Opportunities and Priorities in a New Era for Weather and Climate Services

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1. Progress in Weather and Climate Services

Rapid changes are sweeping through atmospheric science and through the public and private weather and climate services. Scientific and technological advances are creating powerful new capabilities for observing and predicting atmospheric events. Information technologies are enabling entirely new approaches for disseminating weather and climate information. And the traditional emphasis on weather phenomena that threaten lives or property is expanding to a broader interest in atmospheric information as a key component of more sophisticated approaches to management of weather and climate risks.

Weather and climate services in the United States are provided by a partnership (National Research Council, 1998) in which

?? The government acquires and analyzes observations and issues forecasts and warnings;

?? Private sector firms use government data and products as a basis for creating information and special products for the media and clients;

?? The government and communication media disseminate atmospheric information, forecasts, and warnings to the public while tailored products move through information networks or dedicated channels;

?? Scientists in the academic community, the government, and the private sector advance atmospheric understanding and assist in creating new capabilities for service.

Advancing rapidly in capability and sophistication in recent decades, the partnership has served the nation well. The national benefits from weather and climate information (NRC, 1998) include protecting life and property, enhancing economic vitality, maintaining environmental quality, strengthening fundamental understanding, and contributing to national defense.

Today, weather and climate services are evolving in response to some contemporary realities:

?? Time scales of interest to the private sector are expanding along with improving capabilities in atmospheric observation, prediction, and information management.

?? Effective strategies for management of weather and climate related risk depend increasingly on integrating atmospheric observations and prediction with operational and financial models.

?? The national weather and climate services system is becoming more distributed as a consequence of advancing information technology.

These realities are shaping a new era in weather and climate services and thus this first AMS Presidential Policy Forum inquires whether they mandate new priorities or policies. This essay argues, as did the NRC (1998), that

?? The top priority for improvement in weather and climate services is optimization and integration of the observation, modeling, and prediction system with a special focus on improved observations of water and other key variables.

?? The weather and climate services partnership will be more effective in serving the nation and individual clients if the public, private, and academic sectors focus together and collaboratively on the priorities and resources that are critical for progress.

2. Managing Weather and Climate Risk

There are several strategies for mitigating the risks posed by weather and climate.

Adverse events can be avoided, as in fleeing from severe weather. Protection can be secured by designing and constructing buildings or critical systems to withstand potential threats. And in some cases, the financial risks or costs of weather or climate events can be transferred to other parties.

The agricultural industries have developed a focused and sophisticated system for integrating weather, climate, and risk information, as illustrated in Figure 1. Weather and climate information is used directly in planning and managing crops and protecting against pests. The various risks faced by food producers and processors can be exchanged or hedged with insurance or commodity futures contracts. In the case of agriculture, the futures contracts are traded extensively in markets that respond to weather events as well as to other forces acting on supply and demand. By limiting both downward risk and upward potential, these contracts provide the grower or processor with acceptable financial boundaries while creating the possibility

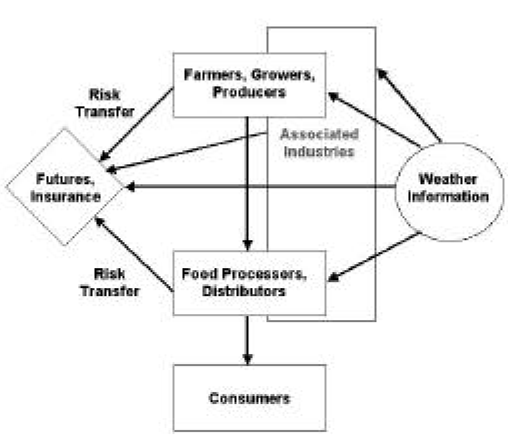

Figure 1. Flows of agricultural products, weather information, and transfers of financial risk.

that third parties who absorb the risk may achieve profit in return. The point for the atmospheric sciences community is that contemporary agriculture requires a wide variety of meteorological services related directly to food production and processing and to the markets in which the weather risks are hedged as well.

Transportation, public utilities, retail sales, recreation, and construction are all sensitive to weather and climate. These and other industries have developed various coping strategies that require atmospheric information. For example, Figure 2 shows that residential natural gas consumption is strongly dependent on temperature. Cold temperatures lead to greater consumption and presumably greater profit for distributors; warm temperatures reduce sales and create the possibility of a financial loss that might be hedged. Thus the energy industry is rapidly developing a system similar to that of agriculture for securing weather information and hedging risk, as shown in Figure 3.

As suggested in Figure 3, mechanisms may develop through which consumers could also hedge their price risks, perhaps by acting together. Indeed, energy suppliers and consumers generally have opposing meteorological and financial risk and could, as in agriculture, act on opposite sides of a trade with each other or by transferring risk to a third party.

3. Forecast Skill, Risk, and Opportunities

The time scales of meteorological forecasts have expanded in recent years as the reliability for periods of one to three days steadily increased. Satellite imagery and the WSR - 88D radar systems have provided a significant increase in shorter-term information and in warnings of severe weather. Increased computational power, improved observations, especially of sea surface temperature, and the concept of ensemble forecasts

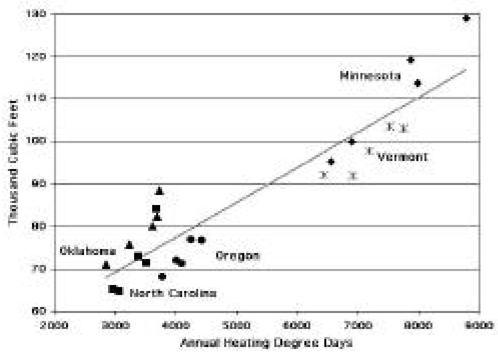

Figure 2. Dependence of total state residential natural gas consumption 1995-1999 on degree days as observed at a major airport in the state. Gas consumption data from the Energy Information Administration; degree days for BVT, MSP, OKC, PDX, RDU from the National Climatic Data Center.

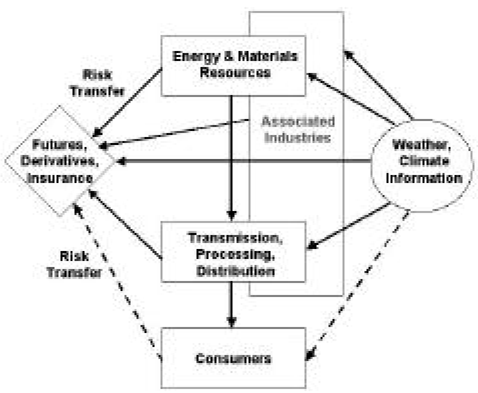

Figure 3. Flows of resources, weather information, and financial risk in energy and some materials industries.

have stimulated experiments with operational prediction of average conditions a season in advance.

The National Centers for Environmental Prediction report a wide variety of verification data on their web sites, and summaries show that 72-hour operational forecasts at 500 mb are now as accurate as 36-hour forecasts were some 20 years ago.

A subjective assessment of forecast skill over a wide range of forecast periods is shown in the lower half of Figure 4. The precise meaning of 'skill' is intentionally not specified and the axis is not labeled with quantitative values. The gray ellipse on the lower right is intended to suggest skill associated with climate statistics and the simulation of forced global change.

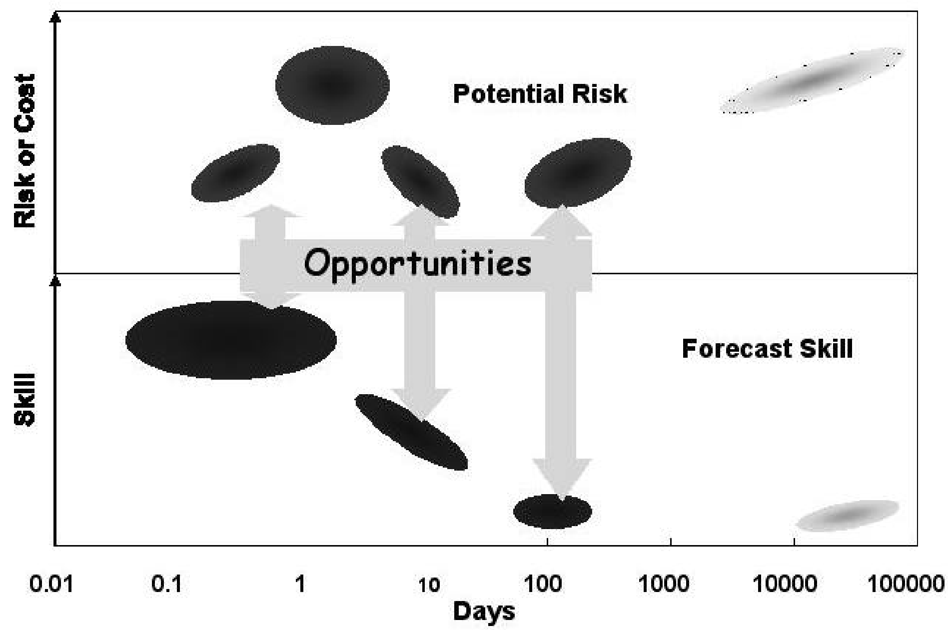

Figure 4. Subjective assessment of forecast skill and potential risk over a wide range of forecast periods.

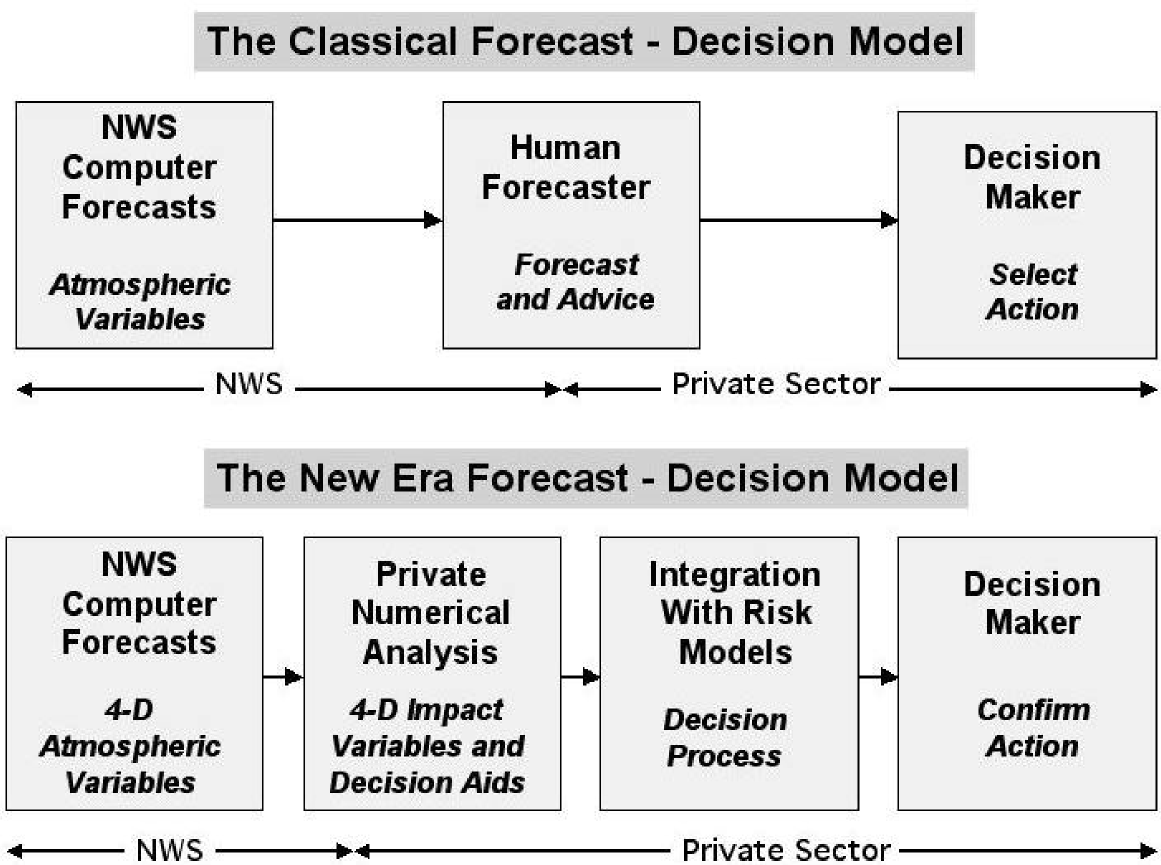

Figure 5. Comparison of forecast-decision models.

The upper panel of Figure 4 is a similar subjective assessment of potential risk by forecast period, with risk related to life and property and to financial loss. The risk is assumed to peak at periods of two or three days with severe weather events such as hurricanes or major winter storms. The gray ellipse at the upper right suggests the possible costs of global change.

The main opportunities for improved weather and climate services, according to this assessment, appear in the ranges as shown in the center of Figure 4. Improved analysis, prediction, and visualization at periods of a 2 or 3 to 12 hours would be advantageous to activities such as aviation. Improving skill at periods on the order of 10 days will permit longer-range planning for a variety of activities. And the linking of seasonal climate forecasts with quantitative risk management models and strategies will be advantageous in a wide range of economic endeavors.

The effects of weather and climate events on various activities are being considered in more sophisticated ways as decision processes are being based on quantitative models. Figure 5 compares the traditional approach for incorporating weather information in decision making and the new approach in which four-dimensional fields of meteorological variables, as predicted by federal forecast centers, are first converted by private sector firms into impact variables and decision aids specific to an industry, and then finally incorporated numerically into the decision processes of individual enterprises (NRC 1994, 1998).

There are a number of important implications of this scenario.

?? The federal forecast centers and the private sector groups computing impact variables will be more tightly linked than now and must cooperate as partners in a joint venture.

?? Meteorologists will be more intimately involved in designing the decision process and less in forecasting the weather.

?? Education for success in professional meteorology will require an entirely new dimension related to business and financial motivations, methods, and modeling.

?? The opportunities for weather and climate information firms to work with clients are expanded as attention turns to information tailored to specific businesses.

Weather and Climate Opportunities

Selected Categories in the U.S. GDP	Wx and Cx Sensitive Components 1998 $B	Days				Weeks				Months to Seasons			
		T	P	V	R	T	P	V	R	T	P	V	R
Agriculture, Forestry, Fishing	125												
Energy Resource Extraction	89												
Public Utilities	217												
Finance and Insurance	260												
Construction	373												
Retail Trade	782												
Hotels and Recreation	147												
Transportation	218												
TOTAL	2,211												

Figure 6. Weather and climate sensitive components of the gross domestic product, as determined from Bureau of Economic Analysis data.

The first two columns of Figure 6 show the major categories of the gross domestic product that have weather and climate sensitive components along with an estimate of their contribution to the GDP. The remaining columns (intentionally blank) suggest that there are many specific possibilities for integrating information on various time scales about T=temperature, P=precipitation, V=wind, and R=radiation variables with the risk management processes of the industries shown on the left.

4. Priorities and Policies for Progress

The priorities and policy goals required to realize the opportunities now before the atmospheric science community involve observations and models, meaningful inter-agency cooperation, effective public and private sector cooperation in developing services, and finally, convincing arguments that funding based on progress, opportunity, and impact will be a wise national investment.

Advances in atmospheric science and service will depend on the success with which we improve, optimize, and integrate observations and models of atmospheric, oceanic, and land surface processes (NRC

1998). It will depend on the extent to which we take advantage of technology to obtain new observations of critical variables. It will depend on whether we maintain the free and open exchange of observed atmospheric data—worldwide. The science may be well advised to emphasize atmospheric observation as the foundation of the entire enterprise, with all else being based upon it, as shown in Figure 7.

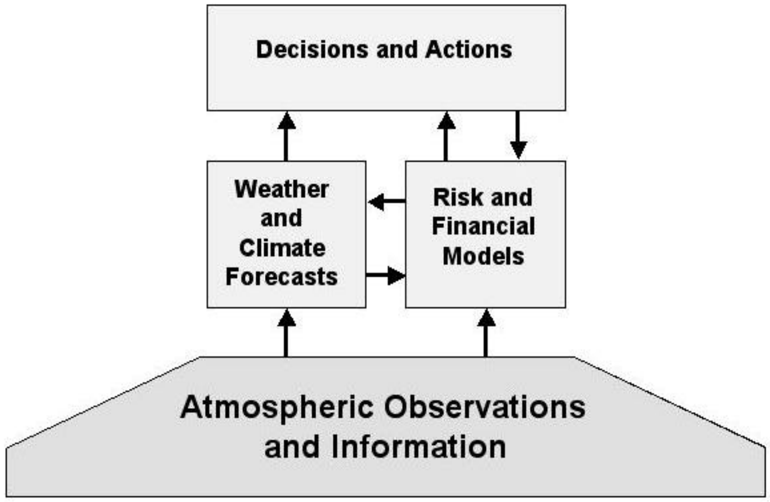

Figure 7. Conceptual links between atmospheric observations, weather and climate models, and risk and financial models, and decisions and actions.

If improving, optimizing, and integrating obser-vations, analysis, and models is the top priority, then the community must insist that the federal agencies involved in atmospheric science integrate their efforts and contribute in meaningful ways to a major national initiative to improve the atmospheric observation and modeling system. Recalling that the disciplinary based science coordinating mechanism of the Reagan and Bush administrations was more effective than the problem-based approach of the Clinton administration, we can argue for a group to coordinate atmospheric research and services and urge that the members be sufficiently high ranking officials for the group to be effective. The main players—NOAA, NASA, NSF, and DoD—must combine to create an observation and modeling system tuned to the capabilities and requirements of the 21st century.

At the same time, the community needs to examine carefully whether the public, private, and academic components could collaborate in more promising ways as the atmospheric information system becomes more distributed. The approaches shown in Figures 5 and 7 and the onrush of technology make it clear that there are important issues. Some of them are examined by the NRC (1998, 49-50).

Finally (as always), resources are required. All members of the community should argue together for federal funding of the observations necessary to provide the benefits listed in the introduction of this essay. All should support the research on which advances are based and the education that provides talented professionals.

But, in the end, all members of the community—private, public, and academic—must unite to make the case in concert that further investment in atmospheric observations, science, and services will return remarkable dividends to the nation. As pointed out by Gingrich (2000), "a worldwide climatology project [including] space-based and land-based ocean and atmospheric modeling that is technically possible with modern systems" should be a part of a federal "science budget for the next generation based on the opportunities in science...".

The atmospheric sciences community has a fairly clear vision of the opportunities for advances in understanding and service in the decades ahead.. The challenge is to determine how we can—together—optimize our efforts and obtain the resources to realize those opportunities.

References

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