ENVIRONMENTAL INFORMATION SUMMARIES C-24

HISTORICAL CLIMATOLOGY SERIES

In response to requests by climatological data users, the National Climatic Data Center (NCDC) has published various data summaries which are of particular interest and importance in the area of historical climatology. Examples of the types of records and summaries are: atlases of anomalies from long-term averages, indexes of records of climatologically-related observations, long-term summaries of degree day data, and comprehensive climatic summaries for specific geographical locations in the United States. These publications are issued in the NCDC's Historical Climatology Series (HCS) under one of six major categories according to their principal content:

1. Long Record of Weather Observations
2. Historical Index
3. Atlases
4. Areally-Weighted Data
5. Population-Weighted Data
6. Climatography

These categories are described below.

1. Long Record of Weather Observations

These publications provide long-term climatological data and related historical information for selected observation sites which are located in distinctly nonurban environments. The location of the site, combined with the long-term record, makes these summaries valuable reference materials in the study of natural climate variability over the past century.

Each publication contains a narrative summary on the history of the station and pertinent topographic maps of the surrounding area. Tabular data presented are as serially complete as possible and include sequential tables of monthly and annual mean temperature, mean maximum temperature, mean minimum temperature, highest temperature, lowest temperature, total precipitation, and total snowfall; seasonal values of mean temperature, total precipitation, and total snowfall with supplemental graphs; and dates of last freeze (temperature 32° Fahrenheit or less) in spring and first freeze in fall. Some publications may include summaries of quasi-climatological data that are unique to the particular area; e.g., dates of lake surface freezing and ice disappearance.

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Publications available in this series as of May 1985 were:

1-1 A Long Record of Weather Observations at Cooperstown, New York, 1854-1977 (July 1978)

1-2 Ninety-one Years of Weather Records at Yellowstone National Park, Wyoming, 1887-1977 (March 1979)

1-3 A Long Record of Weather Observations in Southeastern Iowa, 1839-1979 (July 1980)

2. Historical Index

Publications in this category contain information about the availability of specific records of meteorological/climatological information. The information can be from either published or unpublished sources in a large variety of forms, such as: serial or occasional published reports, manuscript records, autographic records, microfilm or microfiche, or electronic storage media (e.g., digital records on magnetic tape or disc). Each publication gives the potential data user a comprehensive overview of the contents of those particular data sets of interest which are available from the NCDC and, occasionally, from other organizations which archive climatological data. Descriptions of the contents of the individual Historical Index publications follow.

2-1 Index of Historical Surface Weather Records, New York (August 1978)

Surface weather records from observation sites in the state of New York from the early 1800's thru 1980 are summarized in this index. Included in the publication is a synthesis of station histories and other sources of documentation from various published and unpublished sources which are on file at the NCDC. Specifically given are: maps showing observation site locations on a decadal basis; an index of station records with encoded instrument, archive, and publication data; an index of long period records (80 or more years of record); and an inventory of digitized data for 22 selected observation sites from the earliest recorded observation years through 1930. Also included is information excerpted from the Climatic Summary of the United States, 1930 Edition, New York Summary because of its relevance to the history of weather observations in New York.

2-2 A History of Sunshine Data in the United States, 1891-1980 (July 1981)

The NCDC has digitized and summarized monthly and annual totals of "duration of sunshine" from 239 observation sites for each available month and year of record in the period 1891-1980. This publication gives the historical background of the sunshine recording network, periods of record for each recording site, information on the types and locations of instruments, and formats for various sources of published

data. The sunshine data set inventory is given in graphical format by state/station. Map presentations show the sunshine station network as it existed in the years 1891, 1900, 1920, 1940, 1960, and 1980, along with other information on station locations. Examples of time series of annual sunshine data, and a discussion on data interpretation are included as information which is generally helpful to the user of the sunshine data. Also given is a table of total possible sunshine in hours and tenths for the sunshine station network which was in operation during 1979.

2-3 Inventory of Sources of Long Term Climatic Data in Microfilm and Publication Form (July 1982) **DRAFT**

This inventory was designed to serve as a guide for users of 19th Century climatic data, but includes references to 18th and 20th Century data sets which are extensions of the data sets of principal interest. The data sources are primarily in manuscript, tabular, or graphical format, either as published hard copy or microform. The microform materials include microfilm copies of Climatological Record Books, journals, and diaries, with the very early diaries and journals being in no particular format. A major portion of this inventory of sources of long-term climatic data refers to holdings of the NCDC; one section refers to sources which have been identified by the Climatic Research Unit of the School of Environmental Sciences, University of East Anglia.

3. Atlases

Charts which depict the areal distribution of climatic elements or parameters are often very useful in studies of climate variability. The atlases in this series are designed to provide maps of climatological parameters which show climatic fluctuations in a relatively long-term or historical context; the areal coverage of the analyses can be on a local, regional, or continental scale. At present, there are 11 publications in this series classification.

3-1 Atlas of Mean Winter Temperature Departures From the Long-Term Mean Over the Contiguous United States, 1895-1983 (December 1983)

This atlas presents seasonal maps of departures of mean winter (December, January, February) temperatures from long-term mean (1895-1979) temperatures over the contiguous United States for each of the 89 seasons in this period. The atlas provides the user of climatic information with a reference that contains the longest available sequence of maps which depict the spatial distribution of winter season temperature relative to the long-term mean. The maps also present a statistical measure of the degree of unusualness of the departures by giving standardized departures (seasonal values minus the long-term mean divided by the standard deviation).

Atlas of Monthly and Seasonal Temperature Departures From the Long-Term Mean (1895-1983) for the Contiguous United States (May 1984)

3-2 Winter (December-February)

3-3 Spring (March-May)

3-4 Summer (June-August)

3-5 Fall (September-November)

This four-volume atlas presents maps of departures from long-term (1895-1983) statewide average monthly and seasonal temperatures, by year, for the contiguous United States. The departures are standardized, and are shown by one of five well-defined categories. The maps are arranged by year and serve to illustrate the degree of unusualness of any given season over the contiguous United States, as well as the variability which can occur between months within a season. Statewide average temperatures used in calculating departures for this atlas were derived from areally-weighted climatic division averages (see Section 4. Areally-Weighted Data) for the period 1931-1983. For 1895-1930, they consist of equally-weighted temperatures from all available reporting stations within a state. Several adjustments to the data from 1895-1930 were made in order to make the entire series (1895-1983) representative of the statewide averages as though calculated from climatic divisional data.

For each season and each month, five categories of temperature departure from the 1895-1983 mean are indicated for each state by various types of shading. The five quantitatively-defined categories are qualitatively referred to as MUCH ABOVE NORMAL, ABOVE NORMAL, NORMAL, BELOW NORMAL, and MUCH BELOW NORMAL. Monthly and seasonal data are usually well represented by the normal distribution; therefore, the Z-score (or standardized departures from average) was used to classify, by category, each month and season for a state. The monthly or seasonal Z-score for the year i is calculated as $Z_i = (T_i - \bar{T})/s$, where T_i is the year i seasonal or monthly mean temperature for a given state, $\bar{T}$ is the mean temperature across the state (1895-1983), and s is the standard deviation of the monthly or seasonal mean temperatures (1895-1983). Each of the two categories MUCH ABOVE NORMAL or MUCH BELOW NORMAL contains 10% of the seasons (or months), each of the two categories ABOVE NORMAL or BELOW NORMAL has 20% of the seasons (or months), and the NORMAL category contains 40% of the seasons (or months).

3-6 Atlas of Monthly Palmer Hydrological Drought Indices (1895-1930) for the Contiguous United States (February 1985)

3-7 Atlas of Monthly Palmer Hydrological Drought Indices (1931-1983) for the Contiguous United States (February 1985)

The Palmer Hydrological Drought Index is an objective measure of moisture conditions, applicable to the United States. It is a quantitative indicator of water availability (i.e., soil moisture, streamflow, and lake levels), and is strongly dependent on slow response water storage parameters. This pair of atlases contains maps of the index on a monthly basis, which serve to illustrate the spatial and temporal variability of hydrological drought in the contiguous United States. Seven categories of drought are delineated by various thresholds of drought and wetness. The atlases are especially useful to water resource managers, economists, hydrologists, climatologists, and geographers. The maps are invaluable if used appropriately; their interpretation requires familiarity with the Palmer Drought Model.

The map depictions are by state climatic divisions (see Section 4. Areally-Weighted Data). HCS 3-6 is for the years 1895-1930; for that period, the divisional averages of temperature and estimates of total monthly precipitation were obtained by a series of regression equations which related statewide monthly temperature and precipitation amounts to divisional values. HCS 3-7, for the period 1931-1983, is based entirely on state climatic divisional data.

3-8 Atlas of Monthly Palmer Moisture Anomaly Indices (1895-1930) for the Contiguous United States (February 1985)

3-9 Atlas of Monthly Palmer Moisture Anomaly Indices (1931-1983) for the Contiguous United States (February 1985)

These atlases, which depict areal distributions of monthly values of the Palmer Moisture Anomaly (Z) Index, are of the same format, derivation, and utility as HCS 3-6 and 3-7 described above. The value of Z is regarded as the "moisture anomaly index," and expresses on a monthly basis (from a moisture standpoint) the departure of the weather of a particular month from the average moisture climate of that month. Z values reflect short-term moisture deficiencies or excesses, and the index is quite sensitive to unusually wet (dry) months even in an extended period of dry (wet) weather.

3-10 Atlas of Monthly Palmer Drought Severity Indices (1895-1930) for the Contiguous United States (February 1985)

3-11 Atlas of Monthly Palmer Drought Severity Indices (1931-1983) for the Contiguous United States (February 1985)

This pair of atlases is of the same format and derivation as HCS 3-6 and 3-7 described above. The Palmer Drought Severity Index, in contrast to the Palmer Hydrological Drought Index, is a meteorological drought index which attempts to classify spells of weather. This means that once the weather begins

to change to a new regime, the index will rapidly respond, regardless of soil moisture conditions, streamflow, or lake levels, etc. The index is not very dependent on water storage parameters during wet/dry transition periods, as is the Hydrological Drought Index. As a meteorological drought index, it has been used in meteorological and climatological studies where the classification of spells of wet or dry weather was important.

4. Areally-Weighted Data

The arithmetic average of meteorological data from stations lying within a predetermined area may not be physically representative if the geographical area is characterized by subareas which have distinct and differing climatologies. A meaningful climatological average can be obtained by arithmetic averaging if the geographical region is climatologically homogeneous; or, if that is not the case, by arithmetically averaging station data from climatologically homogeneous subregions and then weight-averaging the subregion averages. To be realistic, the weight must be the percentage of the total area represented by the climatologically homogeneous subregion. As an example of the above, the arithmetic average of temperature data from stations in North Carolina would not represent the average state temperature because there are eight subregions of North Carolina which have distinct climatologies. These range from that of a low coastal region type climatology to that of a high mountainous region type climatology. The continental United States has over 300 distinct climatological subregions, each which lie within a state, and are called "state climatic divisions" in the climatological records. A division represents a region within a state that is, as nearly as possible, climatically homogeneous.

There are three publications in this group, two for United States temperature data, and the other for precipitation data.

4-1 State, Regional, and National Monthly and Annual Temperature Weighted by Area, January 1931-December 1982 (Revised September 1983)

4-2 State, Regional, and National Monthly and Annual Total Precipitation Weighted by Area, January 1931-December 1982 (Revised September 1983)

These two publications contain averages calculated from state climatic divisional data only. The period-of-record begins with January 1931; long-term means and standard deviations are included along with the averages for the individual months and the annual totals. Annual values are ranked relative to the entire period-of-record. For these publications, the regional values are for the nine census regions as defined and used by the Bureau of the Census.

4-3 Regional and National Monthly, Seasonal and Annual Temperature Weighted by Area, 1895-1983 (June 1984)

This publication contains areally-averaged temperature data for the conterminous United States and nine climatologically-defined groups of states (i.e., regions), for the 89-year period, 1895-1983. Tabular listings give the average temperatures by month, and groups of months (which includes the seasons and year) for the individual years in the period-of-record. The rank of the year-value of the calendar event is also given, which facilitates the identification of inter-annual, intra-annual, and intra-seasonal climate variability. Time series plots of annual mean temperatures for the nation and each region depict the inter-annual variation about the long-term (1895-1983) mean temperature.

The data summaries in this publication differ significantly, in some respects, from those given in HCS 4-1 described above. The differences are:

- The period-of-record for HCS 4-1 is 1931-1982 (52 years), whereas this publication contains data for the 89-year period, 1895-1983.
- This publication does not contain individual state data.
- This publication contains month-grouped data which includes the usual seasonal monthly groups: Winter (December-February), Spring (March-May), Summer (June-August), and Fall (September-November).
- The rank order in this publication is opposite to that given in HCS 4-1; i.e., here the number one rank is the coldest temperature, whereas in HCS 4-1 it is the warmest temperature.
- The definitions of the regions, in terms of specific groupings of contiguous states, differ significantly. In HCS 4-1 the regions are the nine census regions as defined and used by the Bureau of the Census; in this publication the nine regions are climatologically-defined groups of adjoining states which were shown to be climatically similar during the period 1895-1981.

5. Population-Weighted Data

Meteorological and meteorologically-derived data for climatologically homogeneous areas, such as divisions, are often used in problems related to human activities which have economic importance. (The concept of climatic divisions was described in the previous section on areally-weighted data.) In those instances, a weighting based on population density often gives a measure of human demand relative to climatically-influenced economic matters, such as energy consumption and water resource management. Specific examples of meteorologically-related data which could be used thusly are precipitation amounts, heating degree days, and cooling degree days. (Degree days are a

measure of departure from 65°F of the daily average temperature.) By population-weighting the divisional averages of those types of data, the impact of population demand on the related economic parameters can be quantitized, and comparative population-weighted data can be used in decision-making processes which are related to the general well-being of the population. An example of this would be an equitable distribution of scarce heating fuel resources based on population-weighted heating degree day data.

5-1 State, Regional, and National Monthly and Seasonal Heating Degree Days Weighted by Population (1980 Census) (July 1931-June 1983) (Revised October 1983)

5-2 State, Regional, and National Monthly and Seasonal Cooling Degree Days Weighted by Population (1980 Census) (January 1931-December 1984) (Revised May 1985)

Both of the above publications contain population-weighted degree day data by year based on state division averages. Each publication gives the long-term mean and standard deviations for the individual months and annual total, and a rank value which gives the relative standing of the annual degree day value in the long-term record. Also included are 30-year averages based on data for the 1951-1980 period. The base temperature for the calculated values is 65°F.

5-3 Percent of Normal, State, Regional, and National Monthly and Seasonal Heating Degree Days Weighted by Population (1980 Census), July 1931-June 1983 (July 1984)

5-4 Percent of Normal, State, Regional, and National Monthly and Seasonal Cooling Degree Days Weighted by Population (1980 Census), January 1931-December 1982 (July 1984)

These publications contain the percent of normal of the degree day data given in HCS 5-1 and 5-2 described above. The values were derived for each month and year by dividing the accumulated degree day value by the corresponding 1951-1980 normal value.

6. Climatography

A climatography is a thorough, quantitative description of climate, particularly with reference to the tables and charts which show the characteristic values of climatic elements at a station or over a (well-defined) area (Glossary of Meteorology, 1959). The term "climatography" often has a comparative geographical connotation. The publications in this category are climatographies for specific areas within the United States which are important because of political, social, and economic considerations.

6-1 Statewide Average Climatic History
(available for each of the 48 contiguous states - Alabama through Wyoming) (October 1983)

Each climatography in this group presents historical climatic data for an individual state (except for Alaska and Hawaii). Tabular listings and time series plots are given for temperature, precipitation, heating and cooling degree days, and drought indices. The temperature and precipitation data are the monthly averages for the state which were calculated from areally averaged divisional data for the period 1931-82, and from adjusted U.S. Department of Agriculture state averages for the years prior to 1931. (Divisional data were described in the previous section on areally-weighted data - HCS 4.) The monthly statewide values of heating and cooling degree days are based on population-weighted divisional temperature data for the period beginning with 1895. Population weights were derived from the 1980 census population data; hence, apparent climatic variations in the data record are relative to contemporary population distributions. Drought data are given in the form of two indices: the Palmer Drought Severity Index (PDSI) and the Palmer Hydrological Drought Index (PHDI) (PHDI is Palmer's X_3). The drought indices are presented on a divisional basis for the period 1931-1982, and on a statewide basis from the late 19th Century through 1982. The beginning year of record for the statewide data is the year for which both temperature and precipitation averages were available. The summarization methodology and data presentation formats are completely explained in each state publication as a preamble to the data displays. The data displays are structured so that climate anomalies for the state can be identified in the context of interannual climate variability.

The climatographies in this group (6-1) are available individually by state name; e.g., HCS 6-1, State Average Climatic History - North Carolina.

Background Information for the Historical Climatology Series

The use of climatological data in the context of historical perspective usually entails detailed searches of climatological records for the meteorological observations, site and instrument information, and derived data based on the observations. Although standard summaries of observations are often useful in specific applications to climatologically-related problems, the use of those summaries for comparative historical purposes sometimes becomes difficult, especially when the temporal changes of a long-term sequence of observations are being considered. Very often standard summaries do not contain the information which is relevant to the study of historical climatological records; and, more often than not, the summaries do not identify problems which may exist in the long-term record. Some common problems which can be identified in most long-term data sets, for either a given locale or region, are:

1. The observation records are serially incomplete,

2. The observations are nonhomogeneous -- which could have been caused by any of the following: changes in instrument type, changes in instrument location, and changes in observation practice (including standards and observers), and

3. There are apparent climate variations, shown by the data, which are difficult to explain, but which, in reality, result from recognizable modifications of the environment of the locale or region.

Also, along with those possible problems are the many difficulties usually encountered when actually searching for, locating, and retrieving appropriate data sets and derived parameter summaries which can be used in historical climatology researches. (Here "derived parameter summaries" are meant to include any scalar analyses or summaries which result from calculations based on the observed primary meteorological variables, such as dry bulb temperature, surface pressure, precipitation amounts, etc.) As mentioned before, examples of the types of records and summaries published in the Historical Climatology Series are: atlases of anomalies from long-term averages, indexes of records of climatologically-related observations, long-term summaries of degree day data, and comprehensive climatic summaries for specific geographical locations in the United States.

For ordering information and costs, please contact:

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