Climate data: the ins and outs and where to find what

This article is the first in a two-part series. Part One discusses the National Weather Service's Cooperative observer program and the related Historical Climate Network. In April, Part Two will describe PRISM data, and data from Remote Automated Weather Stations (RAWS) and the Arizona Meteorological Network (AZMET).

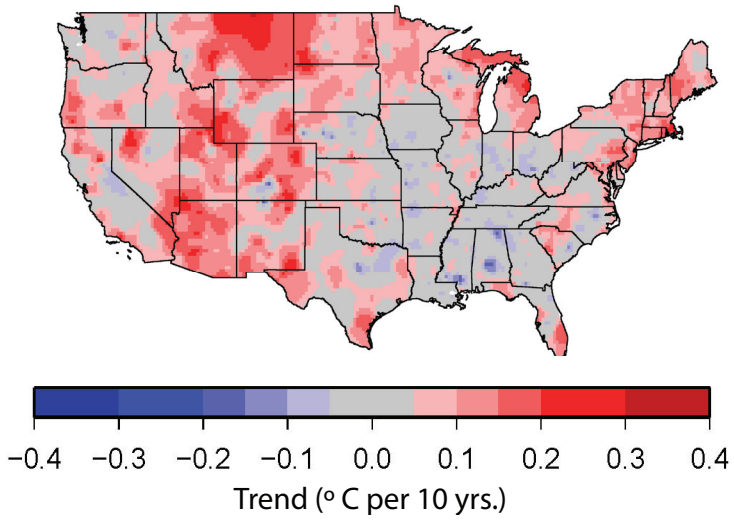

Figure 1. Adjusted maximum temperature in the HCN version 2 data for the period 1895–2007. Every 0.1 degree Celsius equals about 0.18 degrees Fahrenheit.
Source: modified from Menne et al. 2008

Many active weather and climate monitoring networks have collected data for more than 100 years, providing ranchers, forecasters, businesses and others with information they need. But all data are not created equal. Every data set has issues, some more than others. Knowing the details of the data will help match the proper data set to the question at hand.

While some networks bounce information off satellites every minute, others require people to read thermometers once a day and report the values by phone. Some networks have stations in sunny, windy places to monitor fire risk, and others are located in rural areas for farming purposes. And while some have no quality control, others are put through rigorous statistical algorithms and culled into data sets that represent the best and the brightest information.

A wealth of climate data is available, like temperature, precipitation, and snow depth. Learning the advantages, limitations, and Web site locations of each data set is difficult. Two programs in particular, the Cooperative Observer Program (COOP) and the Historical Climate Network (HCN), can help researchers understand climate change and natural variability; influence when ranchers decide to purchase hay and farmers plan crop cycles; aid businesses in correlating product demand and climate; and help resource management agencies allot water to irrigation districts.

Cooperative Observer Program

The Coop network has contributed more to the understanding of climate trends and extremes than any other data source. It contains daily measurements that began in 1890. Since then, the majority of stations have been operated by volunteers. Historically, there have been about 32,000 stations in the U.S. Currently, there are more than 12,000 active sites.

The National Weather Service administers the network, but the National Oceanic and Atmospheric Administration's National Climate Data Center (NCDC) archives it, performs the quality control, produces subsets of the data, and disseminates it in a variety of formats.

Coop observations include once-a-day recordings of the maximum and minimum temperatures, the temperature at observation time, precipitation totals, snowfall totals, and depth of snow at observation time. Many Coop observers provide additional hydrological or meteorological data such as evaporation and soil temperature.

The advantages of the Coop data are the high density of stations, the longevity of the record, daily measurements, and the fact that the data are relatively raw for those who want to perform more rigorous quality control. There are also several shortcomings. First, to analyze changes in the climate through time, more quality control is needed to adjust the data for changes in the time of observation, equipment, and surrounding environment. For example, protocols for the time of observation periodically changed, with pre-1940 recordings occurring at midnight and more recent recordings occurring at 7 am. This change caused jumps in the data. Second, many stations have missing data because measurements are not automated.

While the Coop data is not adjusted for some inconsistencies, NCDC does provide quality control on the raw data. NCDC assures that the minimum temperatures are not greater than the maximum and that the values are reported in the right columns and are not alarmingly greater than neighbor stations.

Accessing daily data costs $2 for each station, or free if the user has a server domain of .edu, .gov, .us, .k12. Monthly data, however, is provided free of charge by the Regional Climate Centers (RCC). This data for Arizona and New Mexico is housed at the Western Regional Climate Center.

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Climate data, continued

U.S. Historical Climate Network

The HCN is a smaller subset of Coop stations that consist of the stations with long and complete records with minimal station changes. The network arose from the need for an accurate and unbiased climate record suitable for detecting and monitoring changes in regional climate. The HCN consists of 1,221 stations; almost all of them have at least 80 years of mean monthly temperature and total monthly precipitation data, were active in 1987, and have experienced few station changes, such as relocations. In some cases, however, these criteria were modified to have a uniform distribution of HCN stations across the U.S. HCN stations span only the 48 contiguous U.S states; a separate data set is available for Alaska, although it lacks the same quality control. There are 25 HCN stations in Arizona and 28 stations in New Mexico.

Like its parent, the HCN data includes daily maximum and minimum temperature, daily precipitation, and daily snowfall totals. Unlike the Coop data, the HCN data have more rigorous quality control, which consists of the following:

1. Using data from surrounding stations to identify potential errors (when values are greater than 3.5 standard deviations from the mean) and outliers (when values are greater than 5.0 standard deviations from the mean).
2. Adjusting temperature data for bias introduced by changing times-of-observation—this adjustment alone changed the temperature trend by 0.3 degrees Fahrenheit (F) between 1960 and 1990.
3. Adjusting temperature to account for artificial errors caused when mercury thermometers were replaced by electronic temperature sensors.
4. Accounting for changes in the data resulting from station relocations and other station changes.
5. Generating data from appropriate nearby stations that fill in for days when observations where not made—data are only generated when records have too many missing values.
6. Correcting for the non-climatic warming caused by urban development.

Although HCN data are quality-controlled in various ways, most data adjustments are based on notes provided by the observer. These notes document, for example, when the observer moved the station, when he or she changed the observation time, and when the thermometer was updated. However, the notes are not always complete—observers may not report replacing a broken thermometer with one calibrated differently. Nevertheless, The HCN data are the best records available for estimating regional temperature trends. They have been used by the Intergovernmental Panel on Climate Change and the U.S. Climate Change Science Program.

Recently, the NCDC created an updated version of the HCN data, called HCN version 2. Version 2 makes a few modifications to quality control and effectively addresses bias introduced by poorly located stations, according to a journal article published this year in the Bulletin of the American Meteorological Society. This is important because proximity of Coop and HCN stations to brick houses, asphalt, and air-conditioning equipment can influence temperature data.

In the journal article, the HCN version 2 was analyzed, generating decadal trends for the period 1895–2007. Not surprisingly, many locations in both Arizona and New Mexico displayed strong warming trends over this period (Figure 1). Currently, this information is only available in monthly summaries. Next year, daily data will likely be available.

Coop and HCN provide long records that correspond to the climate at a particular location. But they also form the foundation of modeled climate data that enable a variety of users to obtain climate information at any location, circumventing the problem of relating a distant station's record to a site with a higher elevation and a different aspect. This gridded PRISM data, along with networks that capture extreme climate conditions and conditions in rural areas, will be addressed in the next issue.

For questions or comments, please contact Zack Guido, CLIMAS Associate Staff Scientist, at zguido@email.arizona.edu or (520) 882-0879.

Related Links

Cooperative Observer Program

1. Daily data:
http://cdo.ncdc.noaa.gov/dly/DLY

2. Monthly data for New Mexico:
http://www.wrcc.dri.edu/summary/Climsmnm.html

3. Monthly data for the Arizona:
http://www.wrcc.dri.edu/summary/Climsmaz.html

U.S. Historical Climate Network

1. Daily and monthly data:
http://cdiac.ornl.gov/epubs/ndp/ushcn/newushcn.html

2. HCN monthly values:
http://www.ncdc.noaa.gov/oa/climate/research/ushcn/