J4.3 UNITED STATES CLIMATE NORMALS FOR THE 1971-2000 PERIOD: PRODUCT DESCRIPTIONS AND APPLICATIONS

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1. INTRODUCTION

Climate is an important factor in agriculture, commerce, industry, and transportation. It affects many human activities such as farming, fuel consumption, structural design, building site location, trade, analysis of market fluctuations, and utilization of other natural resources. The National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center (NCDC) has a responsibility to fulfill the mandate of Congress "...to establish and record the climatic conditions of the United States." This responsibility stems from a provision of the Organic Act of October 1, 1890, which established the Weather Bureau as a civilian agency (15 U.S.C. 311).

The mandate to describe the climate was combined with guidelines established through international agreement. The United Nation's World Meteorological Organization (WMO) requires the calculation of normals every 30 years, with the latest covering the 1961-1990 period. However, many WMO members, including the United States, update their normals at the end of each decade.

The average value of a meteorological element over 30 years is defined as a climatological normal (WMO, 1989). The normal climate helps in describing the climate and is used as a base to which current conditions can be compared. For the 1971-2000 period, 30-year normals have been computed by NCDC for over 7,900 stations (with over 5,500 temperature and precipitation stations) throughout the United States, Puerto Rico, the Virgin Islands, and Pacific Islands. Figure 1 shows the spatial distribution of normals stations in the United States. Table 1 shows the multitude of *daily*, *monthly*, *divisional*, and *supplementary* normals products that are generated.

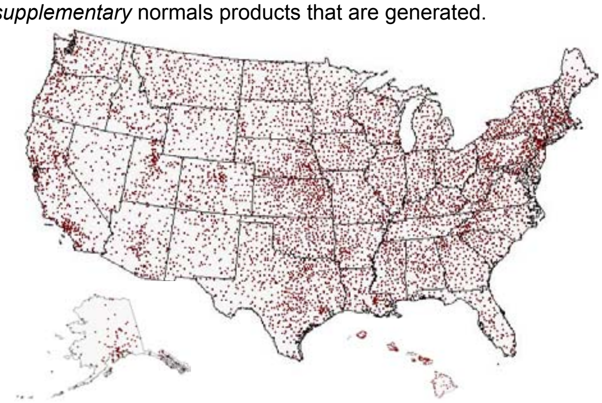

Figure 1. U.S. Normals Locations

2. COMPUTATIONAL PROCEDURES

A climate normal is optimally based on a 30-year period devoid of inconsistencies in observational practices (*e.g.*, changes in station location, instrumentation, time of observation, *etc.*), as well as missing values. When present, inconsistencies can lead to a non-climatic bias in one period of a station's record relative to another, yielding an "inhomogeneous" data record.

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TABLE 1: 1971-2000 Normals Products

Product Name	*Description*
CLIM81: Climatography of the U.S. No. 81	Monthly Station Normals
CLIM84: Climatography of the U.S. No. 84	Daily Station Normals
CLIM85: Climatography of the U.S. No. 85	Monthly Divisional Normals and Standard Deviations
CLIM81-01: CLIM81, Supplement 1	Monthly Quintiles/ Precipitation Probabilities
CLIM81-02: CLIM 81, Supplement 2	Annual Degree Days to Selected Bases
HCS 4-1: Historical Climatography Series 4-1	Area-Weighted State, Regional, and National Monthly Temperature
HCS 4-2: Historical Climatography Series 4-2	Area-Weighted State, Regional, and National Monthly Precipitation
HCS 5-1: Historical Climatography Series 5-1	Population-Weighted State, Regional, and National Monthly Heating Degree Days
HCS 5-2: Historical Climatography Series 5-2	Population-Weighted State, Regional, and National Monthly Cooling Degree Days
CLIM20: Climatography of the U.S. No. 20	Station Climatological Summaries
CLIM20-01: CLIM20, Supplement 1	Frost/Freeze Data

Adjustments and estimations can make a climate record "homogeneous" and serially complete, allowing a climate normal to be calculated simply as the average of the 30 values for each month.

The methodology employed to generate the 1971-2000 normals is not the same as in previous normals, as it addresses inhomogeneity and missing data value problems using several steps, as shown in Figure 2. The technique developed by Karl *et al.* (1986) is used to adjust monthly maximum and minimum temperature observations of conterminous U.S. stations to a consistent midnight-to-midnight schedule. All monthly temperature averages and precipitation totals are cross-checked against archived daily observations to ensure internal inconsistency. Each monthly observation is evaluated using a modified quality control procedure (Peterson *et al.*,1998), where station observation departures are computed, compared with neighboring stations, and then flagged and estimated where large differences with neighboring values exist. Missing or discarded temperature and precipitation observations are replaced using the observed relationship between a candidate's monthly observations and those of up to 20 neighboring stations whose observations are most strongly correlated with the candidate site. Monthly estimates are calculated using the climatological relationship between candidate and neighbor as well as a weighting function based on the neighbor/candidate correlation. For temperature estimates, neighboring stations were selected from the U.S. Historical Climatology Network (*USHCN*; Karl *et al.* 1990) whereas for precipitation estimates, all available stations were potential neighbors, maximizing station density for estimating the more spatially variable precipitation values.

Peterson and Easterling (1994) and Easterling and Peterson (1995) outline the method for adjusting temperature inhomogeneities. This technique involves comparing the record of the candidate station with a reference series generated from neighboring data. The reference series is reconstructed using a weighted average of first difference observations (the

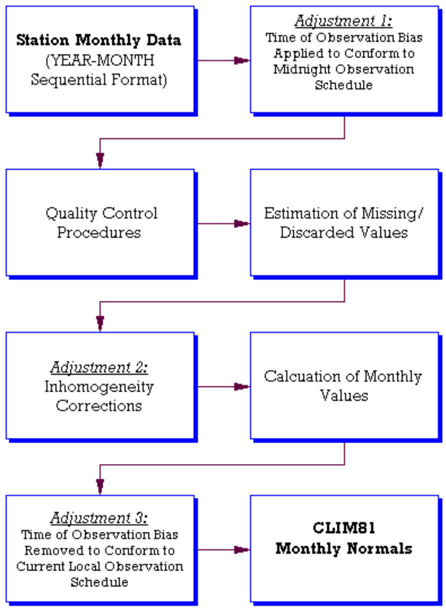

FIGURE 2. Monthly Normals Processing

difference from one year to the next) for neighboring stations with the highest correlation with the candidate. The underlying assumption behind this methodology is that temperatures over a region have similar tendencies in variation. If this assumption is violated, the potential discontinuity is evaluated for statistical significance. Where significant discontinuities are detected, the difference in average annual temperatures before and after the inhomogeneity is applied to adjust the mean of the earlier block with the mean of the latter block of data. Such an evaluation requires a minimum of five years between discontinuities. Consequently, if multiple changes occur within five years or if a change occurs very near the end of the normals period (*e.g.,* after 1995), the discontinuity may not be detectable using this methodology.

The monthly normals for maximum and minimum temperature and precipitation are computed simply by averaging the appropriate 30 values from the 1971-2000 record. The monthly average temperature normals are computed by averaging the corresponding maximum and minimum normals. The annual temperature normals are calculated by taking the average of the 12 monthly normals. The annual precipitation and degree day normals are calculated by adding the 12 monthly normals. Monthly precipitation totals less than 0.005 inch are shown as zero, and that precipitation includes rain and the liquid equivalent of frozen and freezing precipitation (*e.g.*, snow, sleet, freezing rain, and hail). For many NWS locations, heating and cooling degree day normals are computed directly from daily values for the 1971-2000 period. For all other stations, the rational conversion formula developed by Thom (1966) is modified by using a daily spline-fit assessment of mean and standard deviations of average temperature. The Thom methodology allows the adjusted mean temperature normals and their standard deviations to be consistently converted to monthly degree day normals.

Daily normals are computed as shown in Figure 3. They are *not* simple means of the observed daily values. Instead, they are interpolated from the less variable monthly normals by use of the natural spline function (Greville, 1967). The procedure involved constructing a cumulative series of monthly sums from the monthly normals. The cumulative series was for a 24-month period (July, …, Dec., Jan., …, Dec., Jan., …, June) so the interpolating function could adequately fit the end points of the annual series for all elements. The daily normals are also evaluated for daily consistency between elements.

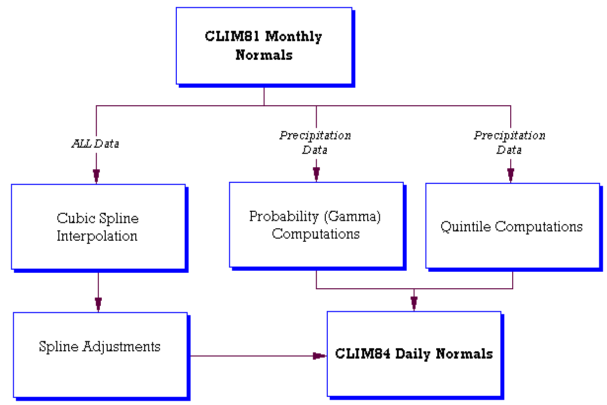

FIGURE 3. Daily Normals Processing

3. APPLICATIONS AND SUMMARY

Normals have a myriad of applications, from establishing a baseline for fuel contracts based on degree days to determination of drought severity. The 1971-2000 normals have been evaluated for their use in monitoring activities, and NCDC is working toward the development of so-called 'dynamic normals' that will allow customized normals-related information for users through the internet. More information on this and other normals activities can be found at http://www.ncdc.noaa.gov/normals.html.

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