate.

Institutional Conflict. Over many decades, some in the NWS and the private sector have expended time and resources working against each other rather in support of each other. The institutional conflict has resulted in behind-the-scenes legislative maneuvering, such as resulted in the mid-1990s termination of agricultural weather services provided by the NWS, and more recently in conflict over the CWSA push to modify the NWS Organic Act. Institutional conflict occurs in less public ways as well, such as occurred in the late 1990s when the NWS Employees Organization pushed to include private sector employees, specifically at AccuWeather, in its union.⁴¹ While healthy competition can improve products and services and the efficiency with which they are delivered, to the extent that healthy competition becomes unhealthy conflict, products and services may in fact degrade. An example of unhealthy conflict occurs when public and private sector institutions use finite resources to position themselves politically or symbolically with respect to actual or perceived opponents. A specific example is the 1996 divestiture of agricultural weather services. The termination of such activities by the NWS was based largely on political maneuvering, not on assessments of whether or not the U.S. public would benefit from such a decision.⁴² In such cases, public interests are arguably served less well than by alternatives.

⁴⁰R.A. Pielke, Jr., and R.E. Carbone, 2002, Weather impacts, forecasts, and policy: An integrated perspective, *Bulletin of the American Meteorological Society*, v. 83, p. 393-403.

⁴¹<http://www.nwsc.org/nat10-00.html>. AccuWeather employees voted not to join the NWSEO.

⁴²General Accounting Office, 1996, *Privatization/Divestiture Practices in Other Nations*, GAO/AIMD-96-23, Washington, D.C., 36 pp.; General Accounting Office, 1997, *Lessons Learned by State and Local Governments*, GAO/GGD-97-48, Washington, D.C., 52 pp.

Efficiency in Resource Use. As science and technology produce results that lead to greater knowledge of weather and climate, new products and services are enabled. While the transfer of such knowledge into products in the public and private sectors faces many challenges, surmounting these challenges creates yet another dilemma. With a steady stream of products and services being made available, this means that there is a greater need for infrastructure to support those products and services. In the private sector, the marketplace balances supply and demand for products and services, and offerings expand and contract based on such forces. However, for the public sector, reconciliation of supply and demand is much more difficult in the absence of market mechanisms. To take an example, an NWS with finite operational resources is inherently limited in the products and services that it can offer because there is little capability to identify demand and to reconcile demand with supply (other than through the long-term budgetary process). Thus, if the NWS is to continually develop new products and services, it must either cease providing certain products and services (to free up operational capabilities) or become generally more efficient in its operations. Consequently, the NWS would generally benefit from a process that transfers services suitable for a market setting to the private sector. Discussion of the nature and criteria that might accompany such transfers goes beyond the scope of this paper, but the net effect of such transfers would be to make available resources in NWS for support of newly developed products and services. Currently, in the area of weather and climate, no such mechanism exists for identification of candidate products and services suitable for transfer. In other areas of government, by contrast, there are such mechanisms.⁴³

Accountability, Transparency, and Legitimacy. The lack of stabilized expectations for roles and responsibilities in the provision of weather and climate services places obstacles in the way of citizens holding government accountable. Government accountability has been a high priority of Congress since the early 1990s; legislation such as the 1993 Government Performance and Results Act and statements such as the 2001 President's Management Plan emphasize accountability in the use of public expenditures.⁴⁴ Accountably depends upon clear goals, shared expectations for the pursuit

⁴³See, for example, General Accounting Office, 1997, *Crop Insurance: Opportunities Exist to Reduce Government Costs for Private-Sector Delivery*, GAO/RCED-97-70, Washington, D.C., 156 pp.; General Accounting Office, 1996, *Privatization/Divestiture Practices in Other Nations*, GAO/AIMD-96-23, Washington, D.C., 36 pp.

⁴⁴<<http://www.whitehouse.gov/omb/budget/fy2002/mgmt.pdf>>.

of those goals, and mechanisms to measure progress with respect to those goals. In the provision of weather and climate services, the lack of shared expectations for appropriate roles and responsibilities means that the public, through its elected representatives, has less ability to shape the evolution of products and services than it might under conditions of shared expectations. This stands in stark contrast to other areas of science and technology—information technology and biotechnology are two examples—where, although considerable debate persists, such debate is highly public and focused on appropriate goals, mechanisms, and measures of accountability.⁴⁵ Accountability is a hallmark of “good government,” and irrespective of one’s views on the particulars of policy issues associated with the provision of weather and climate services it is possible to find lacking the degree of accountability, transparency, and legitimacy of policy processes in this issue area.

Conflict of Interests. Academia in particular must carefully consider the potential for financial conflict of interest at the interface of research and commerce. As the fruits of atmospheric sciences research become increasingly valuable, the question is not if such a potential exists, but when, where, and more importantly what to do about it. This is a sensitive topic because it involves money and money is often a difficult issue to discuss openly. Fortunately, other professions have grappled with this issue and have much to offer the atmospheric sciences in terms of experience and precedent. In 1993, Harvard’s Dennis Thompson defined conflict of interest in the *New England Journal of Medicine*:

A conflict of interest is a set of conditions in which professional judgment concerning a primary interest (such as a patient’s welfare or the validity of research) tends to be unduly influenced by a secondary influence (such as financial gain).

Thompson argued:

The secondary interest is usually not illegitimate in itself, and indeed it may even be a necessary and desirable part of professional practice. Only its relative weight in professional decisions is problematic. The aim is not to eliminate or necessarily to reduce financial gain or other secondary interests (such as preference for family and friends or the desire for prestige and power). It is rather to prevent these secondary factors from dominating or appearing to dominate the relevant primary interest in the making of professional decisions.

⁴⁵R.A. Pielke, Jr., and R.E. Carbone, 2002, Weather impacts, forecasts, and policy: An integrated perspective, *Bulletin of the American Meteorological Society*, v. 83, p. 393-403.

The question to be addressed, then, is not whether the boundary between research and commerce should blur—it has and it will. Indeed, the United States has a long history of using policy to intentionally blur this boundary, using technology policies to stimulate economic growth via public support for research, development, and technology transfer. The question facing the atmospheric sciences instead is what policies and procedures to promulgate and implement given present trends in the discipline. Since the mid-1980s, several disciplines, the medical profession being the most prominent, have been engaged in discussion and debate about conflict-of-interest policies and procedures.⁴⁶ The atmospheric sciences have much to learn from these debates.

CONCLUSION: ONE OF TECHNOLOGY POLICY'S LAST FRONTIERS?

Acceptance of the problem definition presented here would imply that progress toward its resolution will necessarily focus on establishing a “level playing field” for healthy competition rather than “drawing a line” restricting competition. To the degree that promulgation, adoption, and implementation of specific policies would facilitate judgments of appropriate roles and responsibilities, such policies will likely focus on the establishment of flexible processes rather than regulation or proscription of specific activities. Specific recommendations for how such policies might be formulated and implemented are beyond the scope of this paper. Clearly, adoption and enactment of such policies would not serve as a panacea to all issues associated with the provision of weather and climate services; simply coming to agreement on such policies would represent a significant achievement. It would nonetheless bring the atmospheric sciences more closely into the fold of other areas of technology policy where similar issues have a longer history.

To the extent that a lack of shared expectations has limited the transfer of scientific and technical knowledge into products and services, national interests are not served. Formulation and application of mechanisms that would allow for more efficient and effective judgments of proper roles and responsibilities of the various elements of the nation's weather and climate forecasting enterprise could lead to an increased pace of technology transfer

⁴⁶See, for example, D.F. Thompson, 1993, Understanding financial conflicts of interest, *New England Journal of Medicine*, v. 329, p. 573-576; S. Krimsky and L.S. Rothenberg, 2001, Conflict of interest policies in science and medical journals: Editorial practices and author disclosures, *Science and Engineering Ethics*, v. 7, p. 205-218; M. Angell and J.P. Kassirer, 1986, Editorials and conflicts of interest, *New England Journal of Medicine*, v. 335, p. 14.

more in line with the rapid pace of scientific and technological developments. This would mean that a greater portion of the nation's considerable investment in the science and technology of the atmospheric sciences would result in societal benefit. This would in turn lead to the enhanced development of markets. Ultimately addressing the policy problem associated with the provision of weather and climate services will contribute to the useful application of science to national needs.

The general policy problem has unique features in the context of the different participants in the nation's weather and climate services enterprise. To summarize:

- The NWS and its private sector partners have made frequent attempts to establish means for judging appropriate roles and responsibilities, yet without complete success. The existing policy, the NWS partnerships statement of 1991, is widely perceived by those inside and outside the NWS to be deficient in important respects.
- Non-NWS government agencies comprise a hodgepodge of activities that with varying degrees of independence—from each other and the NWS—provide weather and climate services. With a few notable exceptions—the National Climate Act and the U.S. Global Change Research Act among them—there is little in the way of means for judging appropriate roles and responsibilities.
- Academic institutions are seeing a great rush toward the commercialization of weather and climate research and development. There exists in academia a substantial body of precedent for judging appropriate roles and responsibilities. However, for the most part, such precedents do not appear to have been applied routinely across the atmospheric sciences.
- The private sector is intimately integrated with and dependent upon each of the other sectors in varying degrees. Accurate understanding of the private sector cannot occur without a broad conception of the forest rather than of individual trees. Of note is the considerable (but unmeasured) market for weather and climate services that do not depend on centralized government provision of data, models, or forecasts.

The atmospheric sciences are at a crossroads in their historical evolution. For many years the development and delivery of products and services were almost exclusively a government activity. Today, the increasing perception and reality is that weather and climate services have real economic value in the marketplace. To best tap that value will require thinking comprehensively about the weather and climate enterprise, which has existed largely unchanged in important respects for more than a century.

Although specific recommendations for action needed to better tap the potential value of weather and climate services are beyond the scope of this

paper, the first steps are to comprehensively recognize the weather and climate services enterprise and the need for the establishment of criteria and processes for judgments of appropriate roles and responsibilities. Weather and climate services are among the “last frontiers” of technology policy. In this regard, weather and climate services are following in the technology policy footsteps of areas such as biotechnology and information technology that have successfully tapped the power of the market to accelerate the transfer of knowledge into products and services that benefit society. Make no mistake: these areas with more developed technology policies continue to grapple with difficult questions at the interface of government, markets, and societal needs. But by taking these issues on, society is the ultimate beneficiary.