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A REGIONAL CLIMATE SERVICES CORE FOR THE WESTERN UNITED STATES: AN ORGANIZATIONAL PERSPECTIVE

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1. INTRODUCTION

In a recent report the National Research Council (2001b) presented a definition of climate services as:

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

The central emphasis of climate services is on assisting a "user" faced with a decision that has a climate-related component. The needs of users span orders of magnitude in the amount and sophistication of information desired, as does their ability to process such information.

The requisite information is often contained in one or more "products". A product can range, in the simplest and very common case, from a listing of the data values themselves, up to very complex statistical or graphical summaries of the data or information.

To the extent that a user is indeed assisted, a true "service" can be considered to have been rendered. Our main goal is to improve such service. The provider of climate services acts as an intermediary between two worlds, the world of climate knowledge and the world of users. To best serve in this capacity, these intermediaries must strive to simultaneously understand both worlds in some detail. The focus here is on how to best enlist contributing organizations, within NOAA, in bringing about an improved system of climate services.

2. THE WEST AS A TESTING GROUND

Most needs and uses for climate information are for a specific location or setting. Where climate behavior is heavily influenced by geography and topography, this need becomes especially strong. The western United States provides innumerable examples where a high degree of fine-scale structure is present in many aspects of climate.

In this complex region, geography and topography lead to a great variety of climates, climate extremes, and climate behaviors, sometimes closely juxtaposed; a physical hydrologic system which operates very differently from those in the flatter realm to the east; significant dependence on water supplies whose source environment is often far removed in time and space from the demand environment; and aridity (in both precipitation and in relative humidity) as a prevalent condition (Redmond, 1998, 2002). In addition, these physical circumstances have very much shaped the region's history (and thus also its psychology and culture), and have had an enormous effect on the social structures, legal institutions and practices, and organizations that evolved as this portion of the continent was settled. Included in these latter considerations is the significant role of the federal government as principal steward of about 50 percent of the region.

Climate services in this region cannot be most effectively provided in the absence of an understanding of this setting. An assumption here is that any approach to climate services that succeeds in this diverse and often difficult setting should have a good chance of succeeding elsewhere.

Although always known at the most local levels, in recent years the realization has become much more widespread of the need to incorporate these scale considerations in designing and implementing an integrated national climate services structure (NRC 2001a, 2001b). Consequently, the need for regional emphasis has received considerable attention.

As specialized institutions have developed in response to these specific regional characteristics, they have often also developed regional data sets in support of their missions. These variously pertain to water supply and allocation, fire, agriculture, air pollution and health, transportation, and other sectors. Many of these networks overlap state borders, and most are managed differently for different purposes. Despite their long histories in each others' presence they are generally today still only partly coordinated, even though most are publicly funded. A general consensus is that the region is still not observed at an adequate level of detail for many purposes. An ongoing challenge remains to effectively integrate the information from all these disparate sources, and to guide the establishment of additional sensor platforms and networks.

3. ORGANIZATIONAL ROLES

A wide range of organizations have roles as sources of observations and other basic climate information. Some of these occur at the municipal, county, and state levels. Others span political boundaries of every sort. The federal government is the most obvious and prominent of these, but an increasing number of regional entities are focused on watersheds or airsheds, the migratory patterns of animals, or urban growth patterns, or areas of high public value such as the Lake Tahoe Basin or the Greater Yellowstone Ecosystem.

As a consequence of the complex history of the West, a variety of organizations have evolved to become providers of observations and products. The largest among these are federal, but did not all arise within NOAA or its predecessor agencies. More than in any other region of the country, non-NOAA data and information plays a bigger role in climate services. Even in terms of forecasting, a traditional and important NOAA role, the primary responsibility for streamflow and water supply forecasts rests with the NRCS in the headwaters regions (about two-thirds of the forecasting points) or with state agencies (e.g., California), and the downstream mainstem forecasts are issued by the NWS River Forecast Centers. Since these forecasts have significant monetary impact, they are coordinated for issuance. The 700-site Snotel system, and the 1000-site RAWS network, are maintained by US Departments of Agriculture, and Interior, whereas NOAA resides in the Commerce Department. A number of other prominent federal agencies (about 20 in all) have significant roles as producers or consumers of climate information, most of them not in Commerce.

With respect to institutions, then, three large challenges face the West in terms of developing and improving a more effective system of climate services delivery:

1) Most of the important problems are regional and local in scope, and need more detailed information at those scales, often derived from a diverse set of federal and non-federal organizations with equally diverse missions, histories, information needs, and institutional cultures.

2) A large number of federal agencies are involved in making measurements and in using climate information. Many of the observational components are not coordinated well (some are), although slow improvement is occurring. Less well developed is the capability to rapidly turn the various types of information into products that are actually helpful to users within, between, and among those agencies.

3) Within NOAA itself, the different elements that comprise the necessary ingredients for climate services are widely scattered, many as accidents of history; are not tightly integrated; do not communicate as well as needed; are often disconnected from and even unaware of the immense user community; and have not had effective closure of feedback loops.

The climate services picture in the United States is extremely complicated, a comprehension of which often seems as daunting as that of the climate system itself. Because of the complex web of interactions present, there is significant value in preserving institutional memory, to minimize continual re-learning of old lessons. The institutions with the longest histories in dedicated climate services are the National Climate Data Center (established in 1951 as the National Weather Records Center), and the State Climatologist program initiated by Helmut Landsberg. The National Weather Service, and predecessors, has over the past century played several primary and secondary roles as well. By far the most valuable of these has been, and continues to be, the generation of observations, the raw material for much of the rest, a role predating the state and national climate centers. In recent years (mid 1980s) the regional climate centers were established to address issues intermediate in scale, and to help bridge the large range of scales between state and national levels.

With that somewhat cursory background, we will now focus more closely on the NOAA role in implementing a system of regional climate services.

4. REGIONAL IMPLEMENTATION OF NOAA CLIMATE SERVICES

In the public sector, a healthy system of climate services requires a mix of components. Although a loose hierarchal structure can be helpful, many elements of web-like connectivity are needed to ensure robustness, provide a prudent degree of redundancy, and allow for significant interaction across the wide range of spatial and temporal scales encompassed by climate and by user needs.

One recurring theme in efforts to establish a comprehensive system of climate services is that existing experience and expertise and institutions be enlisted and incorporated as much as possible.

A. Operations and services

The various climate data centers (national, regional,

state) are primarily linked through NESDIS. This group has the strongest and most numerous links with the broad nationwide user community, and handles such interactions as a routine function. By virtue of their geographic distribution, and history, the regional and state centers have especially strong ties with users. It is vital that good relations exist between this group and the NWS, including its environmental prediction centers, its many local field offices, river forecast centers and other hydrologic functions, which are primarily concerned with shorter time scales, and with CPC, whose responsibilities lie mostly at climate time scales.

The most significant contribution needed from the National Weather Service for climate services is the continuous production and rapid distribution of accurate and homogeneous data sets, compatible with the "ten guidelines for climate monitoring" (NRC, 1998, Appendix F). In this regard, the administrative separation within NOAA of the data generation function from the archival, distribution, summary and interpretation functions, with their inherent organizational emphases on different "weather" and "climate" time frames, has hindered the establishment of a seamless end-to-end system that receives and incorporates constant feedback from the ultimate users to better serve their needs.

An important feature of these operational activities is that users come *to* them, on their own volition and in large numbers, motivated by some matter of concern to them. They do not have to be convinced of the value of what they seek ("customers in search of a product"), in contrast to the opposite approach ("products and capabilities in search of customers"). This latter point was discussed in the context of "barriers to information use" by Pulwarty and Redmond (1997). It should also be noted that the host organizations of the regional climate centers, typically housed in educational settings, strongly mandate an emphasis on *learning*, i.e., not merely rote response.

B. Regional Integrated Sciences and Assessments

The NOAA RISA Program was implemented to obtain greater depth of understanding of the use and decision-making environment, pertaining to climate information, in selected sectors. Four of these five projects are located in the western U.S. It is very common that users do not feel providers sufficiently understand their situations. One strong outcome from the RISA experience has been reinforcement of the idea that an extended (sector-dependent) period of interaction is needed by user participants to develop a "comfortable" relationship, whereas the research environment in which such studies take place is generally geared toward projects of limited duration, leading to potentially conflicting expectations among the parties involved.
The work is performed in academic settings, primarily in conjunction with NOAA Joint Institutes. Also involved are NOAA research laboratories under OAR. An example of the latter is the close tie between the Western Water Assessment (WWA) RISA and CDC. The RISA program has largely informal (and a few formal) relationships with the NOAA operational climate centers, and methods are being sought to link all components more closely.

C. Regional Experimental Climate Services

A system of Regional Experimental Climate Services would help bridge these gaps. A primary purpose would be the development and implementation of information delivery technology. At the regional level this would involve NESDIS (regional climate centers, and the state climatologist program, and NCDC connections), as well as NOAA research labs and centers within OAR. An example of the type of partnership envisioned forms the basis of a pilot project tentatively called WESTCOR.

5. WESTCOR

A regional climate services core activity for the Western U.S. ("WESTCOR") has been proposed to serve as a test bed for an experimental and expanded NOAA climate services capability. It would entail at least two people, one located at a regional climate center such as WRCC, and the other located at a NOAA lab, such as CDC. The suggested prototype has a number of attributes and objectives:

1) To foster greater cooperation between the NOAA Cooperative (and Joint) Institutes. The regional climate center program is administered under a NOAA cooperative institute (CIASTA), and the western RISAs will soon all have an affiliation with the Joint Institute program.

2) To mix people. The importance of interpersonal relationships in facilitating interactions and scientific interchange between institutions is often underestimated. Personnel involved would be required to periodically spend time in each other's physical facilities.

3) To formalize partnerships and existing interactions between the western RISA projects and centers within OAR and NESDIS, and enhance the strength, depth and content of such linkages.

4) To extend results of scientific research on climate more quickly and thoroughly to users, and on a regular basis.

5) To work with regional entities such as climate centers to routinize certain types of presently experimental or prototype products.

6) To better intermix the "cultures" oriented around primarily point data (such as the national, regional, and state centers) and those which make greater use of gridded, "model-assisted" data. This is particularly problematic in the western U.S., where grid spacings must be very close to accurately capture the extreme variation in climate and climate variability required by real-world applications.

7) To develop improved and faster access to routinely updated standard data, in both point and gridded formats, for practical issues of climate monitoring, and for diagnostic studies of climate. Both types of information can be used to improve quality control of recent data.

8) To work more closely with users to improve presentation, ease of use, and understandability of climate information, and to operationalize experimental products judged by users (or potential users) to be of benefit. Useful approaches have been taken at CDC and others are in the wings, like the distributed system, UCAN (Pasteris et al., 1997).

9) To better describe and portray the connections that exist between local conditions, and regional, continental/oceanic, and global scale processes. An explicit intent is to improve public understanding of climate, its variations, and how it operates.

10) To localize the content of climate forecasts to specific sites within the western U.S. There still remain many public misunderstandings about these outlooks. Such effort can include both official outlooks and experimental forecasts produced by several climate groups in the U.S. and around the world.

11) To better link in an operational sense with a wide variety of non-NOAA federal agencies, as well as with other western organizations.

Space restrictions preclude an exhaustive summary of the roles of all organizations in the region. In particular, a number of non-NOAA agencies and interagency relationships have not been highlighted, even though they are a vital ingredient of a comprehensive approach to climate services in the western states.

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7. ACRONYMS

CDC - Climate Diagnostics Center
CIASTA - Cooperative Institute for Atmospheric Sciences and Terrestrial Applications
CIRES - Cooperative Institute for Research in Environmental Sciences
NESDIS - National Environmental Satellite Data and Information Service
NCDC - National Climatic Data Center
NRCS - Natural Resources Conservation Service
NWS - National Weather Service
OAR - Oceanic and Atmospheric Research
RAWS - Remote Automated Weather Stations
RCC - Regional Climate Center
UCAN - Unified Climate Access System
WRCC - Western Regional Climate Center