ENVIRONMENTAL INFORMATION SUMMARIES C-28
APRIL 1992

CLIMATOGRAPHY OF THE UNITED STATES NO. 84

DAILY NORMALS AND PRECIPITATION PROBABILITIES

The No. 84 series of climatic summaries provides climatic data from 422 National Weather Service Offices and Principal Climatological Stations across the United States and its territories. The data include daily normals for each day of the year. A normal describes the average climate over a long time period. It was decided by international agreements that the appropriate time period would be three consecutive decades.

There have been several issues of the No. 84 series, each covering a different normals period. Daily normals for the 1921-50 and 1931-60 periods included maximum, minimum, and average temperature. Heating and cooling degree day normals were added with the 1941-70 issue. Precipitation normals were added with the 1951-80 issue.

The 1961-90 issue includes two sets of tables: (i) the daily normals for maximum, minimum, and average temperature; heating and cooling degree days; and precipitation; and (ii) precipitation probabilities and quintiles.

Daily Normals: The daily normal values presented in the first set of tables are not simple means of the observed daily values. They are interpolated from the monthly normals by use of the cubic spline function as described by Greville [1]. The series of daily values resulting from the cubic spline yields a smooth curve throughout the year that represents the annual cycle of the climatological element for a station.

There were several reasons for using a cubic spline fit of the monthly normals instead of averaging the daily data. First, simply averaging the observed daily values would result in a daily normal curve that has considerable variability from day to day [2] (for example, the annual temperature cycle would be considerably jagged or ragged). This climatological raggedness could result in daily normals that trend in the opposite direction from what is expected. For example, an autumn daily normal temperature could be considerably warmer than one from several days earlier, or a spring daily normal temperature could be considerably cooler than one from several days earlier. Using a cubic spline fit of the monthly normals eliminates this raggedness from the daily normal curve. Furthermore, a complete and homogeneous (i.e., no change in location, instrumentation, exposure, or observation practices) set of data is necessary for the analysis to be accurate. There are very few stations that have complete and homogeneous daily records. Any change of the types indicated above would introduce a nonclimatic effect which would make the data inhomogeneous. The techniques for estimating missing daily data and adjusting daily data for inhomogeneities are complex and, for some stations, are difficult to apply. However, the estimation and adjustment techniques for monthly data are not as complex or troublesome. Hence, the official daily normals are based on monthly normals which incorporate inhomogeneity adjustments [3].

The daily normal curve begins on January 1 and ends on December 31. The cubic spline function requires data past these end points to serve as an anchor for the computations (this is so the interpolating function can adequately fit the end points themselves). The procedure involves constructing a cumulative series of monthly sums calculated from the monthly normals. The monthly normals were treated as sums in order to facilitate the interpolation of the daily values. For precipitation and degree days, the treatment is straightforward. For maximum, minimum, and average temperature, the monthly sum was computed by multiplying the monthly normal by the number of days in the month. The cumulative series was for a 24-month period (July, August, September, October, November, December, January, . . . , December, January, February, March, April, May, and June) so the end points could be determined. This process was applied independently to all six climatological elements. February 29 is arbitrarily assigned the same value as February 28.

<u>Precipitation Probabilities and Quintiles</u>: The second set of tables at the back of the Daily Normals publication are the monthly precipitation totals that correspond to the indicated probability levels. The probability levels are based on the 1961-90 historical sequential monthly precipitation and are explained below. The historical precipitation data are the adjusted values that were also used to compute the monthly normals [3].

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 display 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 and theoretically takes the form of a bell-shaped curve. Temperature data are more likely to follow a Gaussian distribution than precipitation data. 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, but some values will be considerably higher than the middle range. On the low end of the scale, however, the smallest values will never be less than zero. 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 can be fit by 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. For summarization purposes, the probability levels desired can be preselected at certain individual levels or at regular intervals.

The Gamma distribution was used to estimate the precipitation values in the two tables at the back of the Daily Normals publication. The first table shows the amount of precipitation expected at 15 probability (PROB) 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) for each month of the year and for the annual total. For example, if 1.77 inches corresponds to the 0.20 probability level, that means that, on average, 2 out of 10 years will have 1.77 inches <u>or less</u> of precipitation in that month. It also means that, on average, 8 out of 10 years will have <u>more than</u> 1.77 inches of precipitation in that month.

The second table shows the expected precipitation values at the five quintile levels

LVL	Quintile	Range
1	First Quintile	0-20%
2	Second Quintile	20-40%
3	Third Quintile	40-60%
4	Fourth Quintile	60-80%
5	Fifth Quintile	80-100%

for each of the twelve months and for the year. For example, if 2.91 and 4.07 inches are the bounds for the second quintile, then a monthly total precipitation amount for that month falling in the range 2.91 to 4.07 would be classified as a second quintile precipitation amount and the month would be considered relatively dry. The first line (LVL 0 <) in this table shows the minimum precipitation value derived from the historical record. Quintile level 0 would be used if a future precipitation observation is less than the 1961-90 minimum. The last line (LVL 6 >) shows the maximum precipitation value. Level 6 would be used if the observed precipitation value is more than the 1961-90 maximum. The quintile table is used primarily in National Weather Service operations for composition of information that is transmitted in

CLIMAT messages and published in the Monthly Climatic Data for the World publication.

References

1. Greville, T.N.E., 1967: "Spline Functions, Interpolation, and Numerical Quadrature", Mathematical Methods of Digital Computers, Volume 2 (edited by A. Ralston and H.S. Wilf). John Wiley and Sons, Inc., New York, pp. 156-168.

2. Guttman, N.B. and M.S. Plantico, 1987: "Climatic Temperature Normals", Journal of Climate and Applied Meteorology, vol. 26, pp. 1428-1435.

3. Climatography of the United States No. 81, "Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1961-90", National Climatic Data Center, Asheville, NC.

USCOMM-NOAA-ASHEVILLE, NC 06/92/2,500