Applied Climatology: Some Data Sources and Applications

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ABSTRACT

The importance of climate to early and modern societies is briefly reviewed. Some comments are offered on presently available climatic data, analyses and products. Various applications of climatic data and analyses are discussed. Some alternatives for the future are outlined. Continued dialog between the collectors, processors, disseminators and users of climatic data for application to the needs of present and future society is essential.

The American Meteorological Society sponsors a broad range of topical conferences on weather and climate each year. The conference on "Climatic Impacts and Societal Response" in Milwaukee was especially pertinent to the recent worldwide emergence of an awareness of the impact of climate on the food and energy concerns of societies in most nations, developed or developing. The recognition of the need to apply climatic knowledge to societal planning at governmental, industrial and private levels is gratifying not only to climatologists, but to the members of society affected by the climate-dependent decisions being made.

The Program Committee for the Milwaukee meeting did well in structuring sessions to cover a variety of scales and aspects of climatic impacts and societal responses. Most were subsets of a greater population of climatic concerns. Climatic considerations become important where design and operational planning are required for time periods beyond the range of operational weather forecasts, i.e., for activities with a life span greater than 3–5 days.

The early history of weather dealt more with climate than operational meteorology. Tribal migrations were dictated by climatic factors. In many early civilizations, medicine men, seers, chieftans and high priests came into prominence because the society in which they functioned believed these individuals could foretell the hardships and blessings of coming seasons.

The development of instruments made it possible to quantify climatic data. Galileo introduced the thermometer at about 1590 AD. Torricelli introduced the barometer in 1643. Weather codes came into being two centuries later, in the 1850's, quantifying weather data and making it amenable to statistical analysis.

The early history of our nation was in the hands of individuals greatly concerned with weather and climate. Both George Washington and Thomas Jefferson were planters who kept detailed weather records. Indeed, the last lines Washington wrote on 13 December 1799 were: "Morning snowing and about 3 inches deep—wind at Northeast and Mercury at 30—continued snowing 'till 1 o'clock—and about 4 it became perfectly clear—wind in the same place, but not hard—mercury 28 at night." That night he was attacked by the disorder from which he died. Thomas Jefferson published the first printed climatic summaries in North America in 1787. His interest in climate is so well known that an award is made to an outstanding climatic observer by the U.S. Government each year in his name.

Most early climatic classifications, such as those of Köppen and Thornthwaite, were agriculturally oriented and related to combinations of temperature and precipitation regimes.

As the complexity of our society increased, so did our awareness of the impact of climate on design and operational decisions in non-agricultural endeavors. The Gateway Arch in St. Louis was reoriented from its original design placement to reduce the potential impact of high wind stresses. The Trade Center buildings in New York are stressed for potential hurricane winds from a climatic study. Highway drainage systems must carry off not only the normal precipitation runoff, but the extremes to be expected during their operational existence. Climatic analyses provide the requisite decision data. Strategic decisions on power plant location, heating and cooling for industrial and commercial structures, and airport design are all climate related.

Applied climatology was a popular field during World War II and again in the 1960's. The airport design problem—probably because it was so clear an illustration—was often used as the example of an

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application of climatic data both for design and operational decision making. Placement of the instrument landing system depends on a detailed climatic analysis.

At one time each designer or operator decided what climatic data were needed and performed an analysis of potential climatic impact on the design or operational considerations. Today there are many successful efforts to design climatic data products to have discipline-oriented climatic analyses—or data sets—available to planners and operators. They exist on many scales:

1) International Agreements—the World Meteorological Organization, through its commission on Maritime Meteorology, has established a set of formats for summarizing and publishing marine climatic data by its member nations.

2) National Regulations—the U.S. Federal Aviation Agency has established the format of "Ceiling/Visibility Wind Roses" for airport design considerations.

3) Professional society agreements—the American Society of Heating, Refrigerating and Air-Conditioning Engineers have established a concept of a "Weather Year for Energy Calculations" for use in major building design (both structural and operating).

There are still, of course, particular situations in which a specific local application requires an individually tailored analysis for the particular problem. This will probably always be the case when a particular local problem requires special attention.

While much attention is being devoted to rapid access to computer data bases for "instant analyses," there is need for greater use of the wealth of already processed data.

Climatic summaries have long been routinely prepared and presented in many forms for diverse purposes. Federal and state governments make realistic efforts to prepare and publish summaries to serve the needs of a variety of recognized users. The products, quite naturally, deal with a variety of time and space scales. Indeed, they have become so numerous that a guide has been published to provide information on what is available.

The "Selective Guide to Climatic Data Sources," published by the National Climatic Center, is designed to assist potential users of climatic data by informing them of the availability of such data in published and unpublished form. It is arranged to indicate the publications in which the various categories of data (i.e., temperature, precipitation, wind, pressure, humidity, etc.) may be found for surface, upper air, land, marine, city, state, regional or national areas. Brief reviews of the basis and development of many of the publications, and illustrative examples of publication content are included in the Guide. The front of the Guide refers primarily to published climatic data. The rear portion is devoted to indexes of many sets of unpublished data and summaries.

A first point of reference for many users of climatic data is an atlas. Many standard reference atlases include both large-scale representations of worldwide climatic patterns of heat and moisture, and climatic data on temperature and rainfall patterns on a more detailed continental basis. Much that is well known to meteorologists, climatologists and educated users of their data becomes self-evident to others when climatic, topographic and, vegetation charts and charts of population distribution are examined simultaneously. For more detail, however, it is necessary to look into Atlases which deal with specifics of the climate. Two brief examples are: the Climatic Atlas of the United States. Its purpose is to depict the climate of the United States in terms of the distribution and variation of constituent climatic elements. The climatic maps present in a uniform format a series of analyses showing the national distribution of mean, normal and/or extreme values of temperature, precipitation, wind, pressure, relative humidity, dew point, sunshine, cloud cover, heating degree days, solar radiation and evaporation. This particular atlas contains 40 large sheets, with 271 maps and 15 major tables of processed climatic data. The map projection has been standardized to allow accurate comparison and correlation of the various climatic elements and their patterns. I would urge its periodic updating whenever 10 years of new data become available.

Another widely used atlas is the U.S. Navy Climatic Atlas of the World. It is published in five volumes. It is a revision of eight volumes published under the same title in the years 1955 through 1969, which were extensively used by worldwide marine interests. The present five volumes include: 1) North Atlantic Ocean; 2) North Pacific Ocean; 3) Indian Ocean; 4) South Atlantic Ocean; and 5) South Pacific Ocean. Each volume includes isopleth analyses by months of surface winds, air temperature, temperature extremes, sea surface temperature, humidity, precipitation, visibility, combinations of wind and visibility, and cloudiness, pressure and mean wind. Each isopleth chart is accompanied by graphs of frequency distributions, tabulations of extreme values and similar parametric representations.

On a smaller scale, packaged climatic data products can be applied to the climate of a state, city, or specific location. There is a publication on the climate of each state in a series on the climatology of the United States. Each consists of a narrative that describes some of the principal climatic features and a number of climatological summaries for stations in various geographic regions of the state. Again these publications provide a "jumping-off point" with data that may be sufficient for general use. Specific users may require more detailed information.

On a city scale, *Local Climatological Data* are summarized and published at the National Climatic Center in Asheville, North Carolina, for about 300 cities in the U.S. monthly and annually. Using Milwaukee as an example, the climatic record began on 1 November 1870 and has continued at various of 10 locations in or near the city. The continuity of the record is a bit complex. For example, the height above the ground of the maximum and minimum thermometers—which were not installed until March of 1878 (7.5 years after the station was established)—have been:

	Date	Height (ft)	Distance/moved (ft) and direction
City	3-02-78 to 4-22-99	106	300 E
City	4-22-99 to 3-10-32	126	1000 WSW
City	3-10-32 to 3-28-41	98	20 N
City	3-28-41 to 5-01-54	125	
Airport	4-21-27 to 3-05-40	32	
Airport	8-05-40 to 6-20-55	33	100 N
Airport	6-20-55 to 10-26-61	35	4750 NNE
Airport	10-26-61 to 3-06-69	33	
Airport	3-06-69 to present	6	560 SSE

One single climatic element recorded is snowfall. The greatest annual snowfall was in 1886, with 110 inches; the second greatest was in 1960, with 93 inches. More than 6 ft (72 inches) of snow fell in 14 of the last 96 years. The least amounts were 10 inches in 1884; 12 inches in 1968; and 14 inches in 1922. With a range from 10 to 110 inches, the question of planning for snow removal is complex. The decision data for the system design for Milwaukee snow removal are, however, contained in the climatic record and may be applied to the problem.

The many papers at the Milwaukee conference illustrate modern day applications of climatic data to specific design and operational problems in our society today. The methods of application of climatic data are as diverse as the problems and the people attacking them. They may include the following:

- Table look-ups in published climatic data sets
- Interpolation of values of climatic variables from charts in climatic atlases
- Hand tabulations from published data sets
- Sophisticated computer analyses of large data sets
- Collection and analysis of new data from specially established field networks
- Combinations of the above or other approaches.

There will not soon be a single approach to climatic applications to all design and operational problems.

There is much present attention devoted to development of large "random access" data bases for storage and recall for sophisticated computer analyses of climatic data for specialized application to specific problems. One popular concept is to have a central data storage and recall facility with computer terminal lines to be accessed directly by the user. This will serve well the large computer oriented consultant and design firms and larger governmental organizations. At the same time, there are many individuals and groups who prefer to acquire sets of already preprocessed climatic data for application to specific problems, using less powerful tools at the applications end of the system. It is likely that decisions at the U.S. Government level on the mechanisms for acquiring, processing, storing and recall of climatic data will impact severely on both groups. It is also likely that not all users can be fully satisfied by any single system of data handling and product generation.

Continued dialogue between the collectors, processors, disseminators and users of climatic data for application to the varied problems of today's and tomorrow's society seems essential.