CLIM81 1971-2000 NORMALS

MONTHLY STATION NORMALS OF TEMPERATURE, PRECIPITATION, AND DEGREE DAYS

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SCHEDULE 3-1

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58. Summary

When historical climate data are accumulated and examined, they generally follow a certain pattern called a statistical distribution. For example, if 30 years of June temperature data were assembled and examined, the data would have a pattern that consisted of most of the Junes having temperatures close to the normal or average value, a few Junes having very warm temperatures, and a few Junes having very cold temperatures. This kind of statistical pattern is called a "Gaussian" distribution. Temperature data typically follow a Gaussian distribution, but precipitation frequently does not. This is because precipitation is zero bounded. When historical precipitation data are examined, most of the values will be close to the middle of the distribution, and some values will be considerably higher than the middle range. But on the low end of the scale, the smallest values will never be less than zero, since there can't be a negative precipitation. In particularly dry (e.g., desert) regions, the pattern can be drastically skewed to the left-hand side of the scale, with most of the values being near zero and a few very wet values spread far to the right. This kind of pattern is called a "Gamma" distribution. Once the statistical distribution is identified, the statistical properties of the distribution can be used to estimate the probabilities that certain values will occur, and which values can be expected at certain probability levels. The probability levels desired can be preselected at certain individual levels or at regular intervals. The 0-20%, 20-40%, 40-60%, 60-80%, and 80-100% intervals are called the quintile levels.

In this data set, the Gamma distribution was used to estimate the precipitation values at 15 probability levels (0.005, 0.01, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95, 0.99, and 0.995). The expected precipitation values at the quintile levels are also included.

The climatological normals presented in this publication are based on monthly mean maximum and minimum temperature and monthly total precipitation records for each year in the 30-year period 1971-2000, inclusive. Data are assembled by individual states. Most stations were operating as of December 2000. Some stations were closed prior to 2000, but were identified as "normals stations" for special applications.

Several adjustments were made to the data before the normals were calculated. These adjustments include estimating missing data, adjusting for time of observation bias, and adjusting for exposure changes.

Data are presented in the order shown in the title. Units used in this publication are degrees F for temperature and inches for precipitation. Heating and cooling degree day (base: 65 degrees F) normals are derived from the monthly normal temperatures using the technique developed by Thom (1954a, 1954b, 1966). Degree day normals have also been computed to other bases and may be obtained from the National Climatic Data Center, Federal Building, 151 Patton Avenue, Asheville, NC 28801-5001, or by calling (828)271-4800.

NORMALS FOR FIRST ORDER AND COOPERATIVE STATIONS
TEMPERATURE AND PRECIPITATION NORMALS

First Order (Principal Climatological) Stations: First Order Stations record hourly observations and are usually staffed by professional observers. They can often be identified as having WSO, WSFO, WSMO, WSCMO, or FAA in their name. For all First order stations, any missing data for the 1971-2000 period were estimated from the monthly values of neighboring stations. Time of observation adjustments were made, as necessary, to the data from the neighboring stations before these data were used to estimate the missing first order station data (Karl, et al., 1986). Exposure change adjustments (Karl and Williams, 1987) were made to First order stations in the contiguous 48 States, but not to the stations in Alaska, Hawaii, or U.S. possessions because of the lack of a sufficient number of neighboring stations. The neighboring stations used in the adjustment procedure included stations from the Cooperative Station Network.

Cooperative Stations: Cooperative Stations usually record daily data only and are usually operated by volunteer observers. For all Cooperative Stations, any missing data for the 1971-2000 period were estimated from the monthly values of neighboring First Order and Cooperative stations. Time of observation adjustments were made to those stations in the contiguous 48 States that required the adjustment. No adjustment s were made to stations in Alaska, Hawaii, or U.S. possessions because of the lack of a sufficient number of neighboring stations. No exposure change adjustments were made to the station history information, but also because a Cooperative Station's identity changes (according to National Weather Service standards) when significant moves occur (generally at least 5 miles or 100 feet in elevation, subject to the judgment of the National Weather Service Cooperative Program Manager).

Methodology: A climate normal is defined, by convention, as the arithmetic mean of a climatological element computed over three consecutive decades (WMO, 1989). Ideally, the data record for such a 30-year period should be free of any inconsistencies in observational practices (e.g., changes in station location, instrumentation, time of observation, etc.) and be serially complete (i.e. no missing values). When present, inconsistencies can lead to a non-climatic bias in one period of a station's record relative to another. In that case, the data record is said to be "inhomogeneous". Since records are frequently characterized by data inhomogeneities, statistical methods have been developed to identify and account for these data inhomogeneities. In the application of these methods, adjustments are made so that earlier periods in the data record more closely conform to the most recent period. Likewise, techniques have been developed to estimate values for missing observations. After such adjustments are made, the climate record is said to be "homogeneous" and serially complete. The climate normal can then be calculated simply as the average of the 30 values for each month observed over a normals period like 1971 to 2000. By using appropriately adjusted data records, where necessary, the 30-year mean value will more closely reflect the actual average climatic conditions at all stations.

The methodology used to address inhomogeneity and missing data value problems stations is described in Figure 2. As with all automated quality control and statistical adjustment techniques, only those data errors and inhomogeneities falling outside defined statistical limits can be identified and appropriately addressed. In addition, even the best procedures can occasionally apply corrections where none are required or misidentify the exact year of a discontinuity. In the 1971-2000 monthly normals calculations, the sequential year-month data were adjusted to conform to a common midnight-to-midnight observation schedule. This is necessary since changes in observation time also can lead to non-climatic biases in a station's record. The data were then quality controlled to identify suspect observations and missing or erroneous values were estimated. Finally, the serially complete data series were adjusted for non-climatic inhomogeneities. In the 1971-2000 normals, all stations were processed through the same procedures, whereas in the 1961-1990 normals only NWS First Order stations were evaluated for inhomogeneities.

In order to effectively compare records among various stations, the time of observation bias, if present, must be removed. While the practice at all NWS First Order stations is to use the calendar day (midnight recording time) for daily summaries, Cooperative Network Station observers record observations once per day summarizing the preceding 24-hour period ending generally in the local morning or evening hours. Observations based on observation times other than midnight can exhibit a bias relative to those based on a midnight observation time (see e.g., Baker, 1975). Moreover, observation times at any one station may change during a station's history resulting in a potential inhomogeneity at that station. To produce records that reflect a consistent observational schedule, the technique developed by Karl et al. (1986) was used to adjust the monthly maximum and minimum temperature observations to conform to observations recorded on a midnight-to-midnight schedule. However, no time of observation bias adjustments were applied to stations in Alaska, Hawaii, or the U.S. possessions since no model for adjustment presently exists for these regions.

All monthly temperature averages and precipitation totals were cross-checked against archived daily observations to ensure internal consistency. In addition, each monthly observation was evaluated using an adaptation of the quality control procedures described by Peterson et al.(1998). In this approach, observations at each station are expressed as a departure from the long-term monthly mean. Then, monthly anomalies at a candidate station are compared with the anomalies observed at neighboring stations. Where anomalies at the candidate disagree substantially with those of its neighbors, the observations at the candidate are flagged as suspect and an estimate for the candidate is calculated from neighboring observations (see below). If the original observation and the estimate differ by a wide margin (standardized using the observed frequency distribution at the station), the original is discarded in favor of the estimate. Very few observations were eliminated based on the quality control evaluation.

To produce a serially complete data set, missing or discarded temperature and precipitation observations were replaced using the observed relationship between a candidate's monthly observations and those of up to 20 neighboring stations whose observations exhibited the highest correlation with those at 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's correlation with the candidate. For temperature estimates, neighboring stations were drawn from the pool of stations found in the U.S. Historical Climatology Network (USHCN; Karl et al. 1990) whereas for precipitation estimates, all available stations were potentially used as neighbors in order to maximize station density for estimating the more spatially variable precipitation values.

Peterson and Easterling (1994) and Easterling and Peterson (1995) outline the method that was used to adjust for 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 difference from one year to the next) for neighboring stations with the with the highest correlation with the candidate. The underlying assumption behind this methodology is that temperatures over a region have similar tendencies in variation. For example, a cold winter followed by a warm winter usually occurs simultaneously for a candidate and its neighbors. 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 methodology employed to generate the 1971-2000 normals is not the same as in previous normals calculations. For example, in the calculation of the 1961-1990 normals no attempt was made to adjust Cooperative Network observer data records for inhomogeneities other than those associated with the time of observation bias. Therefore, serial year-monthly data for overlapping periods between normals (e.g., for the 20 years in common between the 1961-90 and 1971-2000 normals) will not necessarily be identical.

Degree Day Normals

Degree day normals were computed in two ways. For 250 selected NWS locations, heating and cooling degree day normals were computed directly from daily values for the 1971-2000 period. For all other stations, the rational conversion formulae developed by Thom (1954, 1966) was 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 converted to degree day normals with uniform consistency. The modification eliminates an artificial month-by-month 'step' in the data output. In some cases this procedure will yield a small number of degree days for months when degree days may not otherwise be expected. This results from statistical considerations of the formulae. The annual degree day normals were calculated by adding the corresponding monthly degree day normals.

Supplementary Data

Individual station values (by-month) of average (maximum, minimum, and mean) temperature and total precipitation used to calculate the normals for the 1971-2000 period are available from the National Climatic Data Center, Asheville, NC, and may be obtained in either microfiche or digital media (TD-9641). In addition, extremes of monthly total precipitation and mean temperature are included, along with the standard deviations of the monthly temperatures. The median (i.e., 50th percentile), 11-year and 21-year means are also provided for both temperature and precipitation.

Precipitation normals less than .005 inch are shown as zero. Precipitation includes rainfall and the liquid water equivalent of frozen precipitation (snow, sleet, hail).

Temperature normals are provided for mean monthly maximum temperature (NORMAL MAX), mean monthly minimum temperature (NORMAL MIN), and mean monthly average temperature (NORMAL). The median (50th percentile) monthly average temperature is shown as MEDIAN. The median is the middlemost value in an ordered series of values. Half of the values are greater than the median and half are less than the median.

Monthly normals for February are based on a 28-day month.

Figures and letters following the station name generally indicate a rural location and refer to the distance and direction of the station from the nearest Post Office. WSO, WSMO, WSCMO and WSFO denote a National Weather Service office, meteorological observatory, contract meteorological observatory and forecast office, respectively. FAA implies a Federal Aviation Administration station with an observing capability coordinated by the National Weather Service. Station elevations are in feet above mean sea level. The December 1990 observation time for temperature is shown on the temperature tables under the station name. LT refers to Local Time (Standard or Daylight, as applicable).

Stations located on islands (U.S. possessions) generally have short records (i.e., less than 30 years) and do not meet the criteria for computation of normals. Short-term or period averages are given for these stations (as shown).

MAX is maximum, MIN is minimum, MID O.S. TIME ADD is the adjustmended factor to convert a normal to midnight observation time, ANN is annual, SEQ NO is sequence number and is used to locate the station on the map. STATION NO. is the Cooperative station number.