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CLIMATE SERVICES: AN ASSESSMENT AND A PREDICTION

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1. INTRODUCTION

As the opening speaker for the 1995 American Meteorological Society Applied Climate Conference in Dallas, Stan Changnon surveyed the status of applied climatology and pondered whether its future could match its past (Changnon, 1995). This of course presupposes a definition of the subject. After due consideration he was led to conclude that the field is much bigger and more diverse than many of its practitioners realized or acknowledged. He then recounted its "glorious past," extending in the U.S. from the earliest days of the nation, through World War II when meteorology experienced rapid growth, and into the early post-war period. In later years the picture became more mixed. Citing issues with 1) whether data and information were being effectively used, 2) significant problems with data, and 3) the gaps between users (or potential users) and providers of data and information, Changnon voiced concern about an uncertain future for this activity. In his opinion the field was in the midst of an identity crisis, and thus was not sufficiently appreciated or understood.

In this assessment, the term "applied climatology" will be used interchangeably with "climate services." The National Research Council (2001a) presented a definition of climate services as:

"*the timely production and delivery of useful climate data, information, and knowledge to decision makers.*"

2. ASSESSMENT OF RECENT DEVELOPMENTS

During the 3284 spins of the earth since his earlier survey, has the picture Changnon outlined changed in any significant way? From this vantage, yes.

Forces inside and outside the realm of climate services have contributed to change. Though this distinction is somewhat arbitrary, the larger external circumstances in effect constitute the "boundary conditions" governing provision of climate services and consequently they have great influence.

A. The world at large

The first of these factors is more recent than the others, but seems significant nonetheless. Among many other things, one outcome of the terrible events of September 11, 2001 was a vivid and enduring reminder of that service--to others, to causes, or to ideas and ideals–constitutes one of the highest forms of human endeavor. In some quarters we had perhaps lost sight of this elementary truth, and failed to encourage, support and reward this activity. As a personal observation, it does not seem mere wishful thinking to note that a large negative has spurred people to react with a positive, and place more value on the general notion of service.

While Changnon was presenting his earlier talk, a dedicated cadre of cubicle-bound computer enthusiasts was busily launching the World Wide Web into explosive growth (Berners-Lee, 2000). Coupled with continuing exponential developments in computer processing, storage and transmission capability, a new phenomenon has burst upon us, in a transformation sure to rival that from any other human invention. Since climate services involves linkage of need and knowledge, this set of interlinked developments has opened the spigot to a vast range of new possibilities.

Another factor that has been at work since those days is the slow but steady realization that our most important, and seemingly intractable, problems are not going to be solved unless we adopt a more interdisciplinary mindset. The physical behavior of the climate system inherently involves a multitude of disciplines, essentially the whole of the earth sciences. Among these, biology especially seems poised to contribute this century to climate understanding. Most of the concerns of climate services deal with how climate relates to, or influences (and sometimes is influenced by) some other activity or arena, introducing even more degrees of freedom and complexity. A result has been increased emphasis on acquiring a more

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holistic understanding of the world about us, and the growth of institutional vehicles to address these dauntingly complicated problems. This is just the arena where much of climate services takes place. A particularly vexing problem has been that of increasing the porosity of boundaries, especially in the social instruments and arrangements utilized in these activities..

Continued concern about the extent, trends and perceptions of environmental degradation have been important motivators. Along with this has come the broad realization that for the first time in history, limit and finiteness at the global scale are not mere abstractions, but something that we actually must reckon with. Climate issues are tightly interwoven into the fabric of these problems.

As well, the prospect that climate, on the largest scales, might actually change is slowly imposing itself on the collective consciousness. Opinions about the likelihood or reality of such changes are undergoing a slow but steady evolution. It has been well understood by perceptive observers that any such change must actually begin before the will power to "do something" materializes in any large sense. The ability to provide "report cards" of various types, about the status of large scale climate and of its consequences to systems of interest, is important in this regard. The climate change issue as a whole, and its frequent appearance in our field of view, form part of the background that helps set the stage for a reinvigoration of applied climatology.

B. The climate community

Over the past half dozen years, an innovative activity known as the Regional Integrated Sciences and Assessment (RISA) program has established a presence within NOAA. The purpose of this program is to examine the relationship between users (or potential users) and providers (or potential providers) of climate information, in a rigorous way. This is a research topic unto itself, harboring a rich trove of intellectual challenges that strain the talents of even the most gifted investigator. The issue of context is central to this discovery process, especially that of obtaining an understanding the decision environment in which the information would be used. Since it is human beings who both render and are usually the recipient of climate services, an understanding of how choices are made or ratified, the province of economics and the social sciences, is crucial.

Among key findings that have emerged, one is that in order to perform the research, and discern the inner workings of this decision environment, there are important issues of trust that must be addressed in working with these "stakeholders." This in turn implies that a lengthy period of interaction is needed. Trust does not spring into existence wholly formed via "live birth;" the process is rather more like a stew than a microwave. Another finding is that the climate information of interest must be packaged and presented in ways that the user can relate to, implying in turn localization to the problem at hand. Very often this means physically local, to "my watershed, my town, my farm, my business." These common sense findings have been known among practitioners in applied climatology for a long time, but the RISA program has documented them. A further significant finding is that, as research entities with inherent reluctance to take on operational functions, they need to link to formal mechanisms to transition products and activities from research to operational modes. This is an area of current investigation.

In like manner the RISA program has also reiterated the need for local and regional climate information, data and services (NRC, 2001b). In governmental spheres and for broad multi-purpose functions, natural locations for this capability are the state and regional climate centers. Stan Changnon, arriving at this conclusion long ago, became the most persuasive and steadfast advocate of the regional climate center concept (Changnon et al., 1990), and ultimately succeeded in causing the program to be established.

The Drought Monitor (Svoboda et al., 2002), which is at once an extended weekly national conversation and a report (a process and a product), has proven to be a great catalyst for improvements in many facets of applied climatology, and has highlighted deficiencies to be addressed (Redmond, 2002). This effort has its roots in the southern plains (TX-OK-NM) drought of 1995-1996, shortly after Changnon's 1995 assessment. That drought spurred the Western Governors Association to provide since then a nearly continual voice and forum for this issue, especially as drought became the dominant climate story in the West through the present time. The Drought Monitor has resulted in numerous discussions of the need for accurate and spatially detailed information, rapidly transmitted, with interpretive tools, to answer real world questions. This is a work in progress and will continue to foster improvements.

During the last 9 years, it has also emerged that information on impacts is indispensable to the delineation of drought, and to distribution of relief. These impacts are often subtle and quiet, even when large, and take watchful eyes. A healthy and active network of state climate offices, a concept vigorously advocated and implemented a half century earlier by Helmut Landsberg, is needed to obtain the requisite level of detail and synthesis.

Within the climate community the AASC (American Association of State Climatologists) has taken an increasingly active role in climate services, utilizing strong partnerships with regional and national climate centers, and increasingly, with a number of agencies and organizations. A new generation of state climatologists has been filling the ranks, and the organization has had nearly a complete turnover in these positions since its inception in the mid 1970s. As a professional organization concerned with improving the viability, stature, and effectiveness of its members, the AASC has recently adopted a set of minimum standards, a category known as an ARSCO (AASC Recognized State Climate Office). This is rather analogous to the AMS Certified Consulting Meteorologist, or Seal of Approval for weathercasters. An important step that awaits is for this designation to be accompanied by financial incentives.

High quality, timely, comprehensive, complete and lengthy climate data provide the underpinning for any useful program of climate services (NRC, 1998). Extreme concern has been voiced repeatedly over the past 10-15 years about the national commitment to good data. Longstanding observational issues now seem to be getting the attention they need and deserve. Improvements in sensing, data logging, storage, communications, ingest, display, retrieval and product generation have occurred. Demands for ever more spatially detailed information have been increasing. Mesonets of various sorts are proliferating. Though we are edging closer to a framework that ties all these disparate activities together, the pieces are still separate. There is serious consideration toward a modernized cooperative network; this may prove to be the binding agent that takes us from dough to cookie. Technology, however, for all its successes, has still not solved the problem of reliably measuring frozen precipitation accurately at modest cost.

Within NOAA much of the climate data base has been gathered as a by-product of operations, mostly by the National Weather Service (NWS). Though forecasts are integral to NWS, there has recently been increased recognition that observations are the lasting legacy of that organization, to be dredged over endlessly by succeeding generations. Climate data have higher standards (homogeneous observing circumstances and readily accessible documentation of those circumstances being chief among them), and this difference from “weather” data is often not well appreciated in the field of meteorology. The NWS has a small but active and visible group in climate, and has recently designated climate service focal points in every local office.

The wide availability of measurement technology, and specialized needs for information for applications in fire, water management, recreation, natural resource management, and others, have led to a proliferation of non-NOAA federal data. Other agencies within the US Departments of Agriculture and Interior, now play major roles in data collection. In the western U.S. for example, with several major networks operating in the region, NOAA data constitute only about half the total climate data distributed by the Western Regional Climate Center. There is as yet no government-wide requirement that these taxpayer-funded efforts additionally serve the national good beyond their immediate purpose, but we are edging closer to that as well.

One specific national need that has been identified from the Drought Monitor experience is for dense soil moisture information. Soil varies tremendously in short distances, increasing the difficulty of the observational problem.

In an ideal world, we would have accurate measurements of all elements at all locations for all times. That not being possible, the next best thing would be values accurately interpolated in time and space to desired scales, perhaps on a grid or other geographic pattern, derived from the sparse networks found in the real world. Most practitioners in applied climate would use such data if they were persuaded of its accuracy. This is a long way from reality, but eventually this will occur.

Improved technology and techniques are steadily making models better, and although there is a clear preference for point data, the range of applications where assimilated model data are acceptable is increasing. Reanalysis, and regional reanalysis, ad infinitum, will eventually reach the scales of interest, perhaps in just 5 or 10 years. The consensus from a variety of sources of user feedback indicates that comprehensive climate information (including temporal behavior) at a 1 km scale would meet a great many needs, and importantly, is finally edging toward being a realistic goal, or even an expectation. Indeed, for wind power applications, running regional mesoscale models at 1 km for a year or two for western-state-size domains is now being done.

Another need in applied climatology is for other data sets from allied fields, such as streamflow and reservoir levels, or chemical concentrations (pollutants and gasses). Reanalyzed (self-consistent) fields are needed for surface data (temperature, precipitation, perhaps wind and humidity) and for streamflow and evaporation. A credible, fine scale, gridded, reconstruction of the physical environment from the top of the atmosphere down to the surface and into the soil column and rivers and lakes, spanning several decades, would have immense utility in applied climatology. This is a vision the field of climate should be collectively working to attain.

The diversity of processes, time scales, observational data sets, and information needs, coupled with the administrative structure responsible for observing all the various climate components, for obtaining a consistent diagnostic picture, and for understanding how the full system works, have led to a disjointed organizational structure for dealing with climate, within NOAA, within the federal government, and among all levels of government. The immediacy and urgency of weather-scale phenomena, and the inborn human reluctance to deal with problems having time scales comparable to lifetimes or careers, have contributed to this fragmentation. This situation is a product of history, and cannot be easily changed. No one structure will be optimal for all purposes. All should strive to have more permeable boundaries between administrative entities housing the capabilities required to address the large range of problems.

The best catalyst for improvement of this fragmented system is to address a broad multi-dimensional problem, and let the solution process drive the integration. Drought seems to offer this possibility, since it has a rich range of social and physical problems, and a strong need for a dense high quality observational system. Furthermore, drought is nearly always present somewhere in the country.

We have also begun to obtain a better perspective on the issue of perspective itself: where our perspectives originate, what hidden and unacknowledged assumptions we have made, what we consider "normal," and the representativeness of the climate records at our disposal for any particular application. There is now greater realization that climate involves non-stationary processes, and that 30-year chunks of time, okay for some purposes, are not sufficient in the general case. Paleoclimate reconstructions are necessary to understand how climate works on longer time scales. Just as important, however, such records are beginning to reach the public mind and influence drought and water planning, fire management, floodplain development, and other fields (e.g., Woodhouse and Overpeck, 1998; Redmond et al., 2002). An essential step in this process has been the interpretative function, so that a city manager can grasp the implications of a tree ring record, for example.

3. CONCERNS

Like clothing, ideas and activities move in and out of fashion and degree of acceptance. Activity trajectories in agencies and organizations often show temporal behaviors that are filtered versions of political and social time series. With its long term emphasis, climate is best served when buffered from such short-term high-frequency fluctuations in attention span.

The activity most susceptible to disruption from such forces is observations. As the raw material for progress in understanding and utilization, the need to maintain adequate (complete, credible, homogeneous, and documented) measurement programs is taken for granted by practitioners. However, this is also the subject about which practitioners typically express the greatest angst. Though vital, this is an arcane and not so glamorous or glitzy world, and no matter how strong the overall support at any one time, experience has shown that it can diminish rapidly when crunches occur. Although observations and associated needs are at this time experiencing an episode of heightened esteem and support, this concern is a perpetual preoccupation of the field.

The same can be said of attitudes about service in general. During crises, this and allied activity can be viewed as a luxury. The underlying infrastructure of observations and people networks necessary for adequate service seems constantly to be just a short distance from jeopardy. Thus, a related recurring background concern is whether the field of climate services has the staying power to retain its current health into the future.

As such, the importance of corporate memory, and of maintaining a sense of history, needs to be encouraged and recognized. It is costly, time-consuming, and inefficient to keep relearning the lessons of the past (e.g., Glantz, 2004, this session).

4. A PREDICTION

The looming issues in climate encompass both climate change, and increased vulnerability to climate fluctuations on many time scales. It should be emphasized that climate change is only one source of this added vulnerability. As an issue, however, it has served very well as a focusing mechanism to learn more about *all* climatic sources of vulnerability. Multiple and simultaneous stresses, most of them not directly climatic, are at work. These considerations have led to the establishment of significant research programs in the human dimensions of climate, and in other portions of the scientific enterprise more generally. Since they directly address the relevance of the scientific and environmental issues to "people problems" and behavior, there seem to be excellent prospects for their continued growth.

Though still in relative infancy, the burgeoning field of studies of complex systems and nonlinear dynamics could offer great potential and unforseen insights. The immensely complicated climate system (a system of systems) interacting with equally complicated human and social systems seems like a natural candidate for such studies. Reflective of the subject itself, it is impossible to predict what influence findings in this area might eventually have, but in our search for helpful perspectives on how we should view problems and issues, we should leave no stone unturned. It seems highly unlikely that this subject will offer nothing of value.

A recurrent theme in climate services is finding adequate scale matches. The temporal and spatial scales of need do not always project very well onto the temporal and spatial scales of our knowledge base. In addition there is often not a good correspondence between the level of detail and degree of certainty with which we wish to know something, and the ability of our knowledge system to provide information with that certainty and specificity. Our ability to address these issues is improving steadily, for many of the reasons outlined earlier. This seems particularly poised to constitute an area of growth in capability and understanding.

The many developments since Changnon's 1995 assessment, the variety and depth of activities now under way, the attention since then to concerns expressed at that time, the pressing nature of the problems we face, and the continued strong motivation to maintain and even increase present momentum, when taken together all bode extremely well for applied climatology and climate services. As he has frequently noted, the playing field is very large and there is room for many contributors.

The prediction from this small viewport on the universe is that applied climatology will experience a very bright and healthy future.

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