Applied Climatology
The Golden Age Has Begun
BY STANLEY A. CHANGNON

Applied climatology has been the foundation upon which the world's weather-sensitive activities and infrastructure have been developed. Applications of climate data and information have likely contributed more to the development of most nations than any other function of the atmospheric sciences. The recent development of useful weather forecasts has been important, but these developments have not overshadowed a parallel recent progress in applied climatology. A variety of scientific and technological advances, coupled with a changing society, have led applied climatology into its golden era.

What is applied climatology? The answer may seem obvious, but the definition of applied climatology is elusive for several reasons. Activities falling under the umbrella of applied climatology are spread among many disciplines, as well as having interfaces with many parts of the atmospheric sciences, collectively forming myriad interactions. The field is truly interdisciplinary, embracing climatologists and those of other disciplines, including hydrology, agriculture, engineering, and business.

Fifty years ago, leaders in the field defined applied climatology as the scientific analysis of climate data in light of a useful application for an operational purpose. My interpretation is that applied climatology describes, defines, interprets, and explains the relationships between climate conditions and countless weather-sensitive activities. For example, if viewed in a business sense, applied climatology would embrace interactions with marketing, sales, customer services, research support, and the delivery arm for climatological data and information. The diversity of the field is one of its hallmarks, and its work ranges over four basic areas: 1) design of structures and planning of activities; 2) assessments of current and past conditions, including evaluation of extreme events; 3) study of the relationships between weather/climate conditions and those in other parts of the physical and socioeconomic worlds; and 4) operation of weather-sensitive systems that employ climatic information in making decisions.

A HISTORY TIED TO DATA. Each of these four types of work is apparent through the history of applied climatology, and progress in each, at various times, has been driven by the collection of data and improvements in data networks. These improvements have seemed, in retrospect, to have arrived so steadily that it's possible that in past ages, applied climatologists did not totally realize—or appreciate—the considerable ongoing improvements in data availability.

The beginning of weather observations, both privately and at military forts, helped further applications of climate data in the nineteenth century; the nation’s weather-data collection system, and science in general, expanded and was organized at this time. Early leaders in the emerging field of meteorology, such as James Espy and Elias Loomis, recognized regional differences in the nation’s climate and identified how these differences created various effects on human endeavors. A key scientist of the century, Joseph Henry, made invaluable studies in applied climatology, and in the 1850s analyzed the impacts of climate on U.S. agriculture. Wladimir Köppen and other scientists began associating climate conditions with various land uses and plant environments as a means to define climate regions in each continent.

Further growth in the understanding of climate interactions with various physical systems, such as water resources, had to await the systematic collection of data about climate as well as the weather/climate-sensitive conditions. By the beginning of the twentieth century, data collection in the United
States had been in progress sufficiently long to allow new, more definitive studies of how climate impacted physical systems and human activities. For example, Albert Thiessen, a noted civil engineer, defined how climate conditions were to be used in structural engineering designs. Famed hydrologist Robert Horton made basic discoveries about the components of the hydrologic cycle, and unraveled the complexities of climate-hydrology conditions of the Great Lakes in the 1920s. Early twentieth-century studies on effects of climate on human health and behavior included key assessments of Charles F. Brooks. A national priority of the nineteenth century was to enhance agricultural production, and this led to the establishment of the U.S. Weather Bureau in 1888 as part of the Department of Agriculture. Establishment of experimental farms around the nation produced the data needed to make definitive studies of how various climatic conditions affected each crop, as well as livestock. Henry Wallace, later to become one of the nation’s vice presidents, made huge strides by developing the first climate-crop yield models. By the 1930s, C. W. Thornthwaite had pioneered modeling of the hydrologic system so as to derive measures of evapotranspiration and soil moisture and their effects on both plants and crops. By 1940, many of the fundamental relationships between climate conditions and other physical systems had been sufficiently delineated to allow effective designs of structures, selections of regionally appropriate crop varieties, and wise management of water resource systems in the varying climatic zones of the nation.

The pressures of World War II for climate data and expertise brought forth a new dimension to applied climatology. For example, studies by Snowden D. Flora and others now focused on severe weather conditions such as tornadoes and hail and their effects on crops, property, and human life. Helmut Landsberg and others contributed key publications within the realm of applied climatology during the 1940s and 1950s. This increase in applied research and information generation was also tied to the creation of computers during World War II and the use of punch cards as a means of digitizing historical weather data. A national center housing all historical climate data was established in 1948, and the center staff began generating in the 1950s numerous climate data-information publications, giving everyone in the nation access to information never before widely available.

Ever-improving computers and digitized climate data also allowed major achievements in modeling of climate effects, such as hydrologic models that related various climatic variables to streamflow behavior. Heavy-rainfall design information, critical to planning and designs to manage flooding, was generated, and a highly useful national drought index was devised. Sophisticated climate-crop yield models appeared, allowing accurate predictions of yield outcomes well before harvest. Other studies addressed another important sector of applied climatology—the economic and environmental impacts of all types of climate conditions, providing better guidance to planners and designers.

By 1970, applied climatology had begun to move to a new level of recognition and ever-higher value to the weather/climate-sensitive communities. Atmospheric scientists within the field turned their attention to improvements in weather-sensing instruments, the quality and archiving of data, access to data and climate information, and generation of user-friendly climate products.

**THE RAPID RECENT PROGRESS.** Despite continual progress over many years, there are specific factors in recent times that have been unique, making this a particularly exciting time for those in the field. The past 30 years have seen a series of scientific and technological changes that vastly enhanced the area of applied climatology. Coupled with these advances have been national and global economic conditions and government policies that collectively acted to greatly increase the demand for climate products. The stage was being set for the golden age of applied climatology.

The agricultural economy became global, and with this expansion came huge economic pressures. American firms searched for every type of information that would give them an advantage. One of these was more effective use of climate information, including climate predictions. Firms that had previously ignored use of uncertain climate outlooks now shifted and became users. Other business sectors also became global, and the net effect was more use of climate data and information.

Another factor enhancing wide interest and use of climate information was the severe impact of major climate anomalies of the 1970s and 1980s. These included the devastating Sahel drought, the record cold U.S. winters of 1976–80, and the droughts in the United States in 1980, 1983, and 1988. Climate and the problems it created, including rapid escalation of
As Stan Changnon describes in this essay, many of applied climatology’s successes and its rise to a new prominence in recent years can be attributed to the field’s interactions with a vast array of disciplines ranging from agriculture to the economics of weather risk management. As applied climatologists, many of our works are published in journals serving the fields in which our results are applied. While such outreach speaks to the importance of the applications of our results, it does not serve the field well internally. Results are often reviewed by scientists outside of the field, providing valuable suggestions concerning the applicability of results, but perhaps overlooking the subtleties of the data, methods, and climatological relationships assumed. Likewise, a succinct venue for learning about the latest methods, impacts, and advances in the field is absent. Scientists are forced to peruse a wide range of journals to continue to develop professionally and keep abreast of the latest research. There is not a singular outlet for authors to communicate their work to others working at the interface of climate, environment, and society.

Development during the 1960s and 1970s of reasonably inexpensive computer systems capable of handling large volumes of climate data was another key factor in the recent growth of applied climatology. The systems allowed continual updates of data and information, and the development and delivery of near-real-time climate information, coupled with wide use of personal computers. Everyone could access a wealth of climate information quickly and at low cost. This enhanced availability, and increasing use of climate information helped create greater awareness of the value of applied climatology.

The above-mentioned fast access was facilitated by other critical technological advances: the development of inexpensive means to quickly collect data and to transmit climate data and information. This included satellites and the Internet. These allowed real-time transmission of data and quick access to it, a huge step forward. Closely coupled with this advance was the establishment of new climate service/research centers, which had been fostered by the National Climate Program, as well as the growth of private-sector providers of climate information. The...
development of these new institutions and firms with expertise and systems to serve the needs of users of climate data and information led to other advances in applied climatology.

Interdisciplinary research by climatologists and other physical and social scientists has increased, and this has led to new levels of understanding and an array of sophisticated climate-effect models for crops, water, transportation, retail, and other uses. Further, these models, when fed with real-time data, allowed decision makers to use them in operational settings. Thus, near-real-time estimates of current and projected climate effects were generated for decision makers.

Since the 1970s, the nation and world have also seen an increase in society's sensitivity to climate conditions and, especially, extremes. Population growth coupled with other demographic changes and wealth have created greater vulnerability to—and higher costs from—climate anomalies. In the United States, these impacts have further promoted growth in the use of climate data and information to more effectively react, manage, and compete. Government de-regulation of power utilities has led to new demands for climate information. As a result of these societal, economic, and policy demands, climate information has taken on much greater value. One reflection of this in the business world has been the development and use of “weather derivatives” during the 1990s, a means of insuring against climatological risk.

One of the applied climate products long sought by weather/climate-sensitive entities has been accurate long-term climate predictions. The past 20 years have seen major advances in climate-prediction quality, partly related to a greater understanding of the climate system, such as the effects of El Niño on the nation's climate. Government-issued predictions have improved, both in accuracy and formats needed by users. Private meteorological firms now work closely with clients to interpret predictions to meet specific corporate needs. The use of climate predictions has greatly increased.

An example of this expansion of climate services by the private sector is the Weather Risk Management Association (WRMA), established in 1999 by several firms active in the weather market/climate services business. The primary products have been weather derivatives (often called “climate contracts”) and climate-based risk models, both extensively utilized by utilities and insurance firms. The WRMA reported that for the year ending March 2003, the member companies had sold 11,756 contracts at a value of $4.2 billion. By any measure, the field of applied climatology has undergone major changes and reached its golden age.

MAINTAINING THE PROGRESS. It is clear that applied climatology is the oldest atmospheric sciences activity in service to society, and its most successful. While applied climatology has been the foundation upon which weather-sensitive activities and infrastructure have been developed over the past 200 years, by 1970 applied climatology had begun to move to a new level of recognition and ever higher value to climate-sensitive sectors of the nation. On the government side, we have seen establishment of state climatologists in all states, a national network of six regional climate centers, and an enhanced National Climatic Data Center. On the business side, there has been a rapid expansion into applied climatology, bringing new climate-based products and services to a vast array of climate-sensitive businesses and government agencies. However, I see four limitations needing action if this golden age is to continue.

My first concern involves education. Ironically, teaching of applied climatology is still too limited, and often not done at many colleges and universities. Quality instruction in applied climatology requires interdisciplinary training and experience to be effective.

A second concern relates to the adequacy of weather instrumentation and data collection. Since weather data collection in the United States is still dominated by the needs of forecasters, there are continuing problems with sustaining adequate spatial sampling of climate conditions and with the use of instruments that allow continuity with historical data. We need national attention to instrumentation and climate networks, as Tom Karl described in the November 2003 Bulletin.

Although the use of climate data and information has grown rapidly, sampling reveals many potential users are still not served and often unaware of applications. Outreach efforts by government agencies involved in climate services and by private-sector partners are needed to demonstrate how climate information is used and what potential values are apt to be realized from usage to manage climate risks.

There is no systematic collection of data on the impacts of climate extremes, and a national effort to begin such data collection is needed. Uncertainty about impacts of a changing future climate due to
global warming is a current dilemma, and one that will continue. The implications of future climate changes remain a major challenge for applied climatologists.

Resolution of these issues—better training, stabilization of weather/climate measurements, outreach, better information on climate impacts, and effects of global warming-induced climate change—is needed to realize the potential of applied climatology.

ACKNOWLEDGMENTS. Many have contributed to the field and its recent progress. My lifelong involvement in applied climatology has greatly benefited from many people. The guidance of two of these, Helmut E. Landsberg and Floyd A. Huff, has been extremely important to my interest in applied climatology, and over the past 15 years I have benefited from my close working relationship with Kenneth E. Kunkel.

FOR FURTHER READING

THE LIFE CYCLES OF EXTRATROPICAL CYCLONES

Edited by Melvyn A. Shapiro and Sighjørn Grønås

Containing expanded versions of the invited papers presented at the International Symposium on the Life Cycles of Extratropical Cyclones, held in Bergen, Norway, 27 June–1 July 1994, this monograph will be of interest to historians of meteorology, researchers, and forecasters. The symposium coincided with the 75th anniversary of the introduction of Jack Bjerknes’s frontal-cyclone model presented in his seminal article, “On the Structure of Moving Cyclones.” The monograph’s content ranges from a historical overview of extratropical cyclone research and forecasting from the early eighteenth century into the mid-twentieth century, to a presentations and reviews of contemporary research on the theory, observations, analysis, diagnosis, and prediction of extratropical cyclones. The material is appropriate for teaching courses in advanced undergraduate and graduate meteorology.

The Life Cycles of Extratropical Cyclones is available for $70 list/$50 members. Prices include shipping and handling. Please send prepaid orders to Order Department, American Meteorological Society, 45 Beacon St., Boston, MA 02108-3693 or call (617) 227-2425. Visa, MasterCard, or American Express accepted.
Dr. James Halitsky, a pioneer in the study of local airflow relative to structures and landscapes, passed away 7 May 2005 at the age of 85.

At the time of his death, he had one paper which he wished to resubmit for publication, but could not do so because of his failing health in recent years. This paper can be viewed in PDF format at the above URL.

Anyone wishing a copy of this paper to study or use should send a request to David Halitsky at

dhalitsky@cumulativeinquiry.com

Researchers are welcome to consider submitting a version of this paper for publication.

Also, there is a guest book at the above URL in which messages can be left by visitors to the site.