CLIMATIC NORMALS

1951-80 CLIMATIC NORMALS

Climate is an important factor in agriculture, commerce, industry, and transportation. It is a natural resource that affects many human activities such as farming, fuel consumption, structural design, building site location, trade, analysis of market fluctuations, and the utilization of other natural resources. The influence of climate on our lives is endless. The National Climatic Data Center (NCDC) inherited the U.S. Weather Bureau's responsibility to fulfill the mandate of Congress "... to establish and record the climatic conditions of the United States," an important 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 end of a decade has been set by the World Meteorological Organization (WMO) as the desirable term for a 30-year period from which to calculate climatic conditions. The average value of a meteorological element over the 30 years is defined as a climatological normal. The normal climate helps in describing the climate and in determining climatic time trends by comparing the current 30-year period with earlier periods.

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Publications of 1951-80 Climatic Normals

A. Climatography of the United States No. 85, Divisional Normals and Standard Deviations of Temperature, Precipitation, Heating and Cooling Degree Days, 1931-80 (1931-60, 1941-70, 1951-80).

This publication presents normals and standard deviations for the three 30-year periods and the 50-year period between 1931-80 for each division in a state. A division represents a region within a state that is, as nearly as possible, climatically homogeneous. Some areas, however, may experience rather extreme variations within a division (for example, the Rocky Mountain states). The divisions have been established to satisfy researchers in hydrology, agriculture, energy supply, etc., who require data averaged over an area of a state rather than for a point (station).

The divisional data are displayed by name and number for a state or island. The states and islands include the contiguous United States, Alaska, Puerto Rico, and the Virgin Islands, and are arranged alphabetically. Hawaii is not included because the varied topography and locations of the observing stations do not allow for the establishment of homogeneous divisions. The data include monthly and annual values of mean temperature, precipitation, heating degree days (base 65°F), and cooling degree days (base 65°F). Standard deviations of these values are also provided.

The divisional normals as well as the 50-year sequential monthly and annual data are also available on microfiche and magnetic tape.

B. Climatography of the United States No. 81 (By State), Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1951-80.

This publication presents normals for the 1951-80 period of average monthly and annual maximum, minimum, and mean temperature, and monthly and annual total precipitation, heating and cooling degree days (base 65°F) for individual locations. There are temperature and degree day data for 3,349 stations and precipitation data for 5,506 stations. The locations represent cooperative weather observer sites, National Weather Service offices, and principal climatological stations in the 50 states, Puerto Rico, Virgin Islands, and Pacific Islands.

The monthly normals are published by state. The data are arranged in four tables representing temperature, precipitation, heating degree days, and cooling degree days. The locations are listed alphabetically within each table. A station locator map and cross reference index providing station name, number, type, location, and elevation are included in the publication for each state.

The monthly normals as well as the 30-year sequential data are available on microfiche and magnetic tape. The cross reference index is also available on magnetic tape and is designated as the "monthly 1951-80 normals name tape."

C. Climatography of the United States No. 84, Daily Normals of Temperature, Heating and Cooling Degree Days, and Precipitation, 1951-80.

This publication presents daily 1951-80 normal maximum, minimum, and mean temperature, heating and cooling degree days (base 65°F), and precipitation for 344 National Weather Service offices and principal climatological stations. Monthly, seasonal, and annual normals of these elements are also presented. The data are published in a separate pamphlet for each location.

The daily normals were derived by fitting smooth curves through monthly values; daily data were not used to compute daily normals. As a result, the published values reflect smooth transitions between seasons. Typical daily random patterns of precipitation are not exhibited; the precipitation normals may be used to compute average amounts accumulated over time intervals.

The published data are also available on microfiche and magnetic tape.

Computational Procedures

A. DIVISION NORMALS. Climatic divisions are regions within each state that have been determined to be reasonably climatically homogeneous. The maximum number of divisions in each state is 10. Monthly divisional average temperature and total precipitation data were derived using data from all stations reporting both temperature and precipitation within a climatological division. The number of reporting stations within a division varies from month to month and year to year. This variation was ignored in the computation of the normals.

Monthly temperature normals and 50-year averages for a station were computed by adding the yearly values for a given month and then dividing by the number of years in the period. The annual normal and 50-year average were computed by adding all the monthly normal or long-term average values and then dividing by 12. As a result of this procedure, an annual normal computed by averaging annual values obtained for each year in the period by adding the 12 monthly values and then dividing by 12, may be slightly different from the average of the 12 monthly normals because of rounding differences. Precipitation normals and 50-year averages were computed in a similar manner, except that the annual values are the totals of the 12 monthly values. Sequential monthly degree days were derived from procedures developed by Thom (1954; 1966). This technique utilizes the monthly average temperature and its standard deviation to compute degree days. Standard deviations of temperatures for given months over the 50-year period 1931-80 were used in all degree day computations. Normals and 50-year averages of the degree days were computed using the procedure discussed in the preceding paragraph.

B. MONTHLY NORMALS FOR COOPERATIVE STATIONS. Normals were computed for a cooperative station if: (1) the station was active at the end of 1980; (2) monthly data existed for the period 1951-80; (3) no more than 24 months or 18 consecutive months of temperature data were missing; and, (4) no more than 30 months or 24 consecutive months of precipitation data were missing. The temperature restrictions apply to both maximum and minimum temperatures.

Missing temperature values T at station s=o in month j and year k were calculated by using the formula

$$T_{(o,j,k)} = \frac{1}{2}\sum_{s=1}^{2} T_{(s,j,k)} + \frac{1}{2}\sum_{\ell=1}^{2} T_{(o,j,k+\ell)} - \frac{1}{4}\sum_{s=1}^{2}\sum_{\ell=1}^{2} T_{(s,j,k+\ell)}$$

where s = 1, 2 (nearby stations within 60-mile radius of station s=o)
j = January, ..., December (month)
k = 1951, ..., 1980 (year)

The resulting value is the average value for the year and month at the nearby stations corrected by the average difference, computed over the succeeding two years for the month, between the value at station s=o and the surrounding stations. The computations were performed so that if $m = k+\ell$ were greater than 1980, then m was set equal to $k+\ell - 30$.

Missing precipitation values P at station s=o in month j and year k were interpolated by averaging values from one to four nearby stations (within a 60-mile radius of station s=o) for month j and year k.

$$P_{(o,j,k)} = \frac{1}{n}\sum_{s=1}^{n} P_{(s,j,k)}$$

where s = 1, ..., n
n = 1, 2, 3, or 4

The interpolated data were merged with the observed data to yield serially complete monthly maximum and minimum temperature values for the period 1951-80 for 3,017 cooperative stations, and serially completed monthly precipitation totals for 5,174 cooperative stations. The three highest and three lowest values for each month for each station for each data set were examined for reasonableness. Suspicious data were verified or subjectively corrected.

Monthly temperature normals for these stations were computed by:

$$T_{(i,j,N)} = \frac{1}{30}\sum_{k=1}^{30} T_{(i,j,k)}$$

where N signifies normal
i = 1, ..., 3 corresponding to maximum, minimum, and mean
j = 1, ..., 12 corresponding to January, ..., December
k = 1, ..., 30 corresponding to 1951, ..., 1980

The annual normal temperature (A refers to annual)

$$T_{(i,A,N)} = \frac{1}{12} \sum_{j=1}^{12} T_{(i,j,N)}$$

Year-monthly mean temperatures (i=3) were computed by:

$$T_{(3,j,k)} = \frac{1}{2} \sum_{i=1}^{2} T_{(i,j,k)}$$

and annual temperatures were computed by:

$$T_{(i,A,k)} = \frac{1}{12} \sum_{j=1}^{12} T_{(i,j,k)}$$

(Note the annual normal temperature $T_{(i,A,N)}$ may not equal the 30-year average of sequential annual temperature because of rounding differences.)

Monthly precipitation normals for the cooperative stations were computed in a similar manner.

$$P_{(j,N)} = \frac{1}{30} \sum_{k=1}^{30} P_{(j,k)}$$

The normal annual and annual precipitation values were computed by:

$$P_{(A,N)} = \sum_{j=1}^{12} P_{(j,N)}$$

$$P_{(A,k)} = \sum_{j=1}^{12} P_{(j,k)}$$

Heating and cooling degree day normals for each of these stations were computed using Thom's (op. cit.) technique. Monthly mean temperature normals ($T_{(3,j,N)}$) and standard deviations of the monthly mean temperatures (derived from the serially complete 1951-80 mean temperature data set) were used in the computations. The annual degree day normal for a station is the sum of the 12 monthly normal degree days.

C. MONTHLY NORMALS FOR NATIONAL WEATHER SERVICE AND PRINCIPAL CLIMATOLOGICAL STATIONS. Monthly normals for National Weather Service (NWS) and principal climatological (PC) stations are computed so as to be representative of the current instrumentation and exposure. If a station had not moved nor changed instrument types over the 30-year period, the normals were computed as described above for the cooperative stations. There were 171 temperature and 267 precipitation stations in this "no change" category.

Temperature normals for 161 NWS and PC stations were developed by comparing the data observed at the current location and instrumentation with data observed at surrounding stations. A list was prepared of all stations with 30 years of data that were within 60 miles of the NWS or PC station with an incomplete record. The list was reduced to those stations which exhibited the same variability of temperature as the NWS or PC station. The criteria were that for period of concurrent observations, the variances of the January, April, July, October, and annual maximum, minimum, and mean temperatures at the surrounding stations and the NWS or PC station must not be statistically different. Bartlett's test (Hoel, 1962) for the equality of variances was used with a .95 significance level. The data for the surrounding stations that met the variance criteria were then averaged to form composite sequential data sets of monthly maximum and minimum temperatures.

Average monthly differences between the composite and the NWS or PC station were computed by

$$D_{(i,j)} = \frac{1}{r} \sum_{k=1}^{r} (T_{(m,i,j,k)} - T_{(c,i,j,k)})$$

where D = average difference
- i = 1, 2 corresponding to maximum and minimum temperature
- j = 1, ..., 12 corresponding to January, ..., December
- k = 1, ..., r corresponding to a year
- r = number of years for month j in which data were available at current location and instrumentation of the NWS or PC station
- m = NWS or PC station
- c = composite station

The differences were smoothed twice using 3-month overlapping averages:

$$D'_{(i,j)} = \frac{1}{3} (D_{(i,j-1)} + D_{(i,j)} + D_{(i,j+1)})$$

$$D''_{(i,j)} = \frac{1}{3} (D'_{(i,j-1)} + D'_{(i,j)} + D'_{(i,j+1)})$$

where j-1 equals 12 if j=1 and j+1 equals 1 if j=12.

Monthly maximum and minimum temperature normals were derived from a weighted average of the NWS or PC data and the composite data adjusted by the second smoothed difference.

$$T_{(i,j,N)} = \frac{1}{30} [\sum_{k=1}^{r} T_{(m,i,j,k)} + \sum_{k=30-r}^{30} (T_{(c,i,j,k)} + D''_{(i,j)})]$$

Monthly mean temperature normals (i=3) are the average of the monthly maximum and minimum normals

$$T_{(3,j,N)} = \frac{1}{2} (T_{(1,j,N)} + T_{(2,j,N)})$$

Annual normal temperatures are the average of the monthly normals

$$T_{(i,A,N)} = \frac{1}{12} \sum_{j=1}^{12} T_{(i,j,N)}$$

Precipitation normals for 65 NWS and PC stations without 30 years of homogeneous data were developed from a comparison between the NWS or PC station and the average precipitation at the four closest surrounding stations with 30 years of data (see Note 1). For the period with concurrent data at the NWS or PC and composite station, where the composite is the four surrounding station (s=1, ..., 4) average

$$P_{(c,j,k)} = \frac{1}{4} \sum_{s=1}^{4} P_{(s,j,k)}$$

a ratio was computed by

$$R_{(j)} = \sum_{k=1}^{r} P_{(m,j,k)} / \sum_{k=1}^{r} P_{(c,j,k)}$$

The ratios were smoothed twice using 3-month averages

$$R'_{(j)} = \frac{1}{3} (R_{(j-1)} + R_{(j)} + R_{(j+1)})$$

$$R''_{(j)} = \frac{1}{3} (R'_{(j-1)} + R'_{(j)} + R'_{(j+1)})$$

where j-1 equals 12 if j=1 and j+1 equals 1 if j=12.

The composite precipitation data for period with missing NWS or PC data were multiplied by the second smoothed ratio. The monthly normal precipitation was computed from

$$P_{(j,N)} = \frac{1}{30} (\sum_{k=1}^{r} P_{(m,j,k)} + R''_{(j)} \sum_{k=30-r}^{30} P_{(c,j,k)})$$

The annual normal precipitation is the sum of the 12 monthly precipitation normals. The reader should note that the normals for these 65 stations were rounded to two decimal places after the summation was completed. As a result, the published annual precipitation normals may differ from the sum of the 12 published monthly normals by one or two hundreths of an inch.

Heating and cooling degree day normals were computed as previously described for NWS and PC stations with 30 years of record at the same site and with no instrument changes. For the stations with adjusted temperature records, the standard deviations were interpolated from maps depicting values for stations with 30 years of record. These interpolated standard deviations were used with the monthly mean temperature normals to compute degree days. If the computed number of degree days in a month totaled five or less, the normal was set equal to zero.

D. DAILY NORMALS. Daily normals of maximum, minimum and mean temperatures, heating and cooling degree days, and precipitation were prepared for 344 stations by interpolating between the monthly normal values. The interpolation scheme was a cubic spline fit through the monthly values. Each element was interpolated independently from the other elements. The procedure is described by Greville (1967).

The series of daily values of an element resulting from the cubic spline yields a smooth curve throughout the year without requiring the use of daily data. Another property of this technique is that the average of the daily temperatures in a month equals the monthly normal and that the total of the daily precipitation or degree days in a month equals the monthly normal. In order to eliminate discontinuities between December 31 and January 1, the spline interpolation was performed on a series of 24 monthly values. This extended series was created by adding July-December normals before January and January-June normals after December. Thus, if $X_1, \ldots, X_{12}$ represent the January through December monthly normals of an element, then the extended series can be represented as

$$X_7, \ldots, X_{12}, X_1, \ldots, X_{12}, X_1, \ldots, X_6$$

Since each element was interpolated independently, the daily series of temperatures and degree days were edited to remove spurious inflection points caused by rounding and to ensure adherence to functional relationships among the elements. Specifically:

1. All inflection points were examined for climatological reasonableness.

2. One-half of the sum of a daily maximum and minimum temperature, after rounding, was checked for equivalence with the daily mean temperature.

3. The relationship between a daily mean temperature T and the heating H and cooling C degree days for the day was checked to ensure that

$$|T-65 + H-C| \leq 1$$

Daily precipitation normals were published as generated by the cubic spline interpolation. The smooth curve through a month does not represent a climatologically reasonable distribution. The spreading of the monthly precipitation by the spline over all the days in a month is useful for accumulating amounts over specified time intervals. A climatologically reasonable normal precipitation, based on daily data, for any one date would be much different from the published normals.

For some dates at most locations the published degree days are shown by an asterisk. The symbol represents a value of less than one degree day, but more than zero degree days. It is used to smooth through aperiodic oscillations of zeroes and ones that are climatologically unreasonable. For example, if a station has 17, 15, and 18 normal heating degree days in June, July, and August, respectively, it is not possible to distribute the 15 July degree days evenly throughout the month using integer values (zeroes and ones) without creating unrealistic oscillations through the 3-month period. The use of fractional degree days (asterisks) does allow for a smooth transition from June through July to August.

Note 1. For a station for which there are no contiguous stations for comparisons, the less than 30-year average is calculated and considered to be the station's normal value. Short-period averages may be used as normals according to current WMO regulations (1979). There are eight sites for which the 1951-80 values were computed in that manner:

Station No.	Name	Period of Record
50-4988	Kodiak, AK, WSO	1973/01 - 1980/12
50-8419	Shemya, AK, WSO AP	1959/09 - 1980/12
50-9686	Valdez, AK, WSO	1973/11 - 1980/12
91-4351	Koror WSO	1951/07 - 1980/12
91-4460	Majuro WSO AP	1954/05 - 1980/12
91-4690	Pago Pago WSO AP	1956/02 - 1980/12
91-4751	Ponape WSO	1951/07 - 1980/12
91-4901	Wake WSO AP	1956/01 - 1980/12

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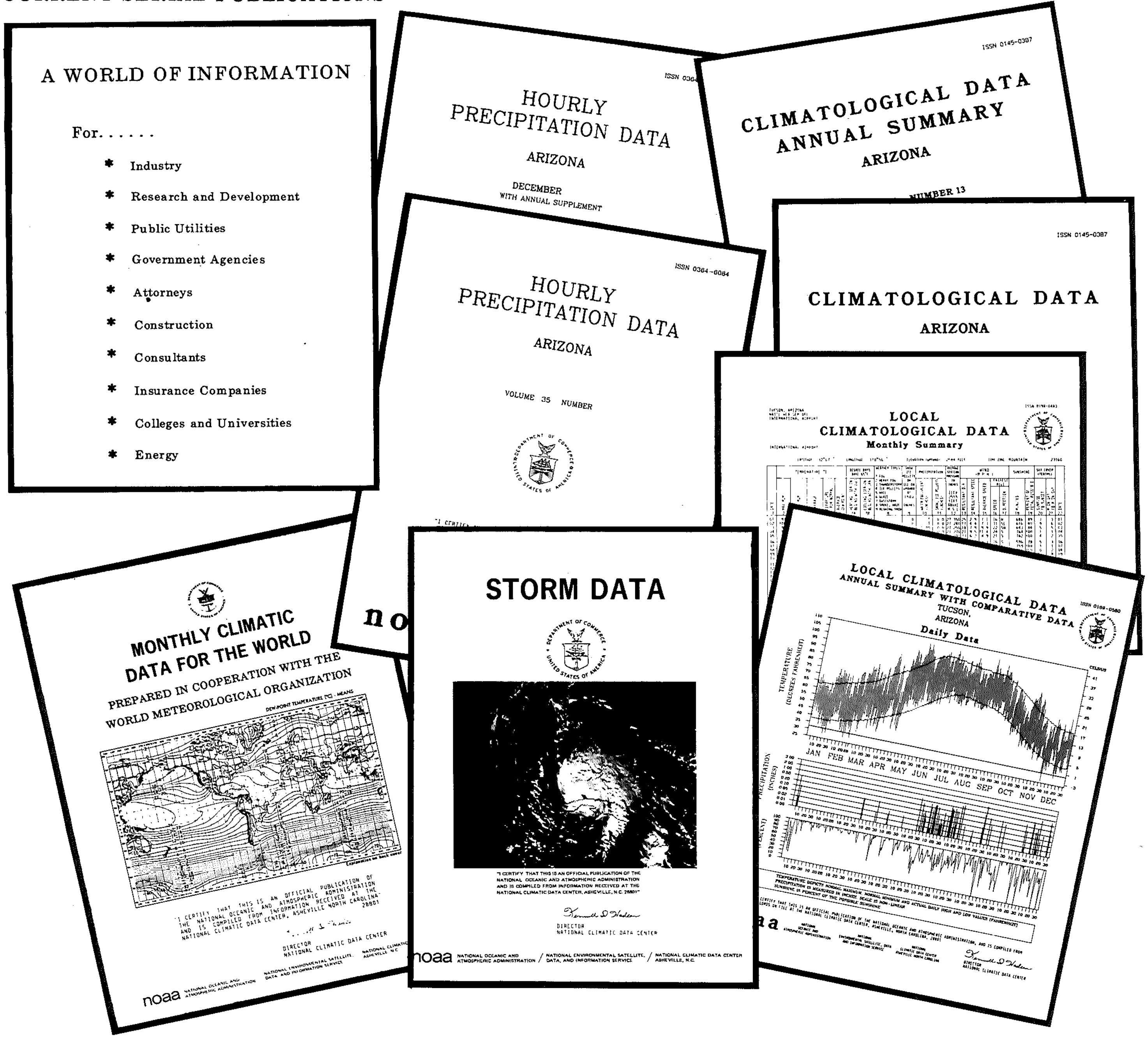

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