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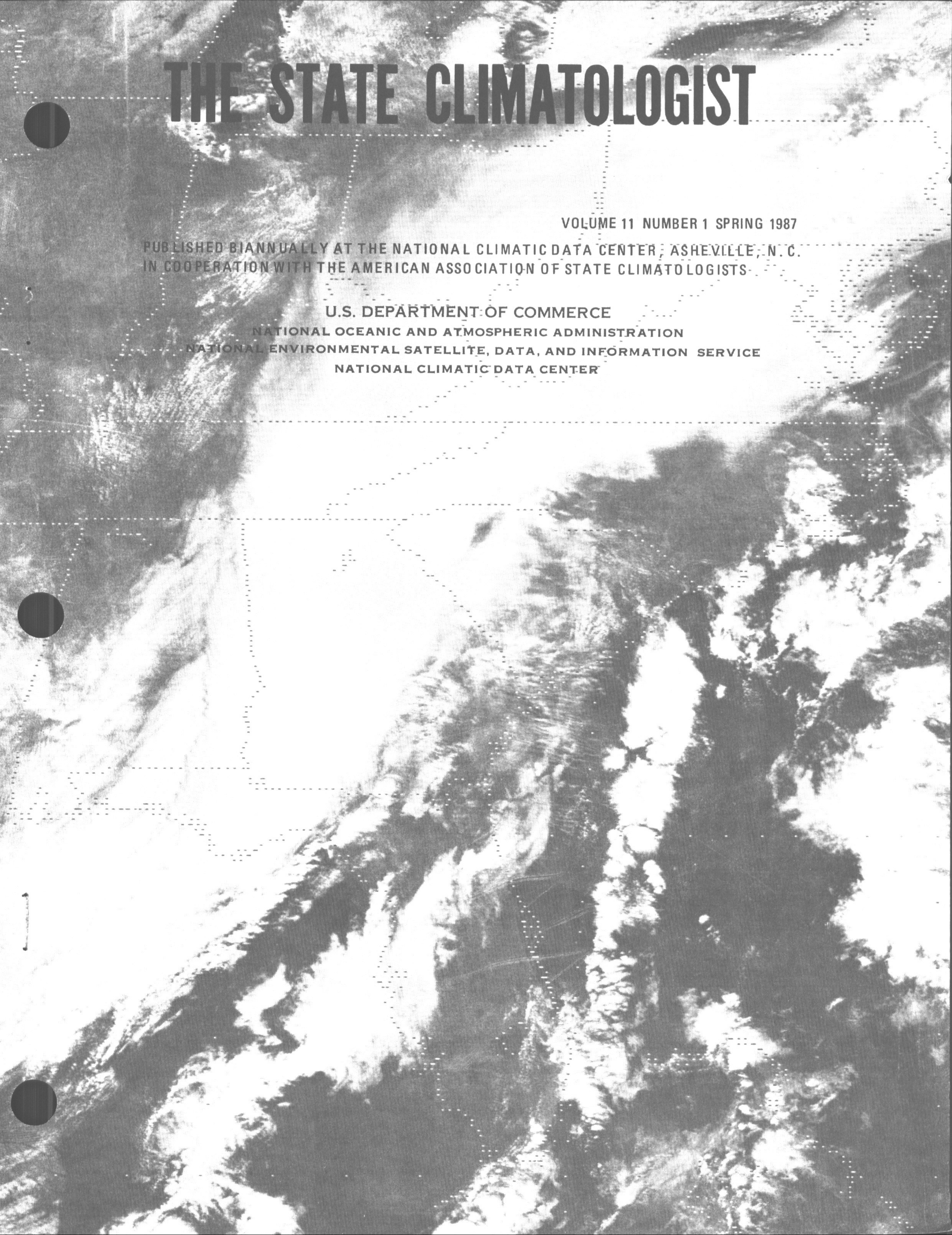
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE
NATIONAL CLIMATIC DATA CENTER



COVER PHOTO: GOES photograph of a record snowstorm taken at 10:00 a.m. EST, April 3, 1987. At this time a low was developing in north Georgia along an old cold frontal boundary. The low deepened as it moved slowly northeastward and blanketed most of western North Carolina and east Tennessee with 12-24 inches of snow by midnight of the 3rd. However, this was only the beginning for the mountain regions along the TN/NC border where an additional 12-36 inches fell over the next two days as strong northwest winds pushed up the northwest slope of the Appalachians. The greatest recorded snowfall was 60 inches at Newfound Gap in the Great Smoky Mountains National Park. This exceeds any other known single snowfall event in North Carolina or Tennessee.

Thanks to Milton Brown, NWS, Columbia, SC, for providng the photograph.

NCDC BRIEFS

Alaska Marine Atlas Updated. The Alaskan Minerals Management Service and the U.S. Navy has contracted NCDC to update this 3 volume atlas. The project is scheduled for completion in October 1987. Copies will be available through the Government Printing Office, Washington, DC.

World Weather Records, 1971-80, Vol. 2 - Europe has been sent to the contractor for printing. (It is anticipated that) Distribution distribution of this volume will take place in August 1987. Copies will be available through NCDC.

Station History Project. NCDC has begun using the new form letter correspondence system with the NWS Cooperative Program Managers (CPM's) to resolve station information problems. These form letters contain sections for station problems or questions. Address labels for the CPM's, as well as return labels for responses, are stored and generated on "PCs." It is expected that this new system will save time in resolving problems, because it is difficult to contact the CPM's by telephone due to their travel schedules.

State Climatologist Exchange Program. This year's exchange program will bring three State Climatologists to NCDC. They will be working on various projects of mutual benefit to each of their state's programs and NCDC. Some of these projects are the update of station histories, climatic summaries, quality control procedures, and research projects. The three participants for 1987 are Dean Bark, Kansas; Glenn Conner, Kentucky; and John James, Nevada.

Visiting Scientist Plan. A draft plan has been prepared for establishment of an NSF-supported visiting scientist program at NCDC. The plan is modelled after the highly successful State Climatologist Exchange Program, but would allow longer stays and more definitive research projects. Benefits include improved research efficiency through increased mutual understanding of research community requirements and NCDC data resources.

NEWS FROM THE STATES

Phone Number Change. For John Purvis, South Carolina, (803) 737-6550 or 6559.

New CAC Product Available for Testing

A newly developed product of the NWS's Climate Analysis Center(CAC) is now available for testing and evaluation by State Climatologists. The product "PMT" (an acronym for Probability of Monthly Temperature and degree day outcomes), is an interactive system of programs and files on a 5.25 inch PC floppy diskette designed to promote the effective use of monthly climate data in decision making.

Key features of the new system are:

- Results are provided for variables derived from climatology alone or for forecast-contingent variables.
- Mid-month to mid-month as well as standard monthly variables are handled.
- Results are provided for user defined degree day bases as well as the standard one (65 def F.)
- non-Gaussian(skewed) degree day variables are handled.

The user must have 1) an IBM PC or clone capable of operating on the MSDOS operating system, and 2) a specific local monthly temperature or degree day outcome of concern. PMT prompts the user for three-letter codes for the location and monthly period of interest from menus of 120 U.S. locations and 24 monthly periods(12 monthly and 12 midmonth-midmonth periods). If the location of interest is not close to one of those listed, PMT asks the user to supply certain monthly temperature statistics from the appropriate local data base. PMT then prompts for the specific critical outcome of concern(e.g. 85 deg F, or 740 cooling degree days), the degree day base, and whether or not the result is to be forecast-contingent.

The result is given in the form of statements as follow:

'A[Gaussian] function [forecast-contingent] climate model [cooling degree day] variable with norm = [540], s.d. = 110, [and degree day base= 67] is used to predict [August cooling degree day] outcomes for [your area]'

'The PROBABILITY that your [AUG cooling degree day] outcome will =< [740] is [.92]'

For more information and a copy of the PMT diskette for trial and comment purposes only, please contact Dr. Richard L. Lehman, W/NMC5, Climate Analysis Center-National Meteorological Center-NOAA, Washington DC, 20233.

INSTITUTIONAL MEMBERSHIP CATEGORY

FOR THE AASC?

By Dr. Wayne Wendland
State Climatologist for Illinois

President Miller asked that I investigate the possibility of initiating an institutional membership category for the AASC. SCs typically receive inquiries concerning the availability of (1) weather observations from sites other than airports in their state and others, (2) instruments for private use, and (3) general climatic information. Each of us answers these requests as our experience permits. This experience level could be improved to our benefit if a medium existed through which information could pass from various venders to the SCs, and vice versa.

An institutional membership in the AASC is one way whereby this transfer of information may be accomplished. Book publishers, instrument manufacturers and distributors, meteorological and climatological consultants, legal associations, and others may well be interested in participating in such a program. In order for such information transfer to be successful, we must scan the potential member field and promote the concept with them prior to the 1988 meeting, where, for the first time, they would be invited to attend, show their wares, and participate.

Prior to the meeting this August in DSM, please give some thought to this idea, particularly how potential weak points can be made strong before we move forward. Second, please construct a list of potential members (with addresses) and either send them to me prior to the August meeting, or give them to me there. Potential members are those who have contacted you for information in the past and might be interested in associating with the AASC in a formal way.

I doubt that this category would produce substantial income to the Association, however, it could be a most effective medium to improve communication with some of our users.

PRECIPITATION AND WATER QUALITY

By

E.A. Carter, Former State Climatologist for Alabama

With the increased concern for our quality of ground water, the precipitation amounts and rate of rainfall become important factors in future plans. The article by Frank Forrester in the April, 1985 **Weatherwise** is an excellent inventory of **The World's Water.** This brief paper is to extend that information and show an application of using precipitation data to evaluate the contribution of the hydrologic cycle to water quality at specific locations.

The approximately 100,000 cubic miles of water evaporated into the atmosphere each year, which condenses and returns as precipitation would average about 32 inches (813mm) of annual rainfall over the entire earth. Of course, precipitation is not evenly distributed and most precipitation falls over the oceans.

Fletcher & Sartos (1951) published a graph of rainfall amounts and rate of rainfall from world weather records, Fig. 1-1. It is reasonable to follow this technique from weather records for a specific area. Rainfall records over the area of a state are readily available and an envelope of past rainfall amounts and rates of rainfall are easily prepared, Fig. 1-2. Any size area may be selected, from a state climate region to several states with similar rainfall patterns.

The resulting envelope may be compared with other regions and an equation developed for use with other factors such as area extent, frequency of wet and dry periods, snow melt, type of soil, estimates of water runoff, etc.

The maximum rainfall rate for Fig. 1-2 can be expressed by R=4.2(D) 0.38 inches and R=107(D) 0.38 mm. Where R is the amount of rainfall for period D and D is the duration of rainfall in hours.

Average precipitation may be presented and used this way also. From the rainfall records for Alabama, the average annual variation among stations is only about 10 inches, or less than 20% variation. Annual maximum variation may be as much as 15 inches, or less than 25%. There are periods, however, when rate of rainfall and total rainfall amounts shown may occur at any place in the state.

An examination of rainfall records for other states may determine that they also may be treated in a similar manner to evaluate the contribution of rainfall in maintaining water quality.

References:

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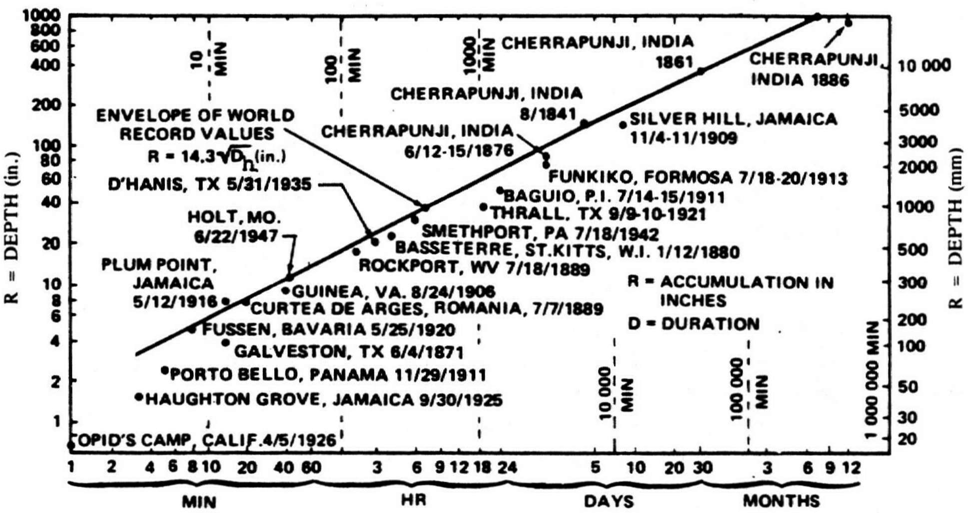
2. Fletcher, R.D. & D. Sartos, Air Weather Service Technical report, No. 105-81.

3. Forrester, Frank H. "The World's Water", Weatherwise, April, 1985.



$R = 363.0\sqrt{D_h}$ (mm) or $R = 14.3\sqrt{D_h}$ (in.) Where R is the depth of rainfall for period D, and D is the duration of rainfall in hours.

Figure 1-1. World Record Rainfalls And An Envelope Of World Record Values. (After R. D. Fletcher And D. Sartos, Air Weather Service Tech. Report No. 105-81, 1951.)

Alabama Maximum And Minimum Rainfalls

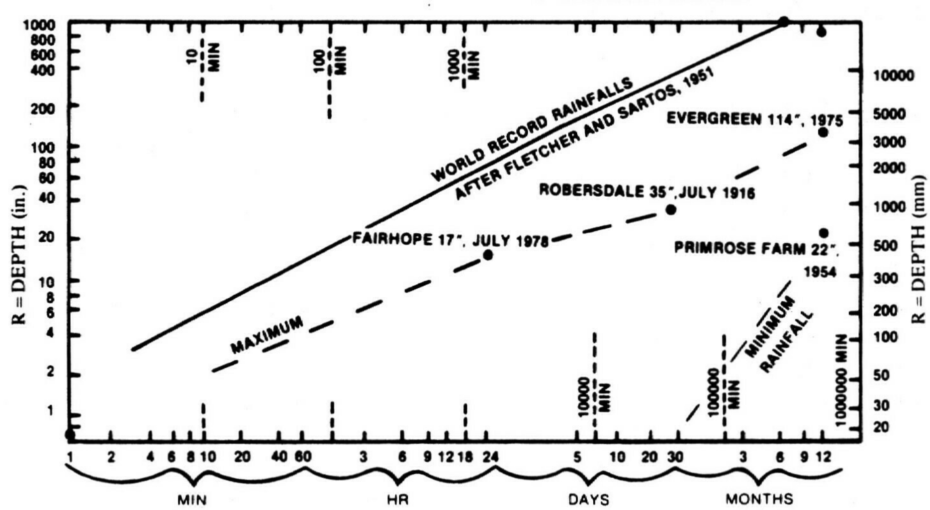


Figure 1-2. Alabama Record Maximum And Minimum Rainfalls And An Envelope Of World Record Values.

Climatic Change In Fact and In Theory: Are We Collecting the Facts?

Thomas R. Karl and Robert G. Quayle

1. Background

Various conflicting theories and forecasts of changing climates and rising or falling sea level have alternately terrified and comforted lay people and researchers alike. Congressional testimony from expert witnesses has varied from nuclear winters to greenhouse warming. With respect to the latter, some scientists with perfectly respectable credentials are forecasting global calamities, while others have foreseen the carbon dioxide-enriched atmosphere as a source of stimulation for plant life, bringing agricultural productivity to new highs.

Observers of these debates can relate theory to fact and policy in two ways: First, we should search out the most comprehensive numerical models for reliable forecasts, but keep in mind that these forecasts may not necessarily be perfect and some may be completely wrong. Second, due to this uncertainty, we should carefully monitor the global climate as well as that of the United States for unusual signals that may portend a change in climate.

This latter point, monitoring for climate change, is itself an extremely complex process. It involves the study of heterogeneous sets of climatological records dating from their historical beginnings to the present time. Fortunately for people seeking practical answers to the question "Is the climate now much different from what it was in the recent past?", a federal infrastructure already exists to keep track of near-surface temperature and precipitation records for nearly every part of the United States (and for many other parts of the world). Temperature and precipitation measurements are two of the most basic and important elements in the climate system.

The need to establish and record the climatic conditions of the United States was recognized by Congress in 1890. The original purpose was agricultural, but many other uses of the data have since evolved. The National Climatic Data Center (NCDC) is the collection center and custodian for many of the United States' weather records. Given adequate climate records, modern computer methods now make it possible to analyze great masses of data and derive definitive statistical statements regarding the likelihood that a climatic anomaly or fluctuation is (or is not) historically consistent with earlier records. Little recourse to speculation is necessary if these basic scientific tools are used properly. Considering the potential consequences of a greenhouse warming, it is most important that we adequately monitor our climate. Without careful measurements, the early detection of any climate change will not be possible. Although the observing networks and data bases currently exist for climate analyses, several problems will need to be overcome to make more dependable, routine monitoring for climate change a reality for the United States. Even more challenging problems will need to be solved to achieve true global monitoring.

2. Current Status

The present monitoring network in the United States, with few exceptions, has been tailored to the needs of day-to-day meteorological and climatological practices. Out of nearly 8,000 National Weather Service stations in the contiguous United States, about 300 primary stations are staffed by paid professional technicians. These stations are shown in Fig. 1. Many are located in major metropolitan airports across the nation. These "First order" and "Second order" (or "primary") weather stations also provide important information with respect to other atmospheric variables besides temperature and precipitation. The instrumentation at these stations is often state-of-the-art technology. Since their major role is to provide information for operational weather-related activities, they were not designed to fulfill the role of monitoring climate change. Most of these stations have had a history of major station and instrument relocations. Furthermore, recent advances in automated observation systems are expected to become fully operational in the near future. Such systems will be welcomed by climatologists only if the observing systems ensure against further inhomogeneities.

Our current national climate monitoring network (the cooperative climate network depicted in Fig. 2) is staffed mostly by volunteer observers who in many instances use 1870's technology to monitor daily temperature and precipitation. Use of older technology is good for homogeneity of records, but can be costly, limited in versatility, and sometimes give an impression of obsolescence. One needs only to inspect Fig. 3 to see the increased observational coverage provided by the cooperative network. In states such as North Carolina, reliance on only the primary station network produces errors in the estimation of annual precipitation of 250mm or more (about 10 inches) in many parts of the state. The importance of the cooperative station network with respect to water resource planning, energy, and agriculture is obvious. In the absence of these additional stations only relative changes could be inferred in many areas. This is not acceptable in many planning scenarios.

Not only is our primary station network inadequate with respect to total national climate monitoring, but the early detection of the greenhouse warming cannot be adequately resolved with these stations. That is, the global warming expected with increased levels of atmospheric greenhouse gases such as CO_2 cannot be easily verified. Many of the First order stations are in the vicinity of major cities where the local heat island effect, common to commercial and urban areas, can obscure the regional climate signal. The detection of the greenhouse warming will be difficult to separate from the heat island warming of growing cities. Several recent papers [1,2] have shown that in the western United States the rise of temperature attributed to the urban heat island in "sun belt" cities is 0.3°C to 0.4°C (about 0.8°F) per decade, and in the eastern United States the rise is over 0.1°C (about 0.2°F) per decade. Figure 4 depicts the enhanced warming in the primary network compared to cooperative climate division data. The time of observation bias in the climate division data was removed by using a recently developed model[3]. The climate division data include all primary stations as well as cooperative stations measuring both temperature and precipitation (now approximately 6,500 stations). The primary station network data was interpolated to the center points of each of the 344 climate divisions as defined by the National Climatic Data Center. Both of these data sets were then areally averaged to calculate national average temperatures. The artificial warming in the primary station network, relative to the climate division data, is nearly 0.17°C (0.3°F) over the past 34 years.

Given that the primary network is not well suited for the early detection of climate change, what about the cooperative station network? In reality, our cooperative station network was never intended to serve as a reference climate network for early detection of climate change. Cooperative weather stations as well as our primary stations are strongly influenced by our dynamic, technological, and mobile society. Cooperative stations also suffer from frequent changes of instrument location, environment, exposure, and observational procedures. In fact, it has been shown that changing observing procedures at cooperative stations can introduce an artificial cooling of as much as 0.5°C to 1.0°C (1°F to 2°F) into the mean temperature in many areas of the United States[3]. Despite the fact that this is a correctable discontinuity, it is highly undesirable for early detection of climate change.

For these reasons, in 1954 the U.S. National Weather Service proposed a reference climatological network of 50 stations to monitor climate change. In 1973 the Special Projects Office of the U.S. Environmental Data and Information Service proceeded with the program on a reduced 21-station network scale. Stations in the network monitor daily surface temperatures (maximum and minimum), precipitation, and wind movement, although wind equipment is wearing out and replacement has been a problem. Some stations also record soil temperature and other climate elements. They are spread fairly evenly across the country (Fig. 5). The annual cost of operation is estimated at about $1,000 per station[4]. The advantages these stations have over routine cooperative stations are:

1) They are located in areas where the surface conditions surrounding the site must remain essentially unchanged for at least 30 meters.

2) They are less subject to station relocations than ordinary cooperative stations.

3) A special effort is made to ensure that the observation of each of the elements is routinely made at the same time each day over the years of operation of the network.

4) The National Climatic Data Center provides a detailed program of timely feedback to the observers with respect to any errors in observations.

5) Site visits are made more frequently at these stations by trained U.S. National Oceanic and Atmospheric Administration personnel than at other cooperative stations.

Such a network is helpful in the early detection of climate change, but as evidenced by the spatial distribution of the stations, large portions of the country are not included in the network. As we have seen in Fig. 3, there is much detail that will be lost. Additionally, some of these sites had inhomogeneities in their records prior to their commissioning. This makes them inconsistent with the concept of long-term retrospective monitoring, i.e., no station inhomogeneities such as station moves, changes in observing time, etc. Furthermore, in such a small network there is always the danger of decommissioning a few stations for unforeseen circumstances. This could jeopardize the entire network.

3. Recommendations

Given the current status of our observing systems we would like to emphasize the importance of improving of our dense, mostly volunteer multi-purpose cooperative climate network, and the processing of the data from these sites. Current estimates for the annual costs of equipment maintenance and replacement, processing of data, the salary of observers (in remote areas some observers are paid), and the salary and travel of the servicing technicians are about $600 per station[4].

Unfortunately, several problems relating to instrumentation and station closings in the cooperative station network could further degrade the value of the network for early detection of climate change and other applications. For these reasons we recommend the following actions be taken:

(1) The entire observing system needs accurate and homogeneous instruments and recording/communications procedures. We need to provide more frequent calibration and servicing. Site visits by professionals are essential. Any new instruments used at cooperative stations must have the capability of providing maximum and minimum temperature on a calendar day basis (to avoid biases introduced by varying the time of observations). Rain gauges, particularly if the tipping bucket design is used, should be able to routinely resolve a wide range of rainfall rates and totals without biases.

(2) We need to recruit more observers. When an observer moves or otherwise separates from the program a new recruit must be located quickly. A large number of stations is necessary to homogenize discontinuous records. Each community, especially non-urban areas, and each major agricultural area should have adequate coverage (currently NOAA strives for at least one station per 1600 sq. km (615 sq. mi.)). This will enable climatologists to separate the climate signal from the noise in the data, and provide adequate spatial resolution of any climate change.

(3) Data must be validated quickly to provide timely feedback to observers and station managers. This will reduce errors in the data and improve the quality of the data base. Personal diplomacy and tact are essential in these transactions because of the volunteer status of the observers.

(4) Up-to-date computing equipment must be made available to the climatologists and computer specialists who analyze the data. The data base should reside on-line for instant recall and processing. Otherwise, too much time and cost are wasted by using outmoded computer processing procedures.

(5) Historical manuscript records need to be digitized. Although some progress has been made, many years of historical data, painstakingly recorded and archived in weather logs, have still not been put into computer-readable formats. Very little pre-1948 daily data are available in digital form and only about 10% of the pre-1948 monthly data has been digitized. Such data are essential for scientific comparisons of current weather with past records.

(6) The original manuscript data should be preserved. Half of the pre-1948 manuscripts have not been microfilmed, and will soon disintegrate due to acid-induced decomposition. Filming these records would be a five million dollar task.

(7) Increased support and emphasis are needed to "homogenize" data into continuous time series that represent actual climatic change as opposed to artificial changes caused by instruments, observing procedures, urban warming and other factors.

Similar practices should be instituted worldwide, with internationally established standards and exchange procedures, such as has been done for marine data. The World Meteorological Organization, World Data Centers and other international bodies can provide the coordination on a global basis, with developed countries assisting lesser developed nations in data acquisition and processing.

4. Conclusions

Currently we are observing the build-up of greenhouse gases at chemical sampling sites around the world. Satellites and surface stations are monitoring changes in the ozone layer. Climate modelers are using the world's most sophisticated computers to estimate future states of the atmosphere. We should place similar emphasis on monitoring for climate change where we live and work and grow our food. Additionally, the past state of the atmosphere as documented by hand-written weather observations should be made accessible to electronic computers and studied in parallel with climate predictions. Only in this way, when talking of "climate change", can we answer the basic question "change from what?" It will be to our long-term advantage to put adequate thought and resources into this problem. At the very least, here in the United States, we need to know the scope and magnitude of any climate change for each major community, agricultural area, and perhaps even each congressional district. A coordinated intergovernmental effort will be essential if true state-of-the art monitoring of the surface climate is to become a reality.

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List of Figures

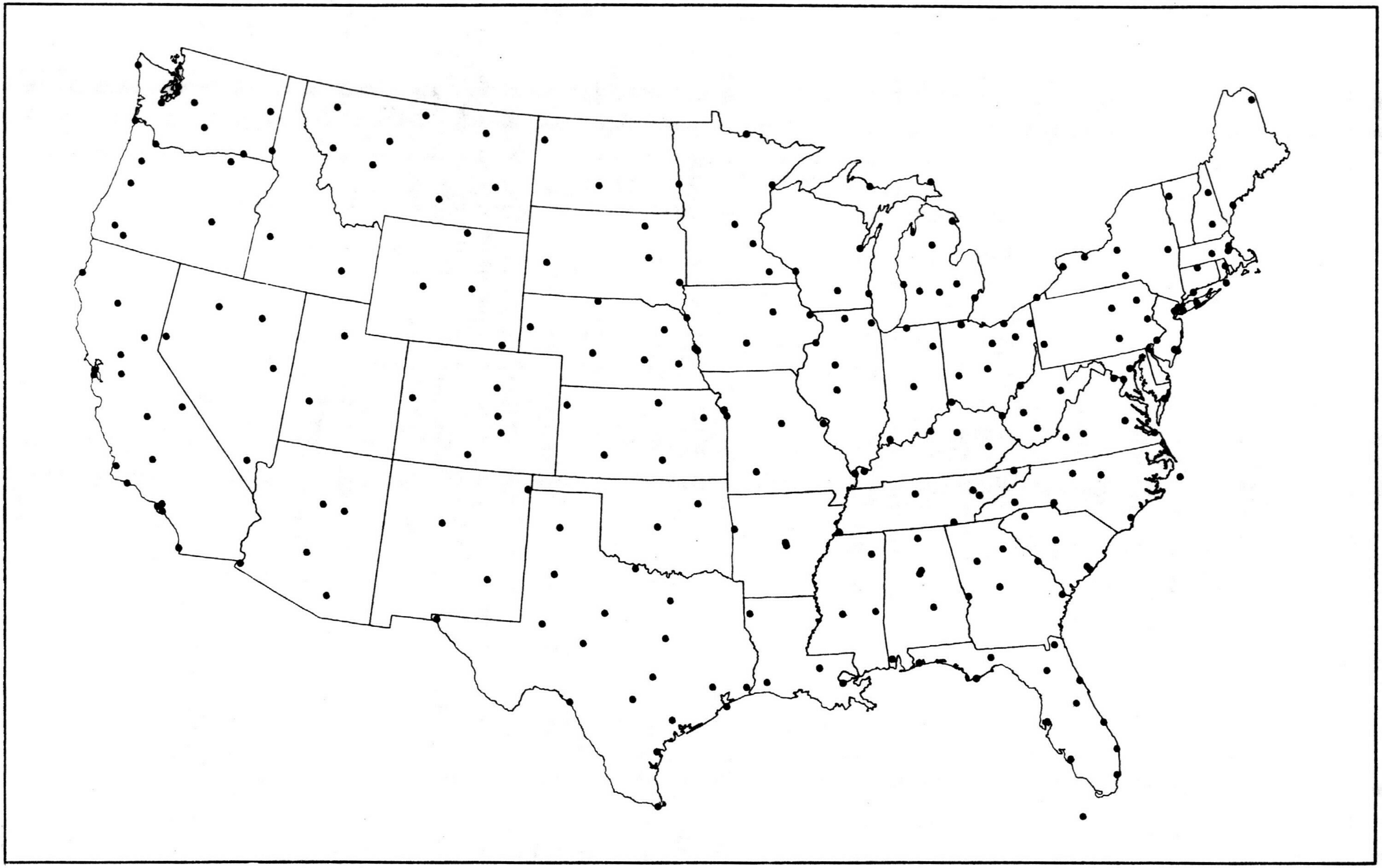

Figure 1 First order station network in the contiguous United States.

U.S. COOPERATIVE DATA STATIONS

JULY 1985

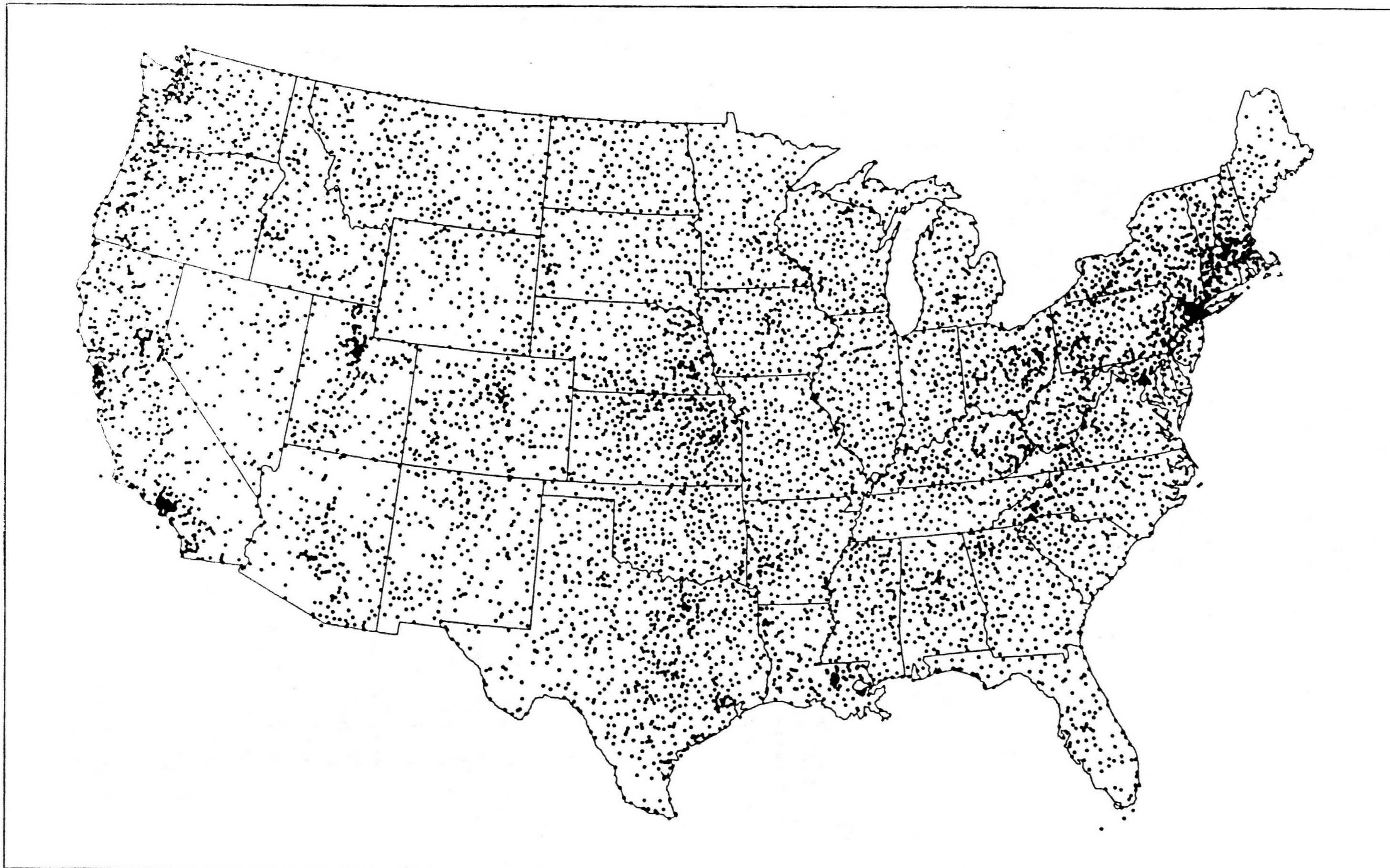

Figure 2 Cooperative station network in the contiguous United States.

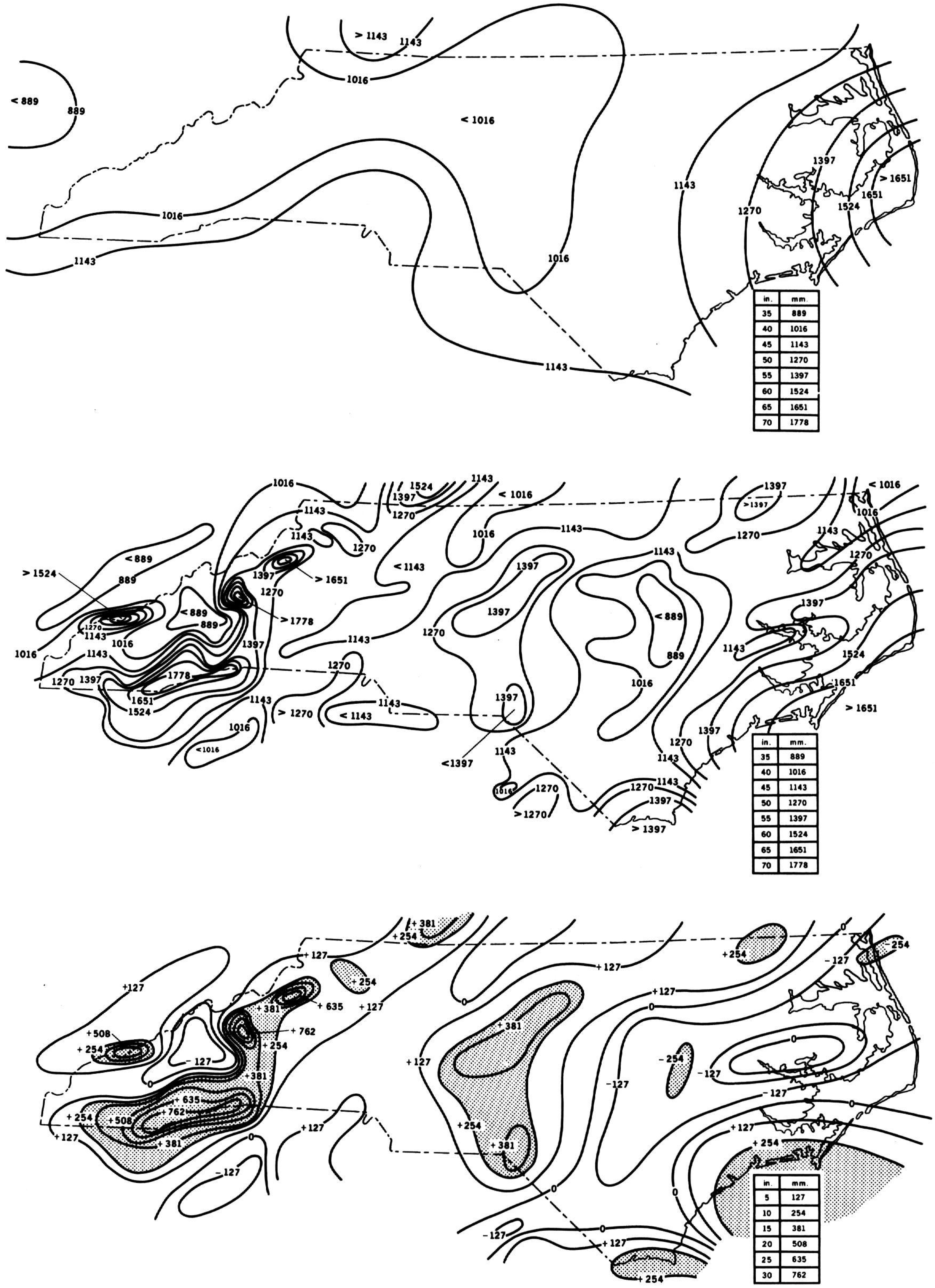

Figure 3 North Carolina's 1985 Annual precipitation (millimeters) from the First and Second order station network versus the cooperative station network and the difference of the annual precipitation (millimeters) from the cooperative station network minus the First and Second order station network (prepared by Grant W. Goodge, National Climatic Data Center).

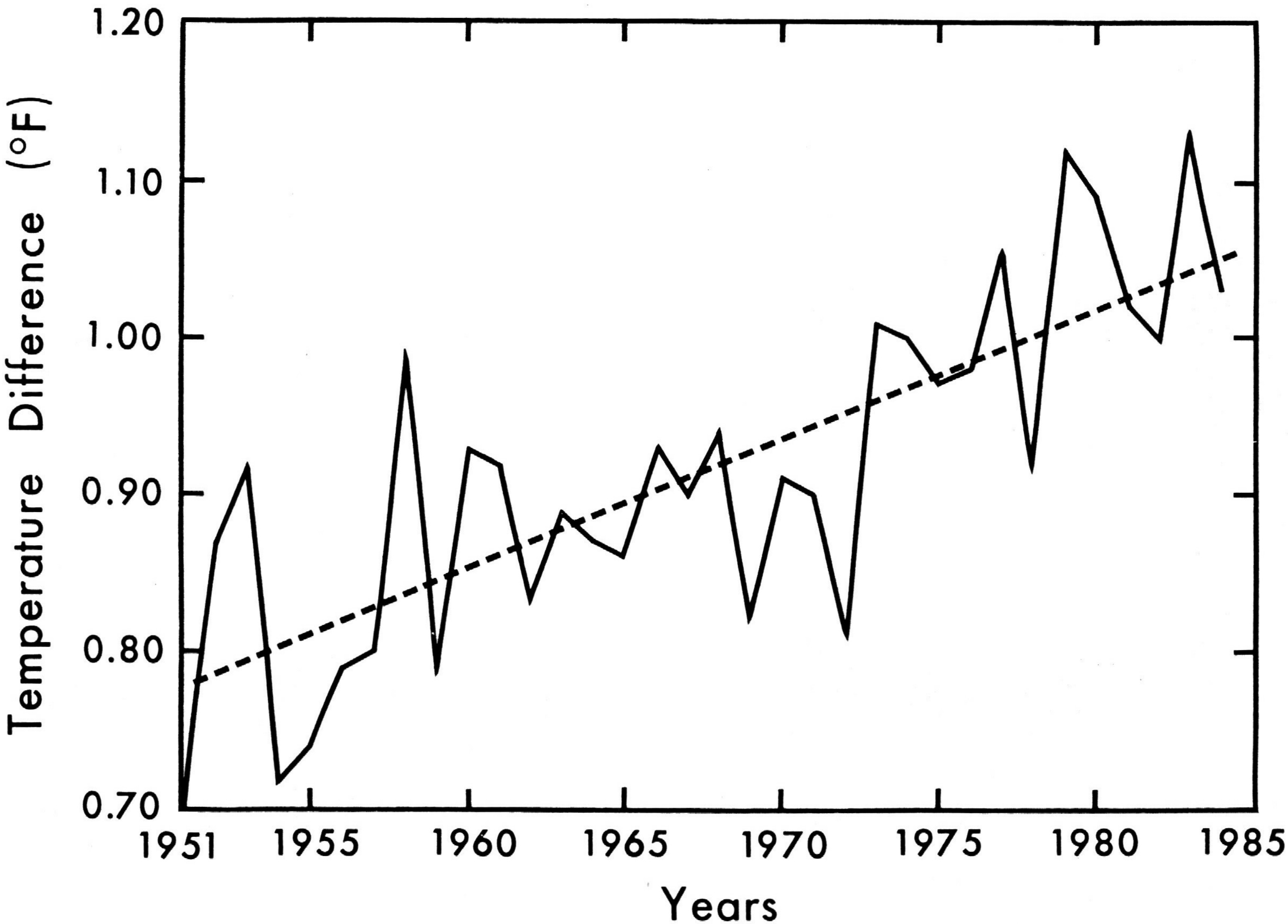

Figure 4 Differences of the contiguous United States annual mean temperature derived from the First and Second order stations minus climate division data. The trend is also shown.

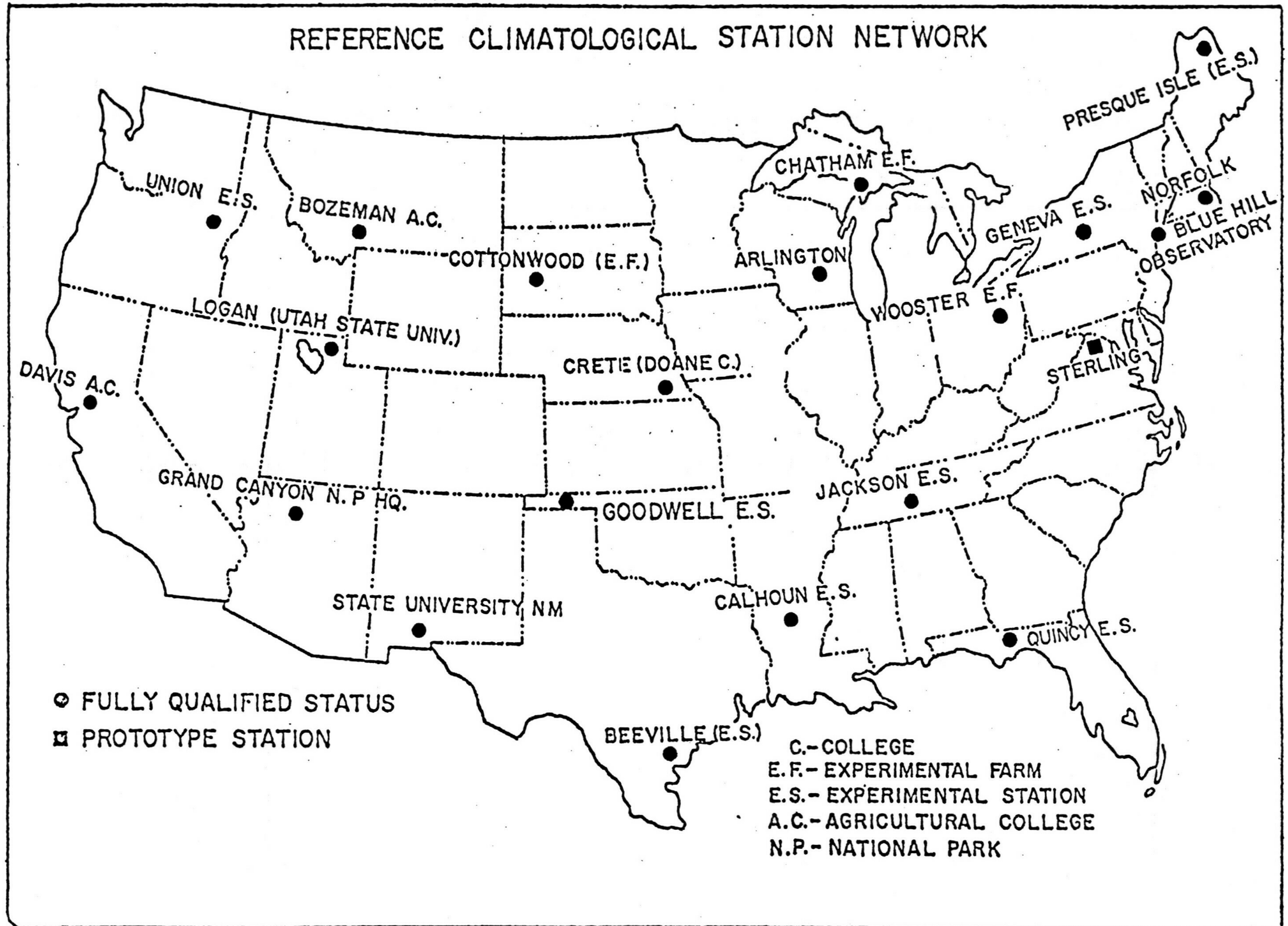

Figure 5 The National Oceanic and Atmospheric Administration's Climate Reference Network.

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