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The Hydroclimatic Characteristics of Nacogdoches, Texas with Implications for Water Resources Management

THE HYDROCLIMATIC CHARACTERISTICS OF NACOGDOCHES, TEXAS, WITH IMPLICATIONS FOR WATER RESOURCES MANAGEMENT

by

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Presented to the Faculty of the Graduate School of
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STEPHEN F. AUSTIN STATE UNIVERSITY
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THE HYDROCLIMATIC CHARACTERISTICS OF NACOGDOCHES, TEX
IMPLICATIONS FOR WATER RESOURCES MANAGEMENT

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ABSTRACT

Sayok's (1986) study and statistical analysis of the climate at Nacogdoches, Texas covering 1901 to 1980 is updated to include the most recent twelve years (1981-92) of records. Missing data are estimated, all analyses are repeated, and the new 1961-90 normal climate is compared to the 1951-80 and other normals. Results showed that the climate at Nacogdoches during the last decade was about the same as that in other recent decades. Thornthwaite's (1957) climate classification defines Nacogdoches as moist subhumid, third mesothermal, with moderate summer water deficiency, and a temperature-efficiency regime equal to a fourth mesothermal climate. There are certain non-random processes contained in the 90-year record of annual precipitation, total number of raindays, maximum and minimum air temperature, hot days, and frost-free days. Further investigation into the non-randomness is warranted.

About 71 percent of the variation in the monthly municipal water demand could be explained by three simple variables; viz., the monthly number of days which equaled or exceeded 35 °C (95 °F), the average monthly maximum temperature, and the reciprocal of monthly total precipitation (1/P). The extreme daily streamflow data for La Nana Creek best fit the Log-Pearson type III distribution while the annual total flow and annual peakflows best fit the Lognormal distribution. The addition of three recent years of record did not significantly affect the streamflow regimes described by Sayok (1986). Observed solar radiation data in 1989 were, on the average, 62.4 percent less than theoretical values calculated for a horizontal surface at the top of the atmosphere. Tornadoes in Nacogdoches County most frequently occurred in May and around 5 o'clock in the afternoon. Based on the Poisson distribution there is a 48 percent chance that no tornadoes will occur in any given year and a 35 percent chance that one tornado will occur in any given year in Nacogdoches.

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INTRODUCTION

Weather and climate are very crucial elements of our physical environment. They affect physical processes, chemical reactions, biological activities, and human's health, comfort, food supply, and routine activities. In the forest, the growth, distribution, development, and composition of species are largely affected by climatic conditions. Many forest related natural resources such as timber, wildlife, water, fisheries, recreation, range and wetlands are influenced by climate.

Climates vary with time and space. Since the effects of weather and climate on humans and the biosphere are so pronounced, profound, and perplexed, information on weather conditions and climatic change is essential for planning and management of our natural resources. For a better understanding of climatic variations, observations are needed to cover a wide range of surface conditions over a long period of time.

Nacogdoches is centrally located in East Texas and is the home of Stephen F. Austin State University. Collection of climatic data at Nacogdoches began as early as 1892 by the U. S. Weather Bureau (name changed to the National Weather Service in 1965). Also, Stephen F. Austin State University and the United States Forest Service began their own weather observations in 1954, and the United States Geological Survey, in 1965, built a permanent stream gauging-station on the downstream side of East Starr Avenue bridge, to monitor daily streamflow of La Nana Creek. These records, and their interpretation, are invaluable for defining the climatic conditions of Nacogdoches for scientific research, and for management of our natural resources. They can be used as references for the surrounding areas.

Sayok (1986) conducted a climatic study of Nacogdoches using data collected between 1901 and 1980. He used numerous parameters from these data to describe the climatic conditions and their statistical characteristics at Nacogdoches. The study is the most comprehensive at present and provides a useful reference for both research and resource management. However, there were missing data contained in the 80 years of temperature and rainfall records in Sayok's (1986) study. Some studies such as time series analysis require unbroken records of long-term observations. Also, information on tornado occurrence and the climate classification of Nacogdoches were not included in his study.

Twelve additional years of climatic data are available since Sayok (1986) conducted his study. An update of Sayok's (1986) data with estimates of missing data and statistical analyses to cover the last period of record were added. In addition some climatic parameters not considered in his study will be most helpful to people in various disciplines.

OBJECTIVES

The major objective of this study was to update and supplement Sayok's (1986) study on the climate at Nacogdoches, Texas. Specifically it was to:

1) Extend his data file from 1901-1980 to 1992; locate missing data and estimate any data which could not be found; and change figures, where practical, to metric units,
2) Classify Nacogdoches climate based on Thornthwaite's 1957 method,
3) Compare observed solar radiation data to those calculated by Sayok (1986),
4) Add a study on the occurrence and distribution of tornadoes in Nacogdoches, County, Texas, and
5) Investigate the relationships between municipal water demand and climatic parameters.

LITERATURE REVIEW

General Background

Edward (1967) gave a very generalized historical view of the climate of Texas by making available the observations of J. A. James and Co. which were first published in 1836. James compared the climate of Texas to that of Louisiana and Mississippi stating that we have "an open and ascending country wherein a swamp or putrid pond is not to be found; with sea breezes, as invigorating to the frame, as they are refreshing to the spirits" (Edward 1967). He contrasted this to the flat and swampy lands to the east which would "create a miasmatic matter not only disagreeable to the feelings, but deadly in its effects" (Edward 1967). Texas was then thought to be a healthy State bringing vigor to all who breathed its air.

Edward told of the diurnal breezes that extend from April to the end of September. He offered caution to all when the wind changes and comes from the "east by south, then happy may they be who are at this time imprudent, if they should escape with their lives" (Edward 1967). This is because the air is coming from the land to the east. By October or November the strong winds from the north have set in, bringing rains that cool the land. By December and January the coldest winds have come from the north, with a northwest wind being prevalent during the winter. By spring, weather is good for getting the crops into the ground. Edward furthered his description of Texas saying that the northern portion of the State was far superior to the southern. This was primarily due to the abundance of disease causing insects in the South.

Even with its great diversity the climate of Texas has been admired since the earliest westward expansion of the U. S. Geophysical characteristics of the State play a large role in the climatic diversity and have been identified as follows. Texas is downwind from large mountains to the west, is between the Gulf of Mexico and the southern Great Plains, is west of the Bermuda high, is at a low latitude, and has great elevational changes (Larkin and Bomar 1983).

In 1818, the United States Surgeon General Joseph Lovell ordered each Army surgeon to "keep a diary of the weather noting everything of importance relating to the medical topography of his station" (U.S. Weather Bureau, 1942). The earliest Nacogdoches climatic data preserved in the National Archives, National Climatic Center, Asheville, North Carolina covered the period between September and December 1836. These early rainfall data of Nacogdoches were observed by Army Surgeons and reported to the Surgeon General's office in monthly values. These data were also the earliest Texas weather records on file in the National Archives.

An organized operation in collecting and recording climatic information of Nacogdoches began in January 1892, two years after the Congress established the Weather Bureau as a branch of the U.S. Department of Agriculture. However, the collection only lasted for 11 months and was not resumed until October 1898. Since 1972 the observations have been under the jurisdiction of the National Weather Service (NWS), Department of Interior. During the entire history of climatic observations at Nacogdoches, Texas, the weather station has been moved to ten different locations around the city and data have been collected under 23 designated observers and some occasional substitutes (Sayok, 1986). These official climatic data are available from the National Climatic Data Center in Asheville, North Carolina and Texas Department of Water Resources, Austin, Texas.

Apart from the official NWS climatic station, there are two other routine climatic observations in the Nacogdoches area. Stephen F. Austin State University (SFASU) started its climatic observation in 1954 near the present football stadium. The station was moved to its present site on Wilson Drive in 1973 when construction began on the football stadium. It was designated as the official substation of the National Weather Service in August 1989. The United States Forest Service has maintained a climatic station since 1954 to monitor air temperature and precipitation in the northeast portion of the SFA Experimental Forest, about 16 km (10 miles) southwest of Nacogdoches.

Routine streamflow measurements in La Nana Creek, Nacogdoches began in October 1964 by the U.S. Geological Survey (USGS). La Nana Creek is a major creek in Nacogdoches running southerly through the east-side of the city. The drainage area above the gauging-station, at the downstream side of the bridge on East Starr Avenue, about 0.4 km (0.25 miles) north of the downtown, is about 81 sq km (31.3 sq miles). Also, a gauging-station was installed on Loco Bayou by the USGS to monitor water storage capacity for Lake Nacogdoches in March 1977. The lake, located about 16 km (10 miles) west of Nacogdoches, is formed by a rolled earth-filled dam on Loco Bayou with a drainage area of 255 sq km (98 sq miles). Water retained in the lake is used for municipal water supply and recreation. The lake provides additional water to that which is supplied to the city by nine municipal water wells.

Few hydroclimatic studies have been conducted to ascertain the climatic conditions at Nacogdoches with most covering a limited number of years. Haltom's (1880) brief description on the climatic characteristics of Nacogdoches was the earliest documentation found in the literature. Recent studies of the climate of Nacogdoches include those made by Reeves (1976 a, b, c, and d), Chang and Boyer (1977), Aguilar (1979), Chang and Aguilar (1980), Chang et al. (1980), Chang (1981), Amonett (1982), Chang and Watters (1984), Sayok (1986), Chang and Sayok (1990), and Sayok and Chang (1991). Sayok (1986) is the most comprehensive to date.

Results of these studies showed that summer storms in Nacogdoches are characterized by high intensity, low frequency, short duration, and afternoon occurrence (Chang, 1981). The average annual temperature in forested East Texas decreases with an increase of latitude at a rate of about 0.74 °C (1.34 °F) per degree of latitude (Chang et al., 1980). Monthly and annual soil temperature has been estimated by air temperature in a periodic regression model (Chang and Boyer, 1977).

The prevailing winds of East Texas are southerly and the wettest spot of Texas is at the southeast corner around the city of Orange. On the average, the annual rainfall decreases with longitude in forested East Texas at a rate of about 0.58 mm per degree latitude, or about one mm per 16 km (one inch per 25 miles) (Chang et al., 1980). The spatial variation of rainfall is even noticeable in the city of Nacogdoches where rainfall was greater in the southeast, south and east areas than that recorded in the northwest, west and north regions (Sayok and Chang, 1991).

The temporal variations of five climatic parameters covering 56 years (1915-70) at Nacogdoches were examined using the techniques of correlogram and spectrum analysis (Aguilar, 1979). The result showed that the number of raindays and total annual rainfall of the previous year had a positive effect while temperature range had a negative effect on the radial growth of loblolly pine. Raindays at Nacogdoches were found to have a tendency of four-year cycles. The reasons for the four-year cycle are not clear.

Streamflow is considered a residual in the hydrologic cycle and is highly correlated with forest cover and land use. In East Texas, a reduction of 10 percent forest cover in the watershed can cause an increase in streamflow by 20 mm (0.79 inches) per year (Chang and Watters, 1984). Another study showed that the rapid urbanization in the northeast section of Nacogdoches since the completion of the northeast loop in 1972 has caused an increase in streamflow by an average of 85 mm (3.35 inches) per year in the La Nana Creek (Chang and Sayok, 1990).

Sayok's (1986) study provides a comprehensive analysis and interpretation of Nacogdoches climate. It covered a wide spectrum of hydroclimatic environments including a variety of climatic parameters; among them were, solar radiation, precipitation, temperature, humidity, wind, and streamflow along with their effects on hay production and forest growth over a period of 80 years (1901-80). However, the study was largely based on conventional statistical methods and frequency analysis and he never actually classified the climate of Nacogdoches.

Sayok (1986) calculated solar irradiation by solving trigonometric functions of earth-sun position in his study. He reported theoretical solar radiation at the top of the atmosphere as well as for a horizontal surface at the top of the atmosphere. Actual observations could be reduced to about 50 percent at the ground surface depending on clouds and the atmospheric conditions. Since the energy required for plant growth, the hydrologic cycle, and the thermal environment of the earth comes from the sun, the study of weather and climate always begins with solar radiation. The potential solar beam irradiation given by Sayok (1986) needs to be verified by instrumental observation in the field.

Long-term records of hydroclimatic variables are invaluable for scientific research and for solving practical environmental resource problems (Chang and Sayok, 1990). Several studies about the climate of Nacogdoches have been written in the past, including Sayok's (1986) comprehensive work. In his study, all available hydroclimatic data collected prior to 1980 were compiled, various parameters describing hydroclimatic characteristics were derived and statistically analyzed, and the results were interpreted. These data were updated and changed to metric units which should prove useful to scientific research.

We must recognize that 1) climatic patterns, especially climate change, is a growing concern at international and national levels, 2) many research projects at SFA require climatic information, 3) the physical environment is a major concern of the public, 4) wetland delineation and other environmental regulations require climatic data, 5) agriculture and forestry are major types of land use in Nacogdoches, and 6) Nacogdoches is one of a few locations in the state that has records long enough to study past climatic patterns.

The compilation of long-term hydroclimatic records provides basic as well as supplemental information for scientific research, engineering applications, environmental planning, and natural resources management. Analyses of these data and their consequent interpretations should be useful to a wide spectrum of disciplines for immediate applications.

Texas Weather

A climatic study would not be complete without a brief description of the regional weather conditions. Bomar (1983) gave a comprehensive summary of Texas weather and the driving climatic factors which influence it.

Frontal systems are regarded as the primary instigators of Texas' day to day weather during non-summer months. There are four air mass types which can result in frontal systems that enter Texas. These are continental polar (or continental Arctic), maritime polar, continental tropical, and maritime tropical. Most of the fronts that move through Texas during the winter are relatively cold continental polar and to a lesser degree Arctic. True Arctic air is responsible for the especially frigid temperatures that bring the Panhandle to below -18° C and freeze the Valley; fortunately this is a relatively rare event. A maritime polar front is almost always warmer than the continental polar front because it originates over the northern Pacific Ocean, and is laden with latent heat. These maritime polar fronts are more common, than continental fronts, to Texas during the spring and fall. Tropical air masses/fronts are common throughout the year with eastern Texas receiving mostly maritime tropical fronts. These four frontal systems are usually more simply classified as warm or cold fronts (Bomar, 1983).

Cold fronts usually enter the State from the north or northwest, causing the wind to shift from the south or east, to the north or northwest (Haragan, 1983). During the cooler half of the year the cold fronts will generally have steeper temperature gradients and produce only short lived precipitation, limited to a zone of 40 to 80 km (25 to 50 miles). These faster moving fronts may disturb the atmosphere to such a degree that several lines of thunderstorms may develop well in advance of the system. Cold fronts in the late spring and early fall, as well as summer, do not have the force of the winter fronts and will have difficulty in pushing the warm air up. This leads to a much broader and longer lived zone of precipitation. Precipitation may not accompany all cold fronts, this is due to the lack of enough moisture in the warm air being pushed up by the cold dense air.

Cold fronts, on the average, invade Texas seven or eight times in April and six times during January through March. The frequency of fronts decreases from North to South Texas. The Panhandle regularly receives six cold fronts during July and August; only one or two will reach the Valley. In some years South Texas will not receive any cold fronts.

Warm fronts typically enter Texas from the south and are much more subtle than the cold fronts. Warm fronts are typified by a gradual progression of worsening weather events. Passage of a warm front is generally marked by veering winds, an increase in humidity and sometimes a distinguishable increase in temperature. Again, precipitation is depended on the moisture content and stability of the warm air mass. Towering thunderheads may develop if the front is coming in from the Gulf of Mexico. Some of these thunderheads may travel all the way to the northern Panhandle producing snow and freezing rain as the moisture falls through a cooler air mass below. Passage of warm fronts are more discernible during the winter and spring and more so in the eastern portion of the State than in the western portion. Warm fronts generally penetrate North Central Texas only about twice during April, the most active month with respect to warm fronts (Bomar, 1983).

Many times, cold fronts will penetrate northern Texas during the spring only to retreat as warm fronts; these are common during May through August. These are often called stationary fronts or quasi-stationary fronts because sometimes they actually oscillate back and forth. For each of the months, May, June, and July, ten fronts may penetrate the Panhandle and then vanish or retreat. While these fronts are common to northern Texas they are relatively rare in South Texas. Many times these fronts will produce copious rain which can lead to flooding (Haragan, 1983).

Considering all the elements of the hydrologic cycle, precipitation is probably the most important to those who study climate and weather. Rain cools the land, cleans the air, waters the plants, and so add infinitum. As important as rain is to us it can also be very destructive if too much comes at once or if the rains persist for long periods of time. Excessive rainfall can lead to flooding. Understanding the frequency of such events is of paramount importance to the natural resource manager.

Precipitation in Texas is predominantly rain which has an immediate impact on surface waters. Only the Panhandle experiences snow pack that is significant enough for delayed runoff. Peak runoff usually occurs in late spring or early summer, a result of the concurrent heavy rains. However, many southern rivers will experience peak runnoff during the fall because of the influence of tropical cyclones. Flooding occurs when the rainfall intensity or duration or both exceeds the grounds ability to absorb the rain.

Two types of storms can be identified as initiators of floods. One is the prolonged continual rain that leads to widespread flooding due to the large quantity of water put upon the earth. The other is due to intense summer thunderstorms that may drop several inches of rain over only a few square miles of land surface within a very short time period. This type of flooding is a flash flood and is typified by a sharp rise in the stream hydrograph, followed by a rapid recession. These can be especially dangerous in localized areas because they often occur with little warning.

Floods have occurred during every month in Texas but are generally limited to the spring and early fall. Thunderstorms are typical to every part of Texas during the late spring, summer, and early fall; therefore flash floods are to be expected during this time at any location in Texas but are more common to the western portion of the State. The eastern portion of the State generally experiences prolonged rains which may be the remains of a dissipating tropical storm or hurricane. This type of rain generally produces longer lived floods which cover a larger land base.

The most destructive weather phenomenon known, based upon intensity and duration, is the hurricane (name given in the western hemisphere) which is the mature stage of a tropical cyclone (Bomar, 1983). A hurricane may begin as an easterly wave, then progresses to a tropical depression, to a tropical storm, then to the omnipotent hurricane; each stage is based on atmospheric pressure and increasing wind speed (Haragan, 1983). Easterly waves are tropical disturbances common to the Caribbean and Gulf during the summer and early fall; only a few ever progress to a hurricane. Hurricanes may also be spawned when the summer position of the intertropical convergence zone spins off an eddy to the north that reaches the northeast trades.

Most hurricanes that reach the Texas coast are at least 160 km (100 miles) wide and are often identified by heavy cloud bands that produce much rain. Even though the wind speed within a hurricane must exceed 117 km per hour (73 mph), by definition, the ground speed of the storm will seldom exceed 48 km per hour (30 mph) when it hits the Texas coast. Hurricanes require heat and energy from the ocean to survive, ocean temperature may even play a large role in the intensity of the hurricane. Due to this and many other conditions, hurricanes never follow the same track so that it is difficult to make long-term predictions as to where they will make landfall (Bomar, 1983).

Soon after making landfall, a hurricane will loose much of its energy and the wind velocity decreases due to frictional drag at the earth's surface, it may now be considered an extratropical storm which can produce heavy rains and affect the weather of much of the rest of the nation to the north and east for several days. Often a hurricane will lead to a extratropical weather feature that will break a drought that may be plaguing the northern or western portions of the State. Hurricanes produce severe thunderstorms which in turn may produce a tornado. In some respects tornadoes are similar to hurricanes but are much smaller having lower pressure and higher wind speed than hurricanes (Haragan, 1983).

As June 21 of each year approaches so does the warmest time of the year, it is then that the sun's rays are most vertical to the State. By this time the polar jet has been forced to its north most position while the intrusion of cold air from the north has stopped. The warm muggy air from the Gulf is only worsened by an occasional gust of arid searingly hot air from Mexico that pushes its way into West Texas.

Occasionally a subtropical ridge known as the Bermuda High takes over the climate of Texas and changes the normally hot summer to one of even greater heat and drying, bringing about a severe drought. Gentle downward breezes of the high pressure cell do not allow for the formation of rain clouds. This large dome of hot air may settle into place over Texas and stay for several weeks. Such heat waves are common to Texas from mid June to late August. The warmest average temperatures in Texas occur in the South during the months of July and August. These hot and often dry months may lead to drought conditions in any portion of the State.

Droughts are different from other weather phenomenon in that they tend to sneak up gradually leaving the last rains as only a distant memory. Though a drought may be hard to define, its effects are obvious to all who witness them. Generally a drought is associated with a long-term water deficit of a land area, and they have been quantified by use of the Palmer Index (Bomar, 1983).

With the exception of the northern Panhandle, Texas is typically under the influence of a southerly wind during the summer. The northern portion of the State experiences some northerly winds, however the southerly wind still prevails. Southwesterly winds are prevalent in western Texas due to the oscillating dry line of the Marfa front. Northerly winds are predominant during the winter months. In South Central Texas northerly and southerly winds occur at equal frequencies due to the effects of passing fronts; namely veering winds. One of the windiest regions in the North American continent is the High Plains region of Texas. Winds gusting to 95 km per hour (60 mph) are not uncommon while the average for March and April may be as high as 27 km per hour (17 mph). The strongest winds have been measured in late winter and spring (Bomar, 1983).

With an even greater regularity the sea breezes and land breezes blow along the coastal areas of Texas. Sea breezes are strongest during the summer when the differential heating is greatest and they attain their greatest velocities when the daily temperature is highest. These breezes often produce cumulous clouds and if sufficient moisture is present in the upper atmosphere thunderstorms may result.

With the diversity and often adverse weather conditions that are associated with Texas, people have not only tried to live with the conditions but have in many cases tried to modify weather on a localized scale. Weather modification in the State is generally concerned with cloud seeding and hail suppression. Nineteen cloud seeding programs were conducted in Texas from 1974-77 and eight hail suppression programs for the same time period (Davis 1978).

It has been said about Texas that if you don't like the weather, just wait a while (Haragan 1983). Even considering the great diversity of Texas weather, the changes are, to some degree, predictable.

Climate Classification

Carter and Mather (1966) pointed out that there are distinctions among plant distributions due to the availability of moisture and energy. The most significant distribution can be described by plant associations which in itself suggests the climate's effect on vegetation. Available energy and moisture conditions are features of the climate called active factors, which serve as an effective surrogate for the concept of the climate of an area (Carter and Mather, 1966).

Classification is a system basic to all sciences. It recognizes individuals having important identifying characteristics in common and groups these individuals into a few classes or types (Trewartha, 1968). Simplicity and order can be introduced to bewildering multiplicity and confusion, by establishing generalities from a multitude of individuals. It is scientific, educational, and philosophical. Scientifically there exists a need to process the climatic data available so that patterns become discernible. Trewartha (1968) elaborated on the philosophical problems of determining the selection criteria for grouping local climates and describing their boundaries. Some methods are quite elaborate while others are not; however, even the most simple climate classification schemes are useful. Probably the simplest include those devised by the ancient Greeks, utilizing zones of solar illumination.

Kōppen elaborated on climate classification in 1900 by looking at the annual and monthly temperature and precipitation. He recognized the importance of evapotranspiration and the relationship of native vegetation to these climatic variables and consequently they served as the basis for his classification system. The classification identifies five main groups of climate; four are based on temperature and one on precipitation. A unique system of symbolic nomenclature that gave each principal type of climate a two-letter description was introduced in the Kōppen classification. All levels of grouping for the boundaries and symbols are quantitatively determined (Trewartha, 1968). He pointed out that even though quantitatively defined boundaries are beneficial, they can lead to some misunderstanding of the accuracy of the system. Boundary definitions should only be viewed as approximations and it should be noted that such boundaries actually represent broad bands of transition zones.

Thornthwaite (1948), using the concept of potential evapotranspiration and climatic water balance, developed a climate classification system with eight main groups; five are related to precipitation and three to temperature. Within the eight main groups there are six degrees of temperature efficiency, five degrees of precipitation effectiveness, and four degrees based on the seasonal distribution of precipitation. The concept of a moisture index was introduced as a ratio of precipitation to the evaporative need of water over 100 years ago to delineate moist climates from dry climates. The moisture index serves as the primary emphasis in Thornthwaite's classification.

Thornthwaite's 1948 climate classification was directed at applied climatology. His classification drew, in part, from many earlier attempts to classify the climate. These early attempts were made in an effort to identify the recognized relationships between vegetation distribution and climatic factors. These early classifiers were biologists and botanists and included de Candolle in 1855, Grisebach in 1866, and Linsser in 1867 and 1869. It was not until 1900 that the idea of classification was finally made practical by Wladimir Kōppen. Though Kōppen's scheme is widely used and easy to learn, it still leaves quite a lot to be desired. His system does not relate the monthly need of water to the supply of water, soil moisture storage, or actual evapotranspiration (Mather 1974).

Trewartha (1968) then developed a climate classification scheme that is empirical and provides for the needs of geographers. It is based on temperature and precipitation, like most climate classification schemes. Trewartha kept his classification simple trying to use less than 15 climate types and then added as many second and third-order subdivisions as needed. He stated that it is important to describe the genesis of the zones where possible.

Around the world many scientists have tried to express the seasonal water budget of a place. Simultaneous advancements of this concept in the 1940's were made by Thornthwaite in the United States, Penman in England, and Budyko in the USSR. Each of their methods differ and have been modified many times. Many arguments exist as to which method should be used to compute evapotranspiration. Indifferent to which method is used the water budget calculations are affected by the accuracy of the input data.

Precipitation data, though collected around the world, are only as precise as the integrity of the rain gauges in which they are collected. It is well known that the accuracy of the rainfall measurements are affected by site geometry and wind velocities. A short distance between two rain gauges can cause the precipitation catch to vary greatly. Mather (1974) points out that both precipitation and evapotranspiration are the major inputs to any water balance technique. Therefore one should not be concerned with the technique used for calculating evapotranspiration while precipitation data are accepted uncritically. Any error introduced by the precipitation data will result in errors as significant as those introduced by evaporation data. It is the comparison of precipitation to evapotranspiration in the water budget that is important to applied climatology, rather than the particular method used in calculating evapotranspiration (Mather, 1974).

Thornthwaite's Climatic Water Balance

Water budget, in its simplest terms, is tracking the fate of precipitation that falls in a watershed for a given time period. It involves a quantitative representation of how that precipitation is moved through the hydrologic cycle. Direct measurement, on a continual basis, of all of the parameters that are involved in the hydrologic cycle is infeasible; indirect approaches must be employed to estimate these parameters.

Water budget is useful in predicting available water supplies for irrigation or reservoir storage. It affects many aspects of human life and can be used to determine the probabilities of flood or drought. Also, seasonal changes in sea level, forest fire danger rating systems and the effect of suburban developments over an aquifer recharge zone can be determined with information from water budgets (Mather, 1978).

Energy and water resources of a region may be better understood by using the water budget approach. Mather (1978) points out that there are several ways of quantitatively determining the water budget: some are so simple that they lead to unacceptable results while some are so elaborate that they are not practical to evaluate in practice.

Water loss to the air from vegetation and soil is very difficult to measure. However, actual evapotranspiration can be estimated by utilizing the water budget approach. This actual evapotranspiration usually differs from a theoretical potential evapotranspiration, defined by Thornthwaite (1948) as the water loss from a large homogeneous, vegetation-covered area (albedo, or percentage of incoming solar radiation reflected from the particular surface, of 22 to 25 percent) that never suffers from lack of water.

There are several ways of determining evapotranspiration. Mass transport techniques utilize Dalton's law of vapor pressure gradient and empirically determined wind speed functions. Aerodynamic or profile techniques involve making assumptions about the turbulent diffusion of heat and water vapor in the atmosphere. Eddy correlation techniques, more recently introduced, concern the observation of vertical wind speed and moisture content of the air (Rosenberg et al., 1983). Reliable observations are difficult to obtain because of the need for sensitive fast response instrumentation. Energy budget techniques involve the separation of available net radiation into latent heat at the earth's surface. Combination techniques involve both the energy-budget and aerodynamic approaches which serves to eliminate most of the unmeasured parameters. Though the range of possible applications may be wider, it is more difficult to evaluate due to the numerous observations which must be made (Mather 1978).

Empirical techniques or bookkeeping methods are generally simple to evaluate requiring only basic climatic data. The most simple method provides an approximation of potential evapotranspiration by doubling the mean temperature or tripling it in some months (Mather 1978). Thornthwaite utilizes the mean air temperature and a heat index to estimate unadjusted potential evapotranspiration (next section).

Multiple regression techniques have also been applied to estimate potential evapotranspiration; however, they make use of many climatic parameters, some of which may be difficult to measure. Thornthwaite's method has been applied worldwide (Mather 1978). However it has some shortcomings in monsoon climates due to the variability of monthly humidity. Because Thornthwaite's method does not consider humidity and wind speed it is also less accurate on a daily basis but can be widely applied on a monthly basis. Because Thornthwaite's expression is based on temperature and length of day alone it is referred to as a climatic water budget (Mather, 1978).

This climatic water budget can be monthly, weekly or daily comparisons of water supply to the actual evapotranspiration and the potential demand for water (Mather 1978). Potential demand for water or potential evapotranspiration is a function of the climatic conditions, relating to the energy from the sun, and is independent upon vegetation types (Mather 1978). Actual evapotranspiration however, depends on vegetation and soil types as well as climatic variables. A comparison of the precipitation and potential evapotranspiration results in quantitative values of soil moisture storage, surplus, run off and water deficit. Some regions receive precipitation in amounts that exceed the potential evapotranspiration resulting in water surplus. In other areas precipitation is less than potential evapotranspiration resulting in water deficit. Mather (1978) pointed out that in most places of the world an annual cycle of deficit and surplus precipitation follow each other.

Thornthwaite's variables

Thornthwaite's (1957) water balance model is characterized by four parameters, i.e., water deficit, soil moisture utilization, soil moisture recharge and water surplus. Water deficit is simply the difference between potential evapotranspiration and actual evapotranspiration. Following a period of water deficit, a period of recharge results in an increase in soil moisture storage if the actual precipitation exceeds potential evapotranspiration. This continues until the water holding capacity of the soil has been reached. Runoff occurs when the precipitation amount exceeds the water holding capacity of the soil. As water demand exceeds water supply, the soil moisture begins to become depleted.

In calculating the water budget, the assumption is made that the vegetation is able to utilize all precipitation as it falls. If the soil moisture content is at field capacity the vegetation can easily obtain the needed water from the soil. As the soil moisture drops below the water holding capacity, the actual evapotranspiration (AE) is equal to the precipitation (P) plus any moisture that can be removed from the soil. As the soil continues to dry in succeeding months, the soil moisture will become increasingly more difficult to remove. The amount of moisture removed is dependent on the ratio of the actual soil moisture to the field capacity. For example, when soil moisture is 75 percent of field capacity, the plants will only be able to remove 75 percent of what they have the potential for at field capacity (Thornthwaite and Mather 1955). Storage change is simply the change in the soil moisture storage from one month to the next.

Actual evapotranspiration will equal potential evapotranspiration (PE) when P is greater than PE. When P-PE is negative the AE is equal to P plus the change in storage (ΔST). More simply, during these months actual evapotranspiration is equal to the precipitation plus any water that the vegetation can remove from soil moisture storage.

Deficit is simply PE-AE, and it represents that amount of water that was not evapotranspirated because of a lack of water. Surplus is the P-PE after the soil moisture content is at field capacity; a positive P-PE does not always indicate a surplus. Surplus is that water that is not needed by the climatic demands and thus is allowed to move through the soil as throughflow. Thornthwaite has given a lag factor of 50 percent for watersheds with a drainage area of less than 25,000 sq km (10,000 sq mi) (Mather 1978). It is assumed that 50 percent of the available surplus for any month will run off via ground water recharge and ultimately becomes stream recharge. The other 50 percent is held over and added to the surplus of the following month.

Lastly, the total moisture detention (DT) is determined. DT represents the total amount of moisture which is temporarily held within or on top of, in the case of snow, the soil at the end of the month in question. It is made up of soil moisture storage, snow on top of the soil, and the portion of surplus which is held over for future run off.

The climatograph

This bookkeeping procedure allows for the quantitative computation for each factor in the water budget, however direct comparisons of stations may be made easier by a graphical representation. A climatograph provides for easy identification of periods of surplus, deficit, soil moisture utilization and recharge. Climatographs present the months on the horizontal axis and the depths of water (precipitation, evapotranspiration and others) on the vertical axis. Monthly totals of precipitation and both actual and potential evapotranspiration are plotted for the end of each month.

Areas on the climatograph which represent utilization and recharge must be equivalent. This is because the moisture removed from the soil, during periods when PE exceeds P, must equal any recharge that has taken place. Actual evapotranspiration equals potential evapotranspiration until the precipitation is less than the potential evapotranspiration. When the precipitation again exceeds the potential evapotranspiration, both potential and actual evapotranspiration are once again equal. Therefore, the line which represents AE begins to differ from the line representing PE at the point where the line representing precipitation crosses over and becomes less than PE. This continues until precipitation again exceeds PE. Areas below or between these curves represent the actual values of PE, AE, P, deficit, surplus, utilization, and recharge. A climatograph is a useful graphical illustration of the long-term hydrological water balance of a place.

Thornthwaite's Climate Classification Scheme

The primary climatic factors, involved with climate classification, relate to moisture and heat. In order to classify the climate of a place, it must be determined if the climate in question is moist or dry and warm or cold, as well as if seasonal variation in moisture exists (Thornthwaite, 1948). The moisture index is the primary element in the classification, it is one of four factors used to describe the climate at a particular place. The other three factors are the thermal efficiency index, summer concentration of the thermal efficiency, and the index of seasonal variation in the effective moisture. The following discussion is based largely on Mather (1974, 1978).

The moisture index

A climate cannot be determined as being moist or dry by simply looking at precipitation alone; instead, precipitation must be compared to the potential evapotranspiration.

Thornthwaite utilizes the mean air temperature and a heat index to estimate unadjusted potential evapotranspiration PE', in cm by the following equations:

$$PE' = 1.6\,(10t/I)^{a}$$

where:

t = monthly temperature in °C

I = an annual heat index calculated by:

$$I = \sum_{m=1}^{12} \left(\frac{t}{5}\right)^{1.514}$$

t = mean monthly temperature

m = Jan, Feb, Mar, ... Dec

a = the heat index, calculated by:

$$a = 6.75 \times 10^{-7}\,(I)^{3} - 7.17 \times 10^{-5}\,(I)^{2} + 1.79 \times 10^{-2}(I) + 0.49$$

Due to the complicated nature of these equations the values can be readily determined with the use of tables and nomograms (Thornthwaite, 1957). The unadjusted potential evapotranspiration PE' calculated above is for months with 30 days and 12 hours of sunshine each day. The value must be adjusted for the actual length of the day and hours of sunlight for each month, based on latitude and time of year, to obtain PE.

Thornthwaite (1948) defines the ratio of water surplus to potential evapotranspiration as the index of humidity (I_h) and the ratio of water deficit to potential evapotranspiration as the index of aridity (I_a). The difference between I_h and I_a is the moisture index I_m, or:

$$I_m = I_h - I_a$$

where:

I_h = 100 (S/PE) or the humidity index

I_a = 100 (D/PE) or the aridity index
S = annual water surplus, calculated from the climatic water balance in the previous section
D = annual water deficit, calculated from the climatic water balance in the previous section
PE = annual potential evapotranspiration
I_m = 100 ((S - D) / PE) or the moisture index
I_m = 100 ((P/PE) - 1)

Nine climatic types are delineated based on the moisture index; each type is denoted by a letter with or without a subscript (Table 1). The aridity index for moist climates and the humidity index for dry climates, as presented by Mather (1974), are given in Tables 2 and 3 respectively. The 1955 revision of Thornthwaite's climatic classification required a change in the limits used to describe the seasonal variation in effective moisture (Carter and Mather, 1966). Oddly enough the 1948 classification used the limits in the present aridity index for the humidity index while the present limits used for the humidity index were used for the aridity index.

This moisture index expresses the degree to which available moisture satisfies the climatic demands for water. Negative values indicate dry climates and positive values indicate moist climates. While the moisture index indicates the degree of aridity or humidity, it provides no indication as to the seasonal variation in moisture.

Seasonal variation of effective moisture

Seasonal variation may have a great impact on local or regional climate. Thornthwaite (1948) recognized the existence of two kinds of exceptional moisture conditions, surplus and deficit. Surplus is exceptional in a dry climate and deficit is exceptional in a moist climate. Thornthwaite did not try to express the seasonality of precipitation, rather he tried to show whether or not a dry period existed in a moist climate or if a wet season existed in a dry climate. It must now be determined whether or not the exceptional moisture condition is large, moderate, or small.

Table 1. The Nine Climatic Types and Their Corresponding Moisture Indices (I_m) in Thornthwaite's (1955) Climate Classification

Symbol	Climatic Type	Moisture index, (I_m)	Vegetation Type
A	perhumid	100 and above	Rain Forest
B_4	humid	80 - 100	Forest
B_3	humid	60 - 80	Forest
B2	humid	40 - 60	Forest
B_1	humid	20 - 40	Forest
C_2	moist subhumid	0 - 20	Grassland
C_1	dry subhumid	-33.3 - 0	Grassland
D	semiarid	-66.7 - -33.3	Steppe
E	arid	-100 - -66.7	Desert

Table 2. Seasonal Variation of Effective Moisture for Moist Climates, A, B, C_2; Aridity Index

Symbol	Description	I_a
r	little or no water deficiency	0 - 10
s	moderate summer water deficiency	10 - 20
w	moderate winter water deficiency	10 - 20
s_2	large summer water deficiency	20 +
w_2	large winter water deficiency	20 +

Table 3. Seasonal Variation of Effective Moisture for Dry Climates, C_1 D, E; Humidity Index

Symbol	Description	I_h
d	little or no water surplus	0 - 16.7
s	moderate summer water surplus	16.7 - 33.3
w	moderate winter water surplus	16.7 - 33.3
s_2	large summer water surplus	33.3 +
w_2	large winter water surplus	33.3 +

Thornthwaite used the letter s to represent a seasonal variation in moisture with the exceptional moisture condition in summer. The letter w was used to represent a seasonal variation in moisture with the exceptional moisture condition in winter. The w and s simply refer to winter and summer, respectively the season in which the exceptional moisture condition occurs. If these letters were followed by a subscript two (2) it would indicate a large surplus or deficit. The lowercase letter r indicates little or no water deficiency in a moist climate while the lowercase d indicates little or no surplus of water in a dry climate. Which of these letters is used is based entirely upon the capital letter which it follows. If the climate is moist, A, B, or C_2, and followed by an s, then there is a moderate summer deficiency. On the other hand, if the climate is C_1, D, or E and followed by s, then there is a moderate summer water surplus.

Index of thermal efficiency

Annual potential evapotranspiration is used as an index of thermal efficiency. The thermal efficiency is further broken down into categories to describe five major thermal climates, including megathermal, mesothermal, microthermal, tundra and frost types. These five thermal climates are denoted by capital letters A' through E'. For example, if thermal efficiency is greater than 114 mm then its climate is megathermal A'. On the other hand, a frost climate E' is given to those places having thermal efficiencies less than 14.2 mm.

The mesothermal climate B' is further divided into four subcategories, each is described by a subscript one (1) through four (4). Similarly, the micro thermal climate C' is divided into two subcategories and are described by subscripts one (1) or two (2) (Table 4).

Table 4. Thornthwaite's Thermal Efficiency (cm), Thermal Climate, and Percent of Summer Concentration

Thermal efficiency (cm)	Thermal Climate	Summer concentration	
		%	Type
	E' Frost		
14.2			
	D' Tundra		d'
28.5		88.0	
	C'_1		
42.7	Microthermal	76.3	
	C'_2		c'_2
57.0		68.0	
	B'_1		b'_1
71.2		61.6	
	B'_2		b'_2
85.5	Mesothermal	56.3	
	B'_3		b'_3
99.7		51.9	
	B'_4		b'_4
114.0		48.0	
	A' Megathermal		a'

Summer concentration of thermal efficiency

The fourth aspect of Thornthwaite's classification, is percent summer concentration of thermal efficiency during the three summer months. Table 4 shows the summer concentration of thermal efficiency for each of the nine Thornthwaite thermal climates. Lowercase letters from a to d, utilizing prime superscripts are used to delineate the percent summer concentration.

Solar Radiation

Crowe (1971) stated that "science begins with measurement". He provided us with the following: the mean solar distance is 149,450,000 km (92,870,000 miles), the sun's semidiameter is 695,300 km (432,700 miles), and the earth's equatorial semidiameter is 6,398 km (3,963 miles).

From these figures, the angle that the earth subtends from the sun can be computed. This coupled with the solar constant (the mean radiative energy delivered per unit area) or 1.97 gram-calories per square centimeter per minute (langley), ultimately leads to being able to estimate the incoming solar radiation.

Sayok's (1986) study investigated the potential amount of solar radiation that could reach the top of the atmosphere. He compared actual data, for only one year, to those obtained at the Stephen F. Austin Weather Station. Stringer (1972) stated that the addition of the earth's atmosphere certainly weakens the intensity of the solar radiation which reaches the surface, and has the following three main effects. Firstly, aerosols tend to scatter solar radiation in wavelengths that are smaller than the aerosols themselves; this causes the sky to appear blue. Secondly, aerosols whose diameters are larger than the wavelengths tend to reflect the radiation in a diffuse pattern, this causes clouds to appear white. Thirdly, water vapor will absorb some of the longer wavelengths, this causes nighttime cloud cover, to result in the prevention of extremely low temperatures at the earth's surface at night.

Temperature

Stringer (1972) stated that even though climatology is becoming increasingly theoretical, observed facts must always be the basis for studies involving climate. For this reason temperature and precipitation data are collected and reported in this study.

Temperature is a scale, it describes the average kinetic energy of all molecules in a substance. Atoms and molecules which make up all substances are continually in rapid and random motion. The energy of this motion is termed kinetic energy; the total of which is called heat. There exists several scales for the measurement of temperature viz., Kelvin (K), Celsius (°C), and Fahrenheit (°F). At sea level respective thermometers will measure 373.15 K, 100 °C, and 212 °F for boiling water. The melting point of ice will be measured as 273.15 K, 0 °C, and 32

°F. The theoretical temperature at which all molecular activity will stop is 0 K, -273.15 °C, and -459.6 °F, usually referred to as absolute zero (Moran and Morgan, 1991).

Precipitation

Precipitation is water in solid or liquid form that falls to the earth's surface. Precipitation will have several forms based on size and state, viz. drizzle, rain, freezing rain, snow, snow pellets, snow grains, ice pellets (sleet), and hail. Drizzle is small drops of water ranging in size from 0.2 to 0.5 mm in diameter. Drizzle originates in stratus clouds associated with fog but never with convective clouds. Rain mostly forms in nimbostratus and cumulonimbus clouds where most of it originates as snowflakes or hail. Rain drops are usually in the diameter range of one to six mm. Freezing rain usually occurs the morning after a temperature inversion when rain falls through a sub freezing ground layer at the earth's surface and is super cooled once it contacts a cold surface. Freezing rain can accumulate on tree branches and power lines causing them to break from the weight of the ice (Moran and Morgan, 1991).

Snow is composed of ice crystals which form flakes that are hexagonal in shape. Snowflake shapes vary from plates to stars to columns or needles depending on the temperature and moisture conditions when they were formed. Snow pellets are soft white ice particles which form as super cooled droplets collide, they range from one to five mm in diameter. Snow grains are similar to snow pellets however they originate as drizzle and are usually less than one mm. Sleet is similar to freezing rain except that sleet is already frozen before it strikes the surface. Hail is produced within intense thunderstorms when ice pellets are circulated in a cumulonimbus cloud until their size is too great for the convective updrafts. Once the hail begins to fall it starts to melt usually landing in the size range of less than one cm. Hail usually occurs with spring and summer thunderstorms (Moran and Morgan, 1991). Precipitation in forms of rain and snow are major concerns to hydrologists (Chang, 1982).

Streamflow

Sayok (1986) studied the streamflow of La Nana Creek, Nacogdoches, Texas for the period of record from 1964 to 1983. Water Resources Data for Water Year 1991 (USGS, 1991) reports that Bayou La Nana at Nacogdoches, Texas has the following period of record: October 1964 to September 1986 and May 1988 to current year. Therefore only four complete years of data could be added to this study.

Cainfield et. al (1980) suggested a common practice to find a probability distribution for describing the frequency of occurrence of existing data is to select a few parametric families and choose the best one according to some goodness of fit criterion. Benson (1968) investigated several commonly used probability distributions used for flood frequency analysis including, two parameter Gamma distribution, Gumbel distribution, log Gumbel distribution, Lognormal distribution, log Pearson type III distribution and the Hazen method. His goal was to determine which method was superior so that a consistent approach would be available for water resources researchers.

Benson (1968) found that the Lognormal, Log-Pearson type III and the Hazen method were three of the six distributions which fitted the streamflow data well. He was not able to conclude that one method was superior to the others. Going back to his attempt for a uniform and consistent method he recommended the Log-Pearson type III primarily for the following reasons. First, the method is in common use among agencies so that detailed procedures for its application have been published and computer programs are available for its use. Second, the Log-Pearson type III distribution includes a skewness coefficient which makes it more flexible than most of the other methods. In other words it can fit data that are highly skewed. The Log-Pearson type III distribution is also the standard method recommended by the U. S. Water Resources Council (1967) for analyzing streamflow. He stated that if it looked like other methods would be better suited that they should be used, however the reasons for doing so should be documented.

One important problem in hydrology concerns the interpretation of past events in terms of the probability of occurrence of future events (Chow, 1964). Chow states that the problem arises in estimating the frequency of hydrologic events including floods, and is known as frequency analysis. Flood frequency analysis is the basis for economic analysis and engineering design of many hydrological projects (Benson, 1968).

Conover (1971) reported that the Kolmogorov-Smirnov test for goodness of fit may be preferred over the chi-square test if the sample size is small because the Kolmogorov test is exact, even for small samples. The chi-square test assumes that the sample size is large enough to provide a good approximation to the chi-square distribution.

Tornadoes

According to Bomar (1983), tornadoes grow from very strong updrafts associated with large thunderstorms in a very unstable atmosphere often caused by hurricanes. Three main flows of air converge over Texas because it is between the Gulf of Mexico and the Rocky Mountains. A cold front may push in from the northwest disturbing the flow of warm wet Gulf air at the surface. At the same time warm dry air is being pushed out of Mexico across Texas. This creates a mixing zone that is highly conducive to spawning tornadoes. Coupling this with the jet-stream results in a very unstable atmosphere. This produces towering thunderheads which often spawn funnel clouds and sometimes tornadoes.

On the average, Texas experiences more tornadoes than any other state each year. There were 3,600 tornadoes from 1953 to 1980 in Texas which is about 128 per year and nearly five per 26,000 sq km (10,000 sq miles). They are mostly concentrated in the Panhandle at 6.5 tornadoes per 26,000 sq km (10,000 sq miles). Mississippi is the only state to lead Texas in the number of tornado related deaths. Eighty percent of tornado related fatalities take place in April and May alone. Fatalities, due to tornadoes, occur in Texas six out of seven years (Bomar 1983).

Most Texas tornadoes traverse the landscape at 25 to 55 km per hour (15 to 35 mph) with the summer occurrences being slower than those of spring or fall. Three of four Texas tornadoes move in a southwest to northeast direction. Most tornadoes touchdown a distance of only about 5 km and cover an area of only about a kilometer wide. Due to the high winds produced by a tornado the area disturbed may be many kilometers wide. Texas tornadoes can resemble the typical funnel shape or be anything from rope-like to a broad pillar and range in color from white to almost black or they can take on the color of the soil that they are picking up as they pass. Tornadoes should not be confused with the Texas dust devil, which is never associated with a thunder cloud, but rather with summer convectional heating of the surface.

Kessler (1976) reported that a growing interest in tornadoes is due to the potential damage to housing, communications and to nuclear power plants. This has instigated new research into tornado mechanics, thus providing insight into detection and warning. Many details about tornado extremes are erroneous due to untrained observers or honest mistakes made by witnesses under the stress of the situation. Kessler (1976) reported that there are less than six "apparently thoughtful" reports of tornado events that support winds in excess of 400 km per hour (250 mph). It is now believed that much tornado damage is caused by winds blowing at about 160 km per hour (100 mph). Doppler radar currently being installed across the U. S. seems to be promising for short term tornado prediction.

Urban heat islands occur when the concentration of heat, generated by human activity, within a city is enough to produce air temperatures greater than those in the surrounding areas. This can even cause flowers to bloom earlier within a city (Moran and Morgan, 1991). Fujita (1973) reported that the effect of the urban heat island is becoming important in tornado suppression and has become obvious in Chicago and Tokyo. He speculates that a threshold population of four million will be effective in tornado suppression.

Frequency

Fujita (1973) reported that the number of reported tornadoes have gradually increased since 1916, when official data collection began in the United States. He attributes a significant increase beginning in 1953 to increased interest in reporting tornadoes by the U. S. Weather Bureau. Annual frequencies at the time of Fujita's 1973 study were about 750 for the United States. He prorated figures for other countries to the size of the United States, excluding Alaska and derived the following frequencies showing a similar increase in "recent" years. Japan went from 100-200 to 300-400 after the 1950's. New Zealand went from 216 (with a maximum of 667 in 1935) prior to 1944 to an increase of 400 to 600 during the 1960's. Italy experienced an increase from 100 in 1950 to 900 by 1965. For the four years (1963-66) of tornado data available from the U. K., an increase of 300 to 1, 300 tornadoes was reported. Again, these figures are prorated for equivalent size to the United States, excluding Alaska. Frequencies in the U. S. are comparable to other mid-latitude industrialized countries. The exception is that in the U. S., frequency of extremely large tornadoes seems to prevail (Fujita 1973).

Seasonal variation

More than half of all Texas tornadoes occur in late spring or early summer. Six out of ten tornadoes will occur in during the months of April, May, and June with May being the most active in regards to tornado activity. Fujita (1973) reported that the height of tornado activity occurs in early spring in the South, then progresses northward across the Great Plains and reaches the Midwest by May. By June the height of tornado activity has reached the northern Plains and finally reaches Canada by July. During the winter, tornadoes are not common in Texas but will occasionally occur. During the spring, tornadoes may occur anywhere in Texas; other times of the year seem to produce tornadoes on a regional basis. Tropical storms result in tornado activity in the southern third of the state from mid July to September (Bomar 1983).

As summer approaches the tornado occurrences seem to move northward to the northern two thirds of the State. During the summer months the Panhandle is the leader in frequency of occurrence. This is because of the presence of the cooling mechanism necessary to instigate tornadoes is then limited to the northern portions of the State. Afternoon and evening hours witness the majority of Texas tornadoes. However tornadoes may occur at any time of day or night especially in association with a hurricane or other tropical storm.

Wolford (1960) reports that there are specific calendar days on which maximum and minimum numbers of tornadoes occurred. From 1916-58 April 30 was the day for which the maximum number of tornadoes occurred with an accumulated total of 124. April 30 was followed by May 20, April 5, and June, 6. April 17, May 6, and May 28 were the days with the fewest tornado occurrence. No tornadoes had occurred on February 2, 23, November 30, December 14 or 16.

Municipal Water Demand

There have been many investigations into the relationships surrounding municipal water demand. Some of these analyses utilize multiple regression such as those conducted by Atkin et al. (1991), Griffin and Chang (1990), Nieswiadomy (1992) and The World Bank Water Demand Research Team (1993). Others studies have utilized time series analysis including those by Agthe and Billings (1980), Kher and Sorooshian (1986), and Maidmont and Miaou (1986). In each of these studies, socioeconomic variables were included in their analyses. Many of the studies utilize elaborate metering schemes involving multiple municipalities.

Regardless of the statistical analyses involved, many of the investigations considered climatic variables, including those done by Maidmont et al. (1985), Danielson (1979), Hansen and Narayanan (1981), Hartley and Powell (1991), Howe and Linaweaver (1967), Kulik (1993), Maidmont and Parzen (1984), Miaou (1990), and most notably Morgan and Smolen (1976). Most of the investigations are conducted in areas where water supply becomes an important issue during one or more months of the year, due in part to a dry season. Because of a temporary shortage of water, many of these studies included a seasonal effect on water demand. It is important to understand this relationship without the effects of a dry season or socioeconomic variables.

Municipal water pricing structure and consumption

The Nacogdoches Water Conservation Plan (1991) suggested that raising the price of water probably would not change water demand due to the current system of pricing. The plan stated that people are much more concerned with electric bills, which are substantially more costly, than they are with a relatively inexpensive water bill. Currently, Nacogdoches is under a flat rate where minimally, customers will be charged $7.70 for the first 2500 gallons per month. Additional water will be charged at the rate of $ 0.183 per 100 gallons.

Average monthly water consumption during the 11-year period (1981-91) ranged from just over one million cubic meters in August to 656,000 cubic meters in February. Annual consumption for the same time period ranged from just over 11.5 million cubic meters in 1988 to 8.9 million cubic meters in 1983.

Municipal water resources

The city of Nacogdoches receives water from nine deep wells and Lake Nacogdoches. Nacogdoches has the capacity to produce 57,000 cubic meters (15 million gallons) per day with a maximum daily production to date of 49,000 cubic meters (13 million gallons). The wells are operated at maximum capacity and the lake is used to augment the supply.

Nacogdoches wells penetrate the Carrizo Aquifer which varies in thickness from 15 to 45 meters (50 to 150 feet). Nacogdoches wells average 116 to 181 meters (382 to 595 feet) in depth. Well numbers 1, 4, and 5 pump to ground storage on Power St. Well numbers 6, 7, 8, 9, and 11 pump to the south-side ground storage tank on Old Lufkin Highway. Well number 10 is isolated and seldom used due to taste and odor problems. Additional ground storage includes the south-west pump station and the Old Post Oak Rd. pump station. The grand total ground storage is 34,000 cubic meters (nine million gallons). Elevated storage includes facilities at

Austin St. (0.2 mg), Power St. (0.25 mg), Shady Ln (0.2 mg), Butt St. (0.2 mg), East College (0.5 mg), Moore (0.17 mg) and Buelah Land (0.5 mg); for a grand total elevated storage capacity of 7,600 cubic meters (2.02 million gallons).

The construction of Lake Nacogdoches was completed in 1977 on Bayou Loco, 13 km (eight miles) southwest of Nacogdoches between highways 225 and 21; water production began in 1978. The lake receives 27 million cubic meters runoff annually (22,000 acre feet) or 74,000 cubic meters per day (19 mgd) from a 230 square km (89 square mile) drainage area. The lake has a maximum storage of 49,628,000 cubic meters (40,250 acre feet) and covers 9 square km of surface area (2,210 surface acres) (Draft EIS for Bayou Loco Dam and Reservoir, 1972).

Nacogdoches serves a population of 39,000 of which 22,000 are city residents. Nacogdoches produces water for 800 retail customers outside the city limits and 40 smaller municipal water supply corporations as well as for the customers within the city limits. Water consumption can be broken down as follows: residential 57 percent, government 11 percent, industrial 11 percent, other municipalities 8 percent, commercial 9 percent, and other 4 percent. Monthly water loss, as determined by the difference in production meters and supply meters, can be as much as 18 percent for a given month. Water losses are attributed to leaks, unmetered connections, fire hydrant line flushes and fire usage, and inaccuracies in metering (City of Nacogdoches, 1985).

METHODS AND PROCEDURES

Study Area

Nacogdoches, the oldest town in Texas and the county seat, has a population of 30,872; this does not include approximately 5,000 part-time student residents of Stephen F. Austin State University. The town was headquarters for several unsuccessful attempts to establish Texas as a Republic during the early nineteenth century. Nacogdoches is centrally located in forested East Texas approximately 200 km north of Houston and 260 km southeast of Dallas. Nacogdoches county has a population of 54,753, including 20,000 households with 2.74 persons per household and is 2,453 square km (947 square miles) in size. Primary industries are agriculture, manufacturing, education, and tourism. Agriculture includes cattle, dairy, poultry, grain, and timber production. Manufacturing includes feed, fertilizer, aluminum furniture, valves, business forms, transformers, and poultry processing (Chamber of Commerce, 1993), along with forest products and motor homes.

The topography is characterized by gently rolling slopes and the elevation is hardly above 178 meters (585 ft). Precipitation during the last normal period (1961-90) ranged from an average of 59 mm in August to an average of 132 mm during May while the annual average was 1175 mm. The average number of raindays ranged from 6.3 during July to 9.2 during January with an annual average of 89.1 days receiving rain. Mean monthly temperature ranged from 7.5 °C in January to 27.9 °C during both July and August. The annual average number of frost-free days was 325.9 and corresponds to an average growing season of 241.2 days.

Climate Data Collection

All available hydroclimatic data including daily temperature, rainfall, and streamflow in the Nacogdoches area between 1901-92 were collected. The Texas Water Commission (TWC) provided daily temperature, rainfall, and streamflow data. The National Climatic Data Center provided some data which were not included in the TWC files. The National Severe Storms Forecast center provided tornado data. The U. S. Geological Survey provided recent streamflow data which were not included in the TWC files.

Missing daily temperature observations were filled by taking an average of data for equal periods before and after the missing observations. For example, if one observation was missing, the day before and day after were averaged to obtain a value to fill the missing observation. In the case of an entire missing month, a 30-year average was calculated to fill for the whole month. Where possible, 15 years before and 15 years after were used. This procedure was used to estimate other relevant temperature data such as number of hot days and frost-free days. This procedure was never documented in the literature; however, after personal correspondence with a meteorologist, hydrologist, and climatologists including the State Climatologists of both Texas and Louisiana the procedure was adopted. For the three months of October, 1978, March, 1979, and May, 1979 the total precipitation data collected at the SFA Weather Station were used to fill the missing data.

The following climatic parameters were derived from these daily data in order to update Sayok's (1986) study.

<u>Precipitation data</u>

a) Total precipitation, by month and year

b) Total number of raindays, by month and year

c) The occurrences of dry-spells by length, by year

d) The occurrences of wet-spells by length, by year

e) Maximum daily precipitation by month and year

f) Greatest number of consecutive raindays, by month and year, and

g) Greatest number of consecutive dry days, by month and year.

Temperature data

a) Mean temperature, by month and year

b) Mean maximum temperature, by month and year

c) Mean minimum temperature, by month and year

d) Number of days with maximum daily temperature greater than 32.2 °C, by year

e) Last day with a minimum temperature less than or equal to 0 °C by year

f) First day with a minimum temperature less than or equal to 0 ° C, by year, and

g) Degree units, heating and cooling, base 18.3 °C.

Climate Classification

The long-term climatic water balance of Nacogdoches was calculated, using the 1961-90 climatic data, to delineate the relationships among monthly potential evapotranspiration, actual evapotranspiration, rainfall, soil moisture deficit, and surface runoff distribution by the methods developed by Thornthwaite (1948, 1957), Mather (1974, 1978), and Thornthwaite and Mather (1955).

The components calculated in the long-term (1961-90) climatic balance described above were used to delineate the climate of Nacogdoches based on Thornthwaite's climate classification system (Thornthwaite, 1948 and 1957; Mather, 1974). The Nacogdoches climate was compared with the climate of El Paso, an arid location in West Texas, using the same procedures.

Solar Radiation

Solar radiation data during 1989 were collected at the United States Forest Service Stephen F. Austin Experimental Forest, located about 25 km southwest of Nacogdoches, by the University of Florida Environmental Engineering Sciences Department. The observed data were summarized by month and compared with the figures given in the Solar Radiation Resources Atlas of the United States (1981).

Climate Change at Nacogdoches, Texas

T-test

T-tests were used to calculate the P-values for differences between the means of the last two normal periods (1951-80 and 1961-90) and between the means of the last two long-term periods (1901-80 and 1901-90) to test for differences between the annual means of the aforementioned precipitation and temperature data (Ott, 1988).

Duncan's multiple range test

Duncan's multiple range test, one of the more popular multiple comparison procedures, was applied to test differences between the annual means of each normal period for the aforementioned precipitation and temperature means (1901-1990) (Ott, 1988).

Sample autocorrelation function

Sample autocorrelation coefficients (SAC) for the working series Z_b, Z_{b+1}, ..., Z_n can be obtained by:

1. The sample autocorrelation coefficient (r) at lag k (r_k) is:

$$r_k = \frac{\sum_{t=b}^{n-k}\left(Z_t - \bar{Z}\right)\left(Z_{t+k} - \bar{Z}\right)}{\sum_{t=b}^{n}\left(Z_t - \bar{Z}\right)^2}$$

where:

$$\bar{Z} = \frac{\sum_{t=b}^{n} Z_t}{n - b + 1}$$

2. The standard error of r_k is:

$$S_{r_k} = \frac{\left(1 + 2\sum_{j=1}^{k-1} r_j^2\right)^{0.5}}{(n - b + 1)^{0.5}}$$

3. The t_{r_k} statistic is:

$$t_{r_k} = \frac{r_k}{S_{r_k}}$$

Bowerman and O'Connell (1993) suggested that a spike exists for lag k if its value exceeds the absolute value of two standard errors, which is roughly equivalent to the 95 percent confidence limits. They also suggested that the t_{r_k} is statistically large if it exceeds the value of 1.6 for low lags, k = 1, 2, and 3, or the value of 2 for larger lags. This leads to the rejection of the null hypothesis if any lag k exceeds the absolute value of two standard errors.

Ho: no significant autocorrelation at lag, k, or that r_k is not significantly different from zero,

Ha: significant autocorrelation at lag, k, or that r_k is significantly different from zero.

4. The sample autocorrelation function is a listing, or graph, of the sample autocorrelation coefficients at lags k = 1, 2, ... (Bowerman and O'Connell, 1993).

Streamflow

Daily flow duration analysis

Daily flow duration analysis consists of dividing the daily flows into classes based on the range of the amount of flow. The total number of days in each class were tallied and the tallied number of days were accumulated from the largest class to the lowest class. The percent of time each flow is equaled or exceeded can be calculated by dividing the accumulated days of observation in each class by the total number of observations. A flow duration curve can be constructed by plotting the magnitudes as ordinates against the corresponding percent of time as abscissas. Chow (1964) explained that the duration curve is a cumulative frequency curve of a continuous time series which displays the relative duration of various magnitudes. He also stated that the curve can be considered to represent the stream hydrograph of the average year, except that the flows are arranged in order of their magnitude.

Frequency analysis

Empirical distribution: The streamflow data were fitted to the empirical distribution by:

1. Rank the extreme flows in ascending order (m) to obtain the plotting position by:

$$F(x) = P(X \leq x)$$

where:

$F(x)$ = the cumulative distribution function

$P(X \leq x)$ = the probability a random variable X is expected to be less than or equal to a threshold value x estimated by:

$$\hat{F}(x) = \frac{m}{N+1}$$

m = the ascending order of an event in the array, and

N = total number of observations in the series

2. Plot the observed x's as ordinates on probability paper

3. Plot the corresponding calculated P's as abscissa. The return period T in years may be substituted for P by:

$$T = 1/(1 - F(x))$$

Lognormal distribution: The following procedures are outlined by Chang (1982).

1. Transform the list of values $Y_1, Y_2, \ldots, Y_n$ (total streamflow or instantaneous peakflow) into a list of corresponding logarithms $X_1, X_2, \ldots X_n$, or $X = \ln(Y_1), \ln(Y_2), \ldots \ln(Y_v)$.

2. Compute the mean (M) of the logarithms by:

$$M = \Sigma X/n$$

3. Compute the standard deviation (S) of the logarithms by:

$$S = \sqrt{\frac{\Sigma(X - M)^2}{n - 1}}$$

4. Compute the estimated discharges in log unit at selected recurrence intervals by:

$$\ln Q = M + K_f S$$

where K_f is the frequency factor of the normal distribution. Values of K_f can be found in Table 5, for a few selected recurrence intervals. Ln Q is the logarithm of a discharge having the same recurrence interval.

5. The ln Q must be converted into observed units by :

$$Q = \exp(\ln Q)$$

6. The estimated Q is then plotted on a Lognormal probability paper for interpretation of other recurrence intervals.

Table 5. K_f Values For a Few Return Periods and Probabilities for Normal Distribution

Probability ($P \geq x$). %	Return Period (T) yr	Kf
90	1.11	-1.28
80	1.25	-0.84
50	2.00	0.00
20	5.00	0.84
10	10.00	1.28
4	25.00	1.75
2	50.00	2.06
1.11	90.00	2.29
1	100.00	2.33

Log-Pearson type III distribution: The following procedures for fitting the Log-Pearson type III distribution are outlined by Benson (1968) and Chang (1982):

1. Transform the list of maximum daily streamflows Y_1, Y_2, ... Y_n to a list of corresponding logarithms X_1, X2, ... X_n, or X = ln(Y), ln(Y_2), ... ln(Y_v).

2. Compute the mean (M) of the logarithms by:

$$M = \Sigma X/n$$

3. Compute the standard deviation (S) of the logarithms by:

$$S = \sqrt{\frac{\Sigma (X - M)^2}{n - 1}}$$

4. Compute the coefficient of skewness, (g) by:

$$g = \frac{n\Sigma (x - M)^3}{(n-1)(n-2)S^3}$$

5. Compute the estimated discharges in log unit at selected recurrence intervals by:

$$\ln Q = M + K_f S$$

Where K_f is the frequency factor of the Log-Pearson type III distribution. Values of K_f can be found in Table 42 for positive g and in Table 43 for negative g, for a few selected recurrence intervals. The K_f corresponding to the value of g at selected recurrence intervals. Ln Q is the logarithm of a discharge having the same recurrence interval.

6. The ln Q must be converted into observed units by :

$$Q = \exp(\ln Q)$$

7. The estimated Q is then plotted on a log-normal probability paper for interpretation of other recurrence intervals.

Gumbel distribution: The following procedures are outlined by Chang (1982). Expected frequencies can be obtained by the following equation:

$$\hat{x} = \overline{x} + K_f S_x$$

where:

$\hat{x}$ = the estimated event in respect to different probabilities

$\overline{x}$ = mean of observed data series

S_x = standard deviation of the observed data series.

K_f = the frequency factor in respect to different probabilities

Values for K_f are determined for various return periods by:

$$K_f = \frac{(y - \overline{y}_n)}{\sigma_n}$$

where:

y = the Gumbel's reduced variate given in Table 44 for a given return period

$\overline{y}_n$ = the Gumbel's expected mean given in Table 45 for a given sample size

σ_n = the Gumbel's standard deviation given in Table 46 for a given sample size

Goodness of fit: Goodness of fit was determined by the Kolmogorov-Smirnov test which compares the empirical distribution to the theoretical distribution.

1. Let $P_X(x)$ be the completely specified theoretical cumulative distribution function under the null hypothesis.

2. Let $S_n(x)$ be the sample cumulative density function based on n observations. For any observed x, $S_n(x) = k/n$ where k is the number of observations less than or equal to x.

3. Determine the maximum deviation, D, defined by:

$$D = \max |P_X(x) - S_n(x)|$$

4. Consider the following hypotheses for the test:

Ho: $S_n(x) = P_X(x)$ for all x

Ha: $S_n(x) \neq P_X(x)$ for at least one x

If, for the chosen significance level, the observed value of D is greater than or equal to the critical tabulated value of the Kolmogorov-Smirnov statistic, the null hypothesis is rejected (Haan, 1977). Critical values for the Kolmogorov-Smirnov test can be found in any nonparametric text including Haan (1977) or Conover (1971).

Total streamflow analysis

Total monthly and annual streamflow from La Nana Creek was identified for the entire record (1964-91). First, the data were tested for independence using autocorrelation coefficients of lag one through four. If the test showed that the total annual flows were independent or that one year's total flow was not related to the flow of the previous year, the data were analyzed for their frequency of occurrence using the Log-Pearson Type III, Lognormal distribution and Gumbel distribution.

Extreme daily streamflow analysis

Maximum daily streamflow from La Nana Creek was identified for each year and for each month by year for the entire record (1964-91). First, the data were tested for independence using autocorrelation coefficients of lag one through four. If the test showed that the extreme flows were independent or that one year's extreme flow was not related to the extreme flow of another year, the data were analyzed for their frequency of occurrence using the Log-Pearson type III distribution, Lognormal distribution, and Gumbel distribution.

Chow (1964) suggested a graphical method for representing the seasonal variation in probability by plotting the return period of yearly values, in years vs the months of the year. Return period is defined as the average interval of time within which a given magnitude of a given event will be equaled or exceeded.

Extreme annual peakflow analysis

Extreme annual peak streamflow from La Nana Creek was identified for each year for the entire record (1964-91). First, the data were tested for independence using autocorrelation coefficients of lag one through four. If the test showed that the extreme flows were independent or that one year's extreme flow was not related to the extreme flow of another year, the data were analyzed for their frequency of occurrence using the Log-Pearson type III distribution, Lognormal distribution and Gumbel distribution.

Wet-dry year analysis

The long-term average streamflow and precipitation was considered as an average moisture regime, any deviation from this average was considered as a wet or dry year. It was assumed that the data from subsequent years were independent. The binomial distribution was used to calculate the probability of occurrence of a number of dry or wet years based on the mean streamflow.

The binomial distribution is given by:

$$P(y) = \frac{n!}{y!(n-y)!} p^{y} (1-p)^{n-y}$$

where :

n = number of trials

p = probability of success on a single trial

1 - p = probability of failure on single trial

y = number of successes in n trials

n! = n(n - 1)(n - 2) ...(3)(2)(1)

Conditional probability allows for the determination of a given number of wet or dry years based on the observed data given that a wet or dry year follows a given number of wet or dry years.

The conditional probability is given by:

$$P(W/W) = Nww/Nw = p$$

$$P(D/D) = Ndd/Nd = q$$

where:

N = total sample size

Nw = total number of wet years

Nd = total number of dry years

Nww = the number of times in which a wet year was preceded by a wet year

Ndd = the number of times in which a dry year was preceded by a dry year

The probability of successive dry years of length n can be determined by:

$$p_r(n) = q^{n-1}(1-q)$$

The probability of successive wet years of length m can be determined by:

$$p_r(m) = p^{m-1}(1-p)$$

Tornadoes

The chronological occurrence of tornadoes in Nacogdoches, County was compiled from records available from the National Severe Storms Forecast Center in Kansas City, Missouri. These data were analyzed for annual distribution and probability of occurrence based on Poisson distribution. The Poisson distribution is typically used for fitting rare events, such as automobile accidents or hail activity.

Poisson Distribution

The Poisson distribution is given by:

$$P(y) = \frac{\mu^y e^{-\mu}}{y!}$$

where:

y = the number of tornadoes occurring in a year

e = 2.718

μ = average number of tornadoes per year

with the following assumptions:

1. events occur one at a time,
2. the number of events in a period are independent of the number in other periods, and
3. number of expected events during any one period is the same as any other period.

Goodness of fit

The test statistic for the Chi-square goodness of fit is given by:

$$\chi^2 = \sum_i \left[\frac{(n_i - E_i)^2}{E_i} \right]$$

where:

n_i = number of observations per cell

E_i = expected number of observations per cell

Consider the following hypotheses:

Ho: the observed cell counts all come from a common Poisson distribution with mean μ

Ha: the observed cell counts do not all come from a common Poisson distribution with mean μ

Municipal Water Demand

This study serves to investigate the relationship of the monthly climatic conditions, including those associated with the water budget, to the monthly water demand of a single municipality which generally does not experience water shortages and to develop a multiple linear regression model useful in predicting the monthly municipal water demand. Relationships between the municipal water demand and climatic parameters were investigated by applying multiple linear regression statistical techniques in an attempt to predict municipal water demand. Parameters included all those associated with Thornthwaite's climatic water balance plus some other precipitation and temperature variables.

Water production data, from January 1981 to December 1991 for the City of Nacogdoches were obtained from the City Water Office. These data include the production figures for all city wells and from Lake Nacogdoches. Monthly climatic water budget figures for the same time period were obtained from the Louisiana State Climatology Office. They have developed a program, WATBUG (Grymes, 1993), which performs the calculations according to Thornthwaite's procedures.

Duncan's multiple range test

Duncan's multiple range test, as previously discussed, was applied to test differences in water production by year and month at Nacogdoches, Texas (Ott, 1988).

Multiple linear regression analysis

Multiple linear regression analysis was employed to find an appropriate set of independent variables which can satisfactorily describe or predict municipal water demand for Nacogdoches, Texas. SAS (1988) gives the two approaches to model selection: all possible regression methods and stepwise regression methods. Stepwise regression methods systematically add or delete variables from the model to find an adequate model. They only examine a subset of all the possible models and generally select only one model from the set of all possible models (SAS, 1988).

One commonly used stepwise method in SAS, the max-R, attempts to find the models of each possible size that have the maximum R-square, rather than attempting to find a single model that maximizes R-square. SAS (1988) provides the following algorithm for the max-R method. It begins by finding the one variable model that has the highest R-square, it then adds the variable that will maximize the increase in R-square. Next it determines if removing one variable and replacing it with another will increase the R-square, it then compares all possible switches and makes the replacement that will produce the largest R-square. This process is continued until the candidate model is selected for each possible model size.

The multiple regression model is of the following form:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n + \varepsilon$$

where:

Y = total monthly water production in thousands of cubic meters,

β_o = the point at which the line crosses the vertical axis,

β_i = the unit increase in Y for each independent variable,

X_i = independent variables of interest, and

ε = the random error which is assumed to be normally distributed with mean zero.

Consider the following hypotheses:

Ho: $\beta_i = 0$ no variables are significant for regression

Ha: $\beta_i \neq 0$ at least one variable is significant for regression

The independent variables used in the study are given below.

T = monthly average of daily average temperature in °C,

MAXT = monthly average of daily maximum temperatures in °C,

MINT = monthly average of daily minimum temperatures in °C,

HD = number days in each month exceeding 32.2 °C,

HD35 = number days in each month exceeding 35 °C,

RANGE = maximum daily temp for a month minus the daily minimum temperature,

P = monthly total precipitation in mm,

1/P = the reciprocal of total monthly precipitation in mm,

RD = monthly total number of raindays,

PE = potential evapotranspiration in mm,

P-PE = precipitation minus potential evapotranspiration in mm,

ST = soil moisture storage in mm,

AE = actual evapotranspiration in mm, and

DEF = soil moisture deficit in mm.

Those variables retained in the selected model should provide not only a high R-square value, but they should also be simple, plausible and have no significant correlation among each other.

RESULTS AND DISCUSSION

Long-term Climatic Water Balance

The long-term climatic water balance (1961-90) was calculated using the procedures described in Thornthwaite (1957) and Mather (1978). The results are given in Table 6 and plotted in Figure 1 for Nacogdoches, Texas, and in Table 7 and Figure 2 for El Paso, Texas.

Nacogdoches, Texas

The water holding capacity for a root zone in a forested region with clay loam soils is approximately 300 mm, therefore this was used in calculations for this region. Subtracting the potential evapotranspiration from the precipitation reveals a series of positive and negative values which indicate alternating periods of a potential for soil moisture recharge and depletion.

At Nacogdoches, precipitation minus potential evapotranspiration (P-PE) is positive 449.2 mm from October through May. This wet period is sufficient to bring the water holding capacity back to 300 mm. The month of June has less precipitation (P) and an increase in potential evapotranspiration (PE). In order to determine the amount of soil moisture storage at the end of the month the various inputs and losses for June must be considered. Precipitation is 110 mm and the PE is 155 mm in June; therefore the vegetation needs an additional 45 mm of water than it receives from precipitation. July AE is 152 mm; obtained from July P of 81 mm and the ΔST of 71 mm, representing 71 mm of soil moisture depletion.

January's total detention is 348 mm as determined by summing 300 mm of soil storage and 48 mm of surplus which has not run off but is being added to the February surplus. The 348 mm exceeds the soil moisture capacity but it must be remembered that the soil moisture capacity is at field capacity and additional water may be temporarily present while on its way through the soil profile (Figure 1 and Table 6).

Overall, there is a water deficit of 94.5 mm in the four hottest summer months, June through September, and a total water utilization of 526 mm in the same period. Water surplus begins in December and continues through May. Precipitation is greater than actual evapotranspiration in October through December, the excess water goes to soil moisture recharge.

El Paso, Texas

The water holding capacity for a root zone in a semiarid region with sandy loam soil is approximately 100 mm, therefore this was used in calculations for this region. El Paso, Texas is included in this study to serve as a comparison of a dry station to the moisture sufficient Nacogdoches station.

At El Paso, P-PE is negative for every month of the year except January. In January, P exceeds PE by 2 mm, which is immediately depleted in February. The sum of P-PE is negative at El Paso; therefore, we may use the nomogram given by Thornthwaite and Mather (1955) to extrapolate the proper value with which to begin accumulating the negative values of P-PE. This must be done in order to continue with the bookkeeping procedure. Extrapolation using the nomogram reveals that the potential deficiency at the end of the wet season (January) is 1400 mm. Unlike Nacogdoches, the soil moisture is never brought back to capacity, rather it is always in deficit (Figure 2 and Table 7).

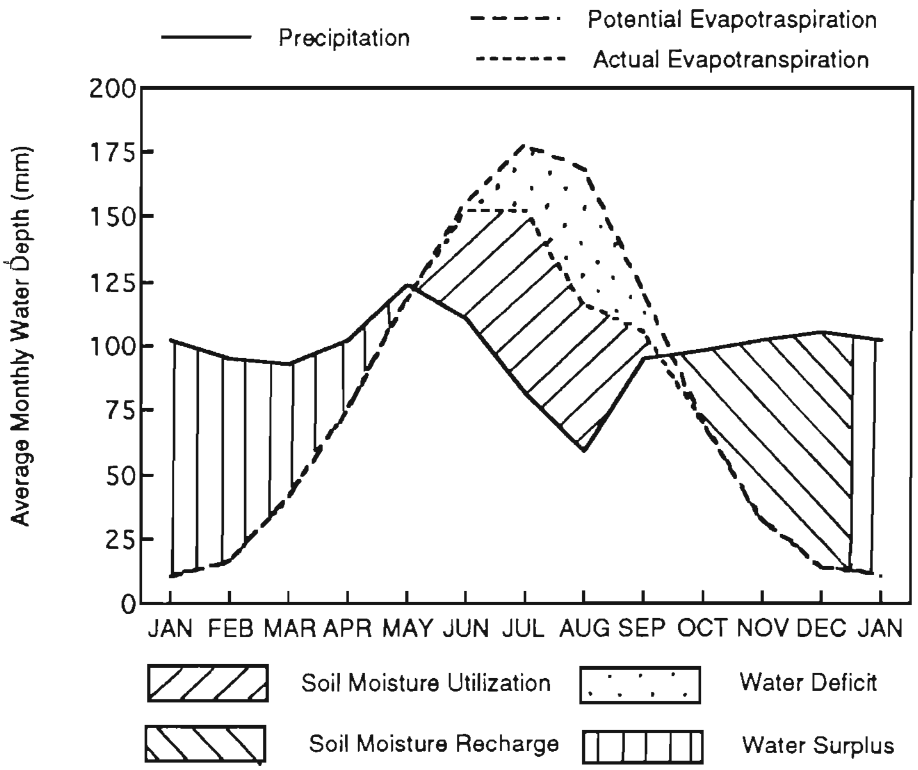


Figure 1. Long-term (1961-90) climatic water balance at Nacogdoches, Texas.

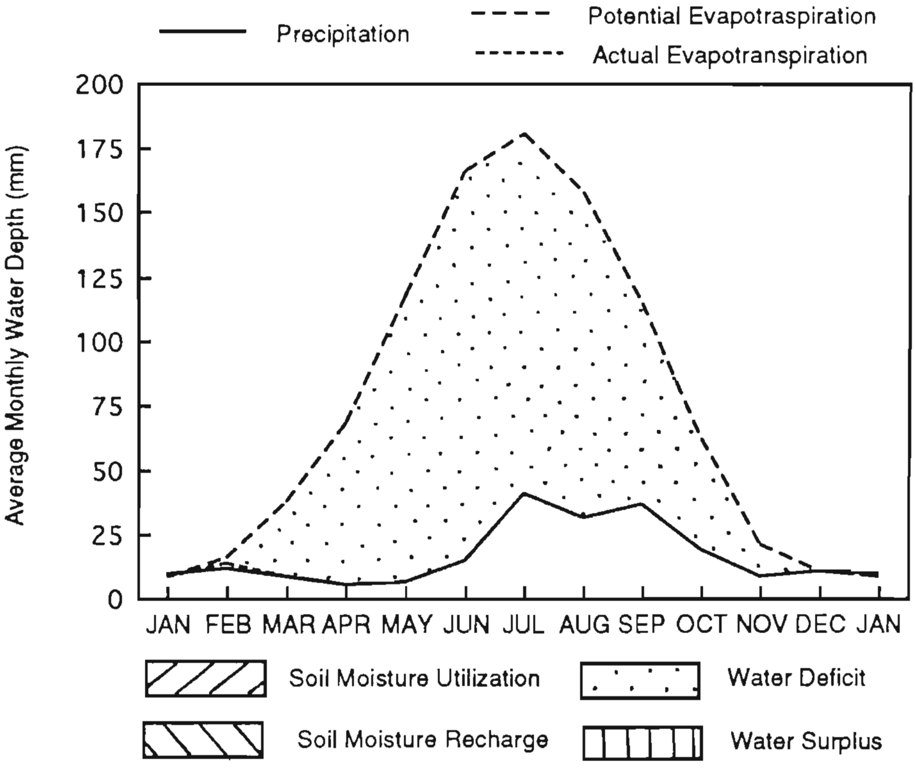


Figure 2. Long-term (1961-90) climatic water balance at El Paso, Texas.

Table 6. Long-term (1961-1990) Climatic Water Budget in mm for Nacogdoches, Texas

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
T°C	7.5	9.8	14.2	18.9	22.7	26.1	28.0	27.9	24.8	19.2	13.9	9.3	18.5
PE	10.8	15.6	40.2	74.5	117.1	154.9	176.9	168.1	120.5	70.6	31.7	13.2	993.9
P	102.1	95.2	93.3	101.8	124.2	110.0	81.4	59.0	94.6	98.2	102.2	105.6	1167.3
P-PE	91.3	79.5	53.1	27.3	7.4	-44.9	-95.5	-109.1	-26.0	27.7	70.5	92.4	
ST	300	300	300	300	300	258	187	130	119	146.7	217.2	300	
ΔST	0	0	0	0	0	-42	-71	-57	-11	+27.7	+70.5	+82.8	
AE	10.8	15.6	40.2	74.5	117.2	152.0	152.4	116.0	105.6	70.6	31.7	13.2	899.4
D	0	0	0	0	0	2.9	24.5	52.1	15.0	0	0	0	94.5
S	91.3	79.5	53.1	27.3	7.1	0	0	0	0	0	0	9.6	268.0
RO	48.1	63.8	58.5	42.9	25.0	12.5	6.2	3.1	1.6	0.8	0.8	4.82	268.0
DT	348.1	363.8	358.5	342.9	325.0	270.5	193.2	133.1	120.6	147.5	222.0	304.8	

All values are in mm depth, except T which is in °C.

PE is potential evapotranspiration, P is precipitation, ST is soil moisture storage in the root zone, ΔST is the change in storage from one month to the next, AE is actual evapotranspiration, D is water deficit, S is water surplus, RO is run off, and DT is total moisture detention within the soil.

Numbers in this table were rounded, therefore the monthly figures may not agree with the annual totals given.

Table 7. Long-term (1961-1990) Climatic Water Budget in mm for El Paso, Texas

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
T°C	6.8	9.1	12.8	17.6	22.2	27.1	28.1	26.8	23.4	17.6	10.8	6.9	17.4
PE	8.1	15.6	37.1	68.0	117.3	165.7	180.8	158.0	114.3	61.7	21.1	10.6	958.3
P	9.6	11.4	8.1	4.8	6.1	14.2	40.6	30.7	36.1	18.5	8.4	9.91	198.6
P-PE	1.6	-4.1	-29.0	-63.2	-111.2	-151.5	-140.1	-127.3	-78.3	-24.7	-12.8	-0.6	
ST	1.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
ΔST	+0.6	-0.6	0	0	0	0	0	0	0	0	0	0	
AE	8.1	13.0	8.1	4.8	6.1	14.2	40.6	30.7	36.1	18.5	9.9	13.2	198.6
D	0	2.6	29.0	63.2	111.2	151.5	140.1	127.3	78.3	43.2	12.7	0.7	759.6
S	0	0	0	0	0	0	0	0	0	0	0	0	0
RO	0	0	0	0	0	0	0	0	0	0	0	0	0
DT	0	0	0	0	0	0	0	0	0	0	0	0	

All values are in mm depth, except T which is in °C.

PE is potential evapotranspiration, P is precipitation, ST is soil moisture storage in the root zone, ΔST is the change in storage from one month to the next, AE is actual evapotranspiration, D is water deficit, S is water surplus, RO is run off, and DT is total moisture detention within the soil.

Numbers in this table were rounded, therefore the monthly figures may not agree with the annual totals given.

Classifying Climates at Nacogdoches and El Paso, Texas

Reference should be made to Figures 1 and 2 which give a visual impression of the various factors involved with the water budget. In order to evaluate the four parameters used in Thornthwaite's (1948) climate classification, the following data must be available and were obtained from Tables 6 and 7: potential evapotranspiration from the three summer months (which represents thermal efficiency), annual precipitation, water surplus, water deficit, the moisture index, and both the surplus and deficit expressed as a percent of potential evapotranspiration, representing the humidity and aridity indices respectively. Table 8 provides the data necessary to define the climatic type of Nacogdoches and El Paso, Texas, with letter symbols representing the climatic type at each station.

Table 8. Comparative Moisture Data for Climate Classification at Nacogdoches and El Paso, Texas

Station	P	Im	Thermal Efficiency	Ia	Ih	Summer PE %	Summer PE mm	Climatic type
Nacog.	1167.3	17.4	993.9	9.5	27.0	50.3	499.9	$C_2B'_3s\ b'_4$
El Paso	198.6	-79.3	958.3	79.3	0	52.6	504.5	$E\ B'_3d\ b'_3$

The various subdivisions of the mesothermal, microthermal, and humid climatic types were never given names, but rather always referred to by their respective symbols (Carter and Mather, 1966).

Nacogdoches has a moisture index (Im) value of 17.4 mm and is given the moist subhumid (C_2) moisture region designation. A thermal efficiency of 993.9 mm corresponds to the third mesothermal climate type (B'_3). Since it is a moist climate utilization of the aridity index (Ia) of 9.5 mm results in the description of moderate summer water deficiency (s). Since the summer concentration of thermal efficiency is 50.3 percent, which is equal to the B'$_4$ thermal climate type, it is given the b'$_4$ designation. Therefore the climatic type at Nacogdoches, Texas can be described as moist subhumid, third mesothermal, with moderate summer water deficiency, and a temperature-efficiency regime equal to a fourth mesothermal climate. Carter and Mather (1966) reported the climate classifications of a few places around the world. Two locations were strikingly similar to Nacogdoches in their climatic descriptions only differing in that they had little or no summer water deficiency, viz. Changking, China and Columbia, South Carolina.

The climatic type at El Paso, Texas can be described as arid, third mesothermal, with little or no water surplus, and a temperature efficiency regime equal to a third mesothermal. This is the same description given to El Paso, Texas in 1966 by Carter and Mather (1966).

Solar Radiation

The solar constant is defined as the rate at which solar radiation falls on a surface located at the top of the atmosphere perpendicular to the sun's rays at a mean distance from the sun. It is estimated to be 0.082 Mega Joules (MJ) per sq. meter per minute, or 1.97 langleys per minute (Crowe, 1971). However, because the orbit of the earth is not exactly circular which can cause the distance from the earth to the sun to vary as much as 3.3 percent in any given year, actual solar radiation at the top of the atmosphere varies with the seasons (angle of inclination). The earth is closest to the sun during winter (perihelion) and farthest during summer (aphelion) for the northern hemisphere, and these days coincide with January 3 and July 4, respectively.

When solar radiation reaches the ground surface, it is further affected by geographic location, time angle, atmospheric conditions (i.e., various gases, CO_2, water vapor, aerosols, etc.), and topography. The effects could be quantitative, qualitative, and directive.

Total solar radiation

Total monthly solar radiation observed in 1989 from a pyranometer located in the SFA Experimental Forest along with observations collected in 1980 at the SFA Weather Station reported by Sayok (1986) and the long-term average interpreted from the Weather Bureau's Climatic Atlas are given in Table 9. According to the Solar Radiation Energy Resource Atlas of the United States (Solar Radiation Research Institute, 1981), Nacogdoches should receive just under 16 MJ (16 MJ = 382 Langleys) per square meter per minute for an annual average daily global solar radiation on a horizontal surface. This value is somewhat lower than Sayok' (1986) interpolations from the Weather Bureau's Climatic Atlas. He reported 423 ly for the average daily as interpolated from the Climatic Atlas of the United States. Sayok (1986) reported 347 ly for the annual daily average for 1980 for data that were collected at the SFA Weather Station. Sayok's figures for 1980 and the figures for 1989 are more in line with the figures reported in the Solar Radiation Energy Resource Atlas of the United States and do not agree with those in the Weather Bureau's Climatic Atlas.

At first glance it would appear that the 1980 and 1989 data are compatible to what should be expected. However, Sayok (1986) reported that the data for 1980 should not have been below Sayok's (1986) interpolated long-term averages from the Weather Bureau's Climatic Atlas. This is because 1980 was a dry year and that would suggest less cloud cover to interfere with incoming solar radiation. The 1989 data are more compatible to the long-term averages because it was a wet year, and therefore should be lower. Precipitation for 1989 exceeded the long-term (1901-90) average by 101 mm and the normal (1961-90) by 132 mm and there were five more raindays in 1989 than there was for the normal. This should justify the lower figures for global radiation.

It should be noted that both the 1980 and 1989 data are close to the expected values given in the Solar Radiation Energy Resources Atlas of the United States (just under 382 ly).

Table 9. Long-Term Global Radiation in Langleys Interpolated from the Weather Bureau's (1968) Climatic Atlas of the United States along with Global Radiation Observed for Two Single Years in Nacogdoches, Texas

	Interpolated	Observed	
Month	Long-Term Average 1/	1980 2/	1989 3/
Jan	241	177	153
Feb	306	303	174
Mar	406	407	297
Apr	467	388	417
May	560	382	446
Jun	604	493	403
Jul	596	476	486
Aug	561	456	469
Sep	459	334	413
Oct	379	319	327
Nov	280	238	204
Dec	225	195	191
Average	423	347	332

1/ After Sayok (1986)
2/ Observed at the SFASU Weather Station (Sayok, 1986)
3/ Observed at the SFA Experimental Forest (University of Florida, 1990).

Solar variation

Seasons and day length change are due to the revolution of the earth around the sun and the earth's revolution around its axis. Annually the sun shifts between 23 ° 27' north (summer solstice, June 22) and south (winter solstice, December 22) of the equator. Thus, there are two days in each year when the sun is directly over the equator. These two days are referred to as equinoxes (or equal nights), one on March 21 (Vernal equinox) and one on September 23 (Autumnal equinox) (Moran and Morgan, 1991). In the north hemisphere, solar radiation is most intensive on the summer solstice and the least on the winter solstice.

Figure 3 illustrates the maximum hourly global radiation for four selected months. This should, in theory, be comparable to the values of the equinoxes and solstices. It should be noted that June was a very rainy month. In the absence of such rain the line representing the maximum average hourly solar radiation for June might show as great a departure from the March and September lines as the line for December does.

The apparent dip in global radiation for June of 1989 as illustrated in Figure 4 might be due to cloud cover from day to day which may greatly influence the total global radiation. June 1989 had received 261.6 mm of precipitation which was 165.7 mm more than the long-term average for June. The same month had 14 raindays which was the maximum value for the normal period and was almost two times the average for the normal period.

Sayok (1986) also calculated the daily total potential insolation at a horizontal surface at the top of the atmosphere for some selected dates throughout the year. Comparing these to the observed data in Table 10 it can be seen how atmospheric effects can greatly reduce the incoming solar radiation. Observed data are daily totals corresponding to the date in which Sayok (1986) calculated figures for. Reductions in observed vs calculated values are as much as 97 percent in March and as little as 36.3 percent in October. On the average the observed values are 62.4 percent below the calculated values.

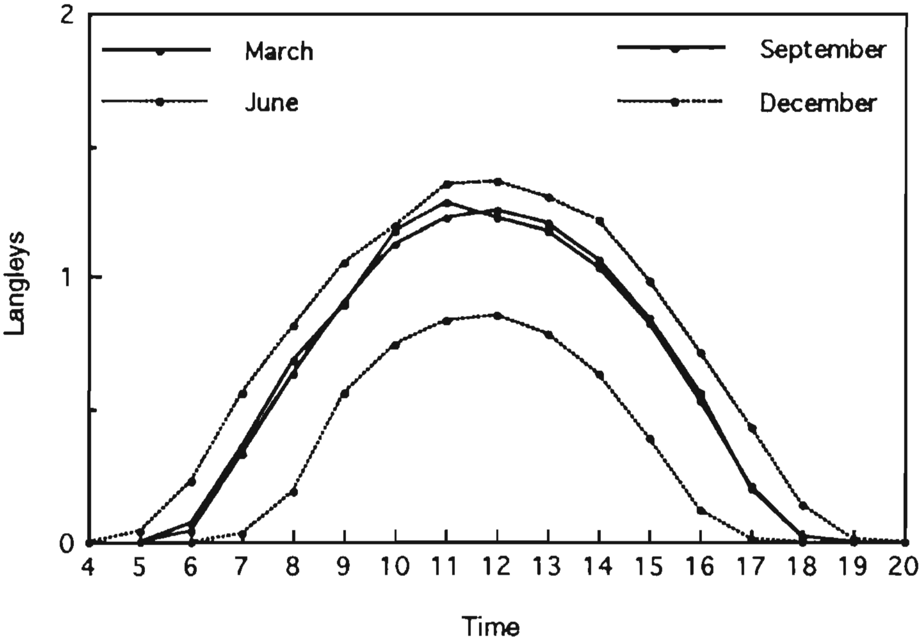


Figure 3. Maximum hourly average global radiation at SFA Experimental Forest for four selected months of 1989.

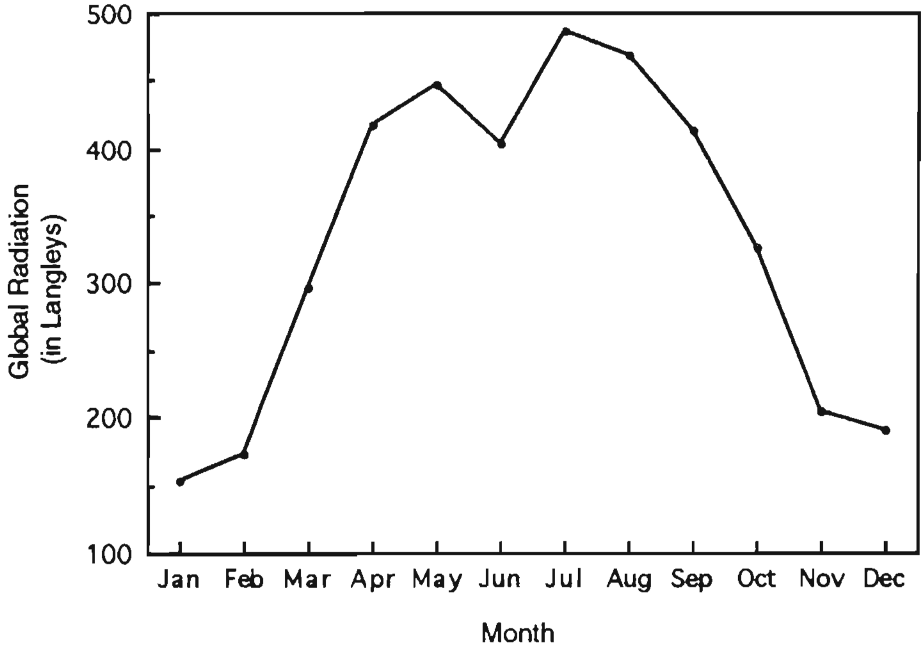


Figure 4. Monthly daily average global radiation at SFASU Experimental Forest for 1989.

Table 10. Daily Total Potential Insolation at 32 °N reported by Sayok (1986) Compared to Daily Total Global Radiation observed at the SFA Experimental Forest (31° 30' N) in 1989 (University of Florida, 1990)

Date	Calculated (langleys)	Observed (1989) (langleys)	% Observed are Below Calculated
Jan 23	540.9	164.7	69.6
Feb 20	658.5	74.1	88.7
Mar 21	794.2	23.9	97.0
Apr 19	906.9	126.5	86.0
May 18	976.3	374.7	61.6
Jun 22	1005.1	422.4	58.0
Jul 12	994.9	558.5	43.9
Aug 10	947.3	491.6	48.1
Sep 9	855.7	494.0	42.3
Oct 8	726.8	463.0	36.3
Nov 5	594.4	81.1	86.3
Dec 3	502.4	298.3	40.6
Average	792.0	297.7	62.4

Climate Change at Nacogdoches, Texas

Overall the precipitation and temperature regimes at Nacogdoches has changed very little in recent years. They were examined by comparing the most recent normal period (1961-90) to the previous normal period (1951-80) and the most recent long-term period (1901-90) to the previous long-term period (1901-80). In other words, this is to update Sayok's (1986) work by testing the effects of ten additional years of data to the results of his analyses. All data have been converted to metric units, rather than the British units used by Sayok (1986). Table 47 in Appendix VII contains some useful conversion factors between metric and non-metric systems. All original and updated data are given in Appendices I to IV. Any inadvertent typographical errors which may have been found in Sayok's (1986) work have been corrected. In addition, some data, viz. five months in 1914, were located in national Climatic Data Center's archives.

Finally, all missing data were estimated by procedures described in the Methods and Procedures section.

For this section the last ten year period refers to the calendar years 1981-90, the last normal period covers the calendar years 1961-90 and the overall long-term average refers to the average of the period 1901-90. Each normal period is denoted by the year in which it ends, for example the 1950 normal period covers the calendar years 1921-50.

Precipitation

All relevant precipitation data are given in Appendix I. Table 22 provides a summary of all relevant precipitation data used in comparing the last two normal periods (1951-80 and 1961-90) and the last two long-term periods (1901-80 and 1901-90). Table 11 also provides the P-values for the t-tests performed on the aforementioned time periods. All statistical tests are performed at the $\alpha=0.05$ level.

Annual: Annual precipitation for the last ten years ranged from 718.3 - 1456.9 mm with a mean of 1190.0 mm and a standard deviation of 274.7 mm. Annual precipitation during the last normal period ranged from 1884.3 mm to 718.3 mm with a mean of 1174.7 mm and a standard deviation of 282.5. This comes close to the long-term extremes of 1886.5 mm in 1957 and 713.5 mm in 1954. These figures are given in Table 22 and are summarized in Table 11. Table 23 provides maximum daily precipitation by month and year. Figure 5 shows that there is no significant difference between the means of any normal period. Also no significant difference is found between the last two long-term periods. Figure 6 shows the fluctuation of annual precipitation over the years.

1921-50	1931-60	1941-70	1901-30	1961-90	1911-40	1951-80
(1227)	(1220)	(1207)	(1175)	(1175)	(1173)	(1171)

Figure 5. Results of Duncan's multiple range test for seven normal precipitation periods. Values in parenthesis under each period are the normal precipitation in mm.

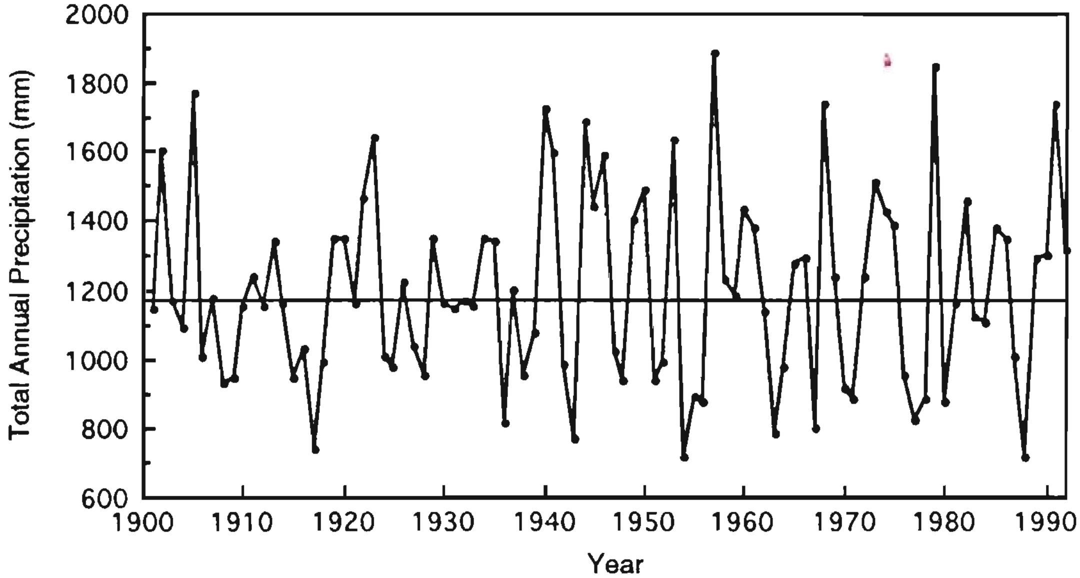


Figure 6. Total annual precipitation (in mm) vs years for Nacogdoches, Texas.

Departures from long-term average: How wet or dry a year or month is can be depicted by their departures from a long-term average. The differences between the monthly and annual precipitation and the overall long-term average are given in Table 24. For the last ten year period 1988 was the driest year while 1982 was the wettest, they deviated from the overall long-term average by -471.7 mm and 266.9 mm, respectively. In the last normal period the two extreme departures were -471.7 mm in 1988 and 653.3 mm in 1979. Over the 90-year period the greatest negative departure was -476.5 mm in 1954 and the greatest positive departure was 696.5 mm in 1957. With a P-value of 0.9633, no significant difference is found between the last two normal periods. A P-value of 0.9964 shows no significant difference between the last two long-term periods (Table 11). The accumulated departures of annual precipitation are plotted against years in Figure 7.

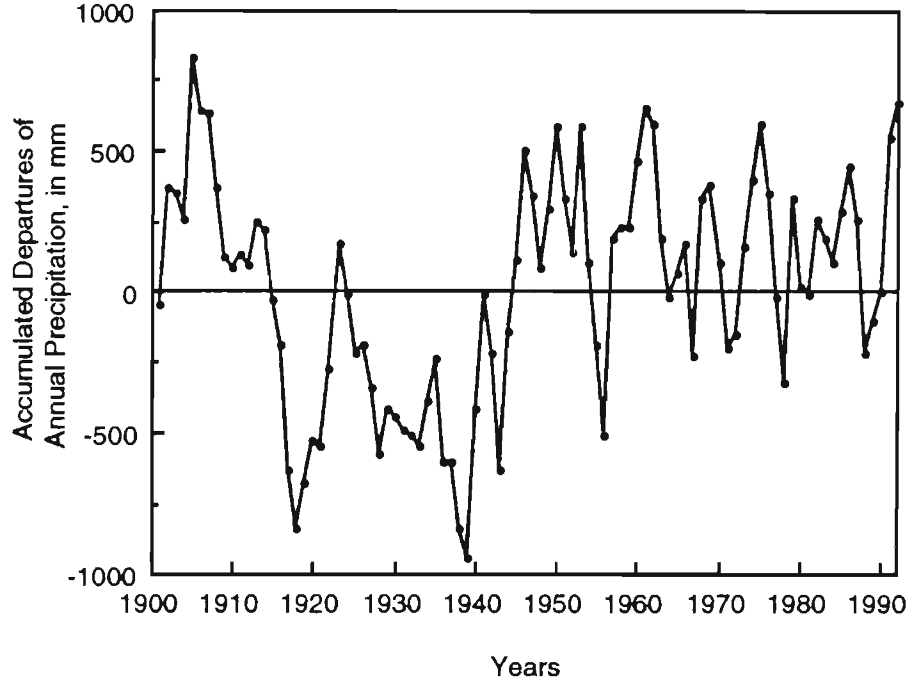


Figure 7. Accumulated departures of annual precipitation vs years for Nacogdoches, Texas.

Raindays: Raindays are the number of days receiving ≥ 0.25 mm of precipitation. Annual raindays for the last ten year period ranged from 78 to 101 days with a mean of 90.3 days and a standard deviation of 8.7 days. Figure 8 shows that the first normal period (1901-30) had significantly fewer raindays than any other normal period. It can also be stated that the second normal period (1911-40) is significantly different from the third (1921-50) and fourth (1931-60) normal periods. The fifth (1941-70), sixth (1951-80) and seventh (1961-90) normals are not significantly different from second, third or fourth normals. There is no evidence of any trend revealed in the Duncan multiple range test.

The last normal period (1961-90) had extremes of 109 and 67 raindays with a mean and standard deviation of 89.1 days and 10.9 days respectively. With a P-value of 0.8803 there is no significant difference between the two normal periods, 1951-80 and 1961-90. For the 90-year period the maximum was 120 days in 1949, the minimum was 50 days in 1917, and the mean and standard deviation were 87.5 and 15.8 respectively. With a P-value of 0.8895 no significant difference exists between the two long-term periods, 1901-80 and 1901-90. Months receiving no raindays were extremely rare, occurring only 5 times in 91 years on the following dates: July 1911, September 1912, August 1924, October 1952 and July 1970. Monthly and annual total raindays are provided in Table 25, and the annual fluctuation is plotted in Figure 9.

1921-50	1931-60	1941-70	1961-90	1951-80	1911-40	1901-30
(96)	(95)	(93)	(89)	(89)	(86)	(78)

Figure 8. Results of Duncan's multiple range test for seven normal rainday periods. Values in the parenthesis under each period are the normal number of rain days.

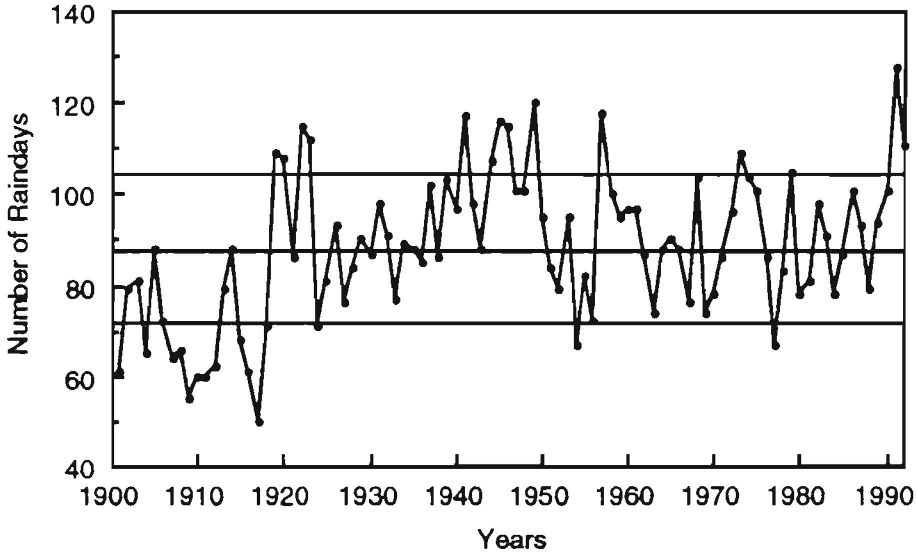


Figure 9. Annual fluctuation of the number of raindays (with mean and plus, minus one standard deviation outlined) vs years.

Maximum wet spell: Consecutive raindays can be considered as a wet spell. Only the monthly and annual maximum wet spells are considered here. These data are given in Table 26.

The last ten year period (1961-90) had a maximum annual wet spell of eight days in June of 1986 and a minimum annual maximum wet spell of five days. This hardly differs from the last normal period (1961-90) which had a maximum wet spell of nine days and a minimum wet spell maximum of four days which occurred in nine different years. With a P-value of 0.1083 there is no significant difference between the last two normal periods (1951-80 and 1961-90). The longest wet spell during the 90-year period was 16 days. Annual maximum wet spell minimum was never less than three days. With a P-value of 0.8329 there is no significant difference between the two long-term periods.

Maximum dry spell: Consecutive non-raindays can be considered as a dry spell. Only maximum monthly and annual dry spells are considered, and are given in Table 27. Monthly boundaries are not considered; a dry spell is reported for the month in which it ends. Crossing of monthly boundaries only occurred eight times in 91 years.

The last ten year period (1980-90) had an annual maximum dry spell of 36 days ending in September of 1982 and a minimum dry spell maximum of 16 days in November of 1983. The last normal period (1961-90) had a maximum of 41 days ending in May of 1977 and an annual maximum dry spell minimum of 13 days in 1973. With a P-value of 0.3205 there is no significant difference found between the two normal periods. The 90-year maximum was 53 days ending in October of 1912, followed by 47 days ending in November of 1957. With a P-value of 0.7546 there is no significant difference between the two long-term periods (1901-80 and 1901-90).

Temperature

All pertinent temperature data are provided in Appendix II. Table 12 provides a summary of all relevant temperature data used in comparing the last two normal periods (1951-80 and 1961-90) and the last two long-term periods (1901-80 and 1901-90). Table 12 also provides the P-values for the t-tests performed on the aforementioned time periods. All tests are considered statistically significant at $\alpha=0.05$. The analyses and discussions that follow concern the average monthly and annual temperatures.

Mean: The mean temperature in the last ten years (1981-90) ranged from 19.4 °C to 17.3 °C with a mean of 18.6 °C and a standard deviation of 0.6 °C. Figure 10 shows that there is no significant difference between the means of any normal period. The last normal period (1961-90) is equivalent to the last ten year period (1981-90) except that the mean was 18.5°C with a standard deviation of 0.5 °C. With a P-value of 0.5576 there are no significant differences between the two recent normal periods (1951-80 and 1961-90). The recent long-term period gives a maximum of 19.7 °C, a minimum of 17.2, and a mean of 18.6 with a standard deviation of 0.6°C. With a P-value of 0.9457 there are no significant differences between the last two long-term periods. Mean temperature data are listed in Table 28, and the annual values are plotted over the years in Figure 11.

1961-90	1931-60	1921-50	1951-80	1911-40	1941-70	1901-30
(18.8)	(18.8)	(18.7)	(18.6)	(18.6)	(18.5)	(18.5)

Figure 10. Results of Duncan's multiple range test for seven normal mean temperature periods. Values in parenthesis under each period are the normal mean temperatures in °C.

Table 11. Comparison of All Relevant Precipitation Data for the Last Two Normal Periods and the Last Two Long-term Periods

	Normals			Long-term Averages		
	1951-80	1961-90	P-value	1901-80	1901-90	P-value
Total Annual (mm)						
mean	1171.0	1174.7	0.9633	1190.2	1190.0	0.9964
s.d.	329.4	282.5		282.3	274.7	
max	1886.5	1884.3		1886.5	1886.5	
min	713.5	718.3		713.5	713.5	
Departures (mm)						
mean	-19.0	-15.3	0.9633	0.2	0.0	0.9964
s.d.	329.4	382.5		282.3	274.7	
max	696.5	653.3		696.5	696.5	
min	-476.5	-471.7		-476.5	-476.5	
Raindays (days)						
mean	88.7	89.1	0.8803	87.2	87.5	0.8895
s.d.	12.9	10.9		6.5	15.8	
max	118	109		120	120	
min	67	67		50	50	
Max Wet Spell (days)						
mean	6.6	5.7	0.1083	6.0	5.9	0.8329
s.d.	2.5	1.4		2.1	2.1	
max	16	9		16	16	
min	4	4		3	3	
Max Dry Spell (days)						
mean	26.3	24.1	0.3205	25.7	25.3	0.7546
s.d.	9.3	7.6		8.5	8.3	
max	47	41		53	53	
min	13	13		13	13	

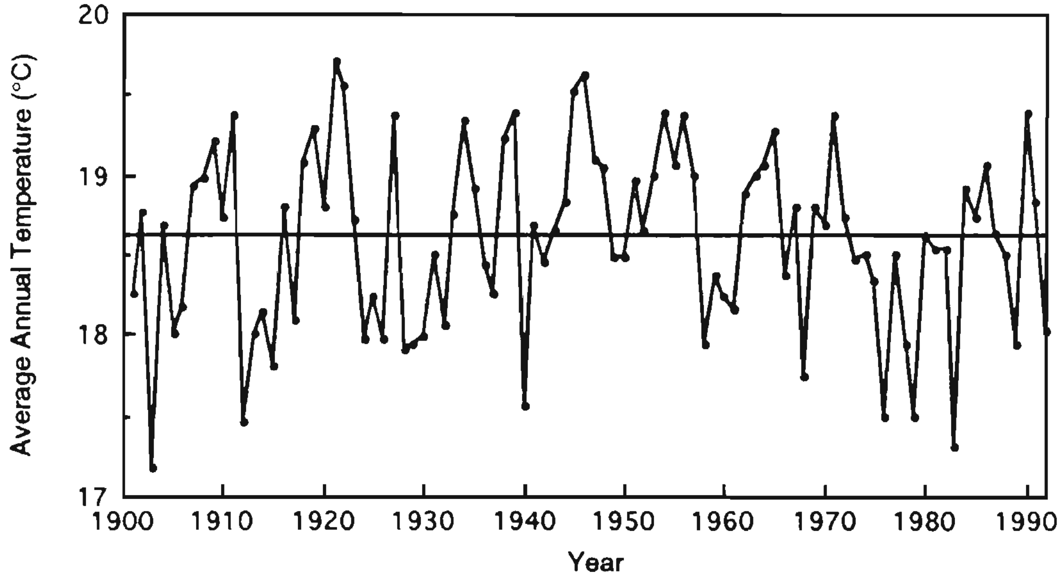
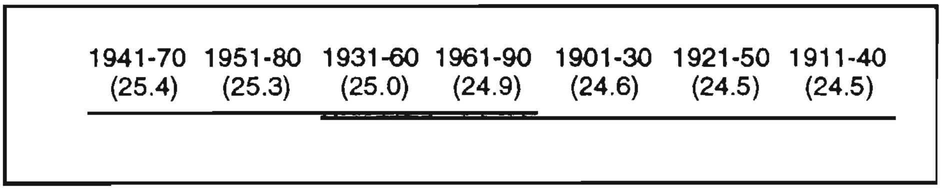


Figure 11. Average annual temperatures (in °C) vs years for Nacogdoches, Texas.

Maximum: Annual maximum temperature in the last ten year period ranged from 26.3 °C to 23.1 °C with an average value of 24.7 °C and a standard deviation of 0.8 °C. Figure 12 shows that there are significant differences between the first (1901-30), second (1911-40), and third (1921-50) normals as compared to the fifth (1941-70) and sixth (1951-80). It can also be stated that the fourth (1931-60) and seventh (1961-90) normals are not significantly different from the other normals. It appears that the earliest normals are significantly cooler than the more recent ones, however the fact that the fourth and seventh are not significantly different from the others suggests that there may in fact be no trend.

During the last normal period (1961-90) only the mean temperature differs from the last ten year period (1980-90) and was 24.9 °C and 24.7 °C, respectively. The corresponding maximum, minimum and standard deviation is 26.3 °C, 23.1 °C, and 0.8 °C respectively . With a P-value of 0.0842 there are no significant differences between the last two normal periods (1951-80 and 1961-90). Extremes for the 90-year period were a maximum of 27.5 °C in 1956 and a minimum of 22.8 °C in 1940. Mean monthly maximum temperatures reached 39.6 °C in August of 1924. The lowest mean monthly maximum temperature was in January of 1978 and was 7.0 °C. With a P-value of 0.9019 there are no significant differences between the last two long-term periods (1901-80 and 1901-90). Average maximum temperature data are given in Table 29, and the annual values are plotted over the years in Figure 13. Table 30 provides maximum daily temperatures by month and year.



1941-70	1951-80	1931-60	1961-90	1901-30	1921-50	1911-40
(25.4)	(25.3)	(25.0)	(24.9)	(24.6)	(24.5)	(24.5)

Figure 12. Results of Duncan's multiple range test for seven normal mean maximum temperature periods. Values in parenthesis under each period are the normal mean maximum temperatures in °C.

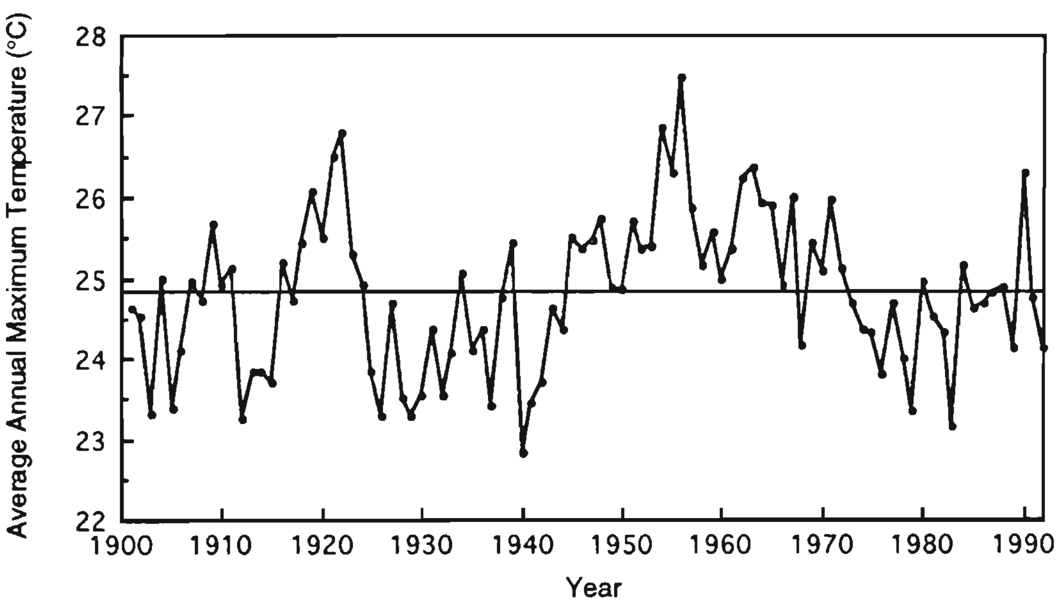


Figure 13. Average annual maximum temperatures (in °C) vs years for Nacogdoches, Texas.

Hot days: Hot days are days which exceed a certain threshold temperature; here we will use 32.2 °C. In the last ten year period (1981-90) the annual number of hot days ranged from 112 days to 65 days with a mean of 88.4 days and a standard deviation of 14.9 days. Figure 14 shows that the number of hot days correspond almost exactly to the results given by the Duncan multiple range test for the average maximum temperature. The only difference is that the second (1911-40) and third (1921-50) normals have switched places.

The last decade (1981-90) differs from the last normal period (1961-90) in that the normal annual maximum was 140 days and the annual minimum was 62 days with a mean of 93.5 days and a standard deviation of 18.6. With a P-value of 0.0669 there is no significant difference between the two normal periods (1951-80 and 1961-90). The 90-year period had extremes of 145 days in 1956 and only 44 days in 1940. With a P-value of 0.9118 there are no significant differences between the last two long-term periods (1901-80 and 1901-90). The number of hot days are given in Table 31 by month and year.

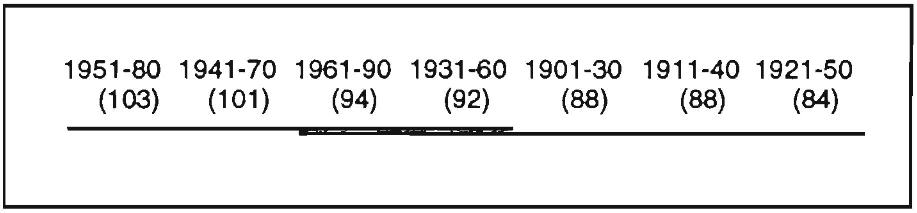


Figure 14. Results of Duncan's multiple range test for seven normal number of hot days periods. Values in parenthesis under each period are the normal number of hot days.

Minimum: The last ten year period (1980-90) had a temperature range from 13.4 °C to 11.5 °C with a mean of 12.4 °C and a standard deviation of 0.6 °C. Figure 15 shows that there are more significant differences among the average minimum temperatures for the normals than for the other temperature variables. The only real significant difference is the distinction between the third (1921-50) and sixth (1951-80) normals. It could be stated that the three most recent normals are significantly different from the second, third, and fourth. However, the first normal period (1901-30) is in the middle of the other normals and is only significantly different from the third and sixth normal.

The last decade is similar to the last normal period (1961-90) in which its mean minimum temperature ranged from 13.4 to 11.0 °C with a mean of 12.1 °C and standard deviation of 0.6 °C. With a P-value of 0.1022 there are no significant differences between the last two normal periods (1951-80 and 1961-90). The 90-year annual maximum minimum temperature was 14.1 °C and occurred in 1927. Sayok (1986) reported that the lowest mean minimum temperature was in 1903 at 10.6 °C however it actually occurred in 1958 and was only 10.7 °C. With a P-value of 0.9525 there are no significant differences between the last two long-term periods (1901-80 and 1901-90). Average minimum temperature data are given in Table 32, and the annual values are plotted over the years in Figure 16. Table 33 provides minimum daily temperatures by month and year.

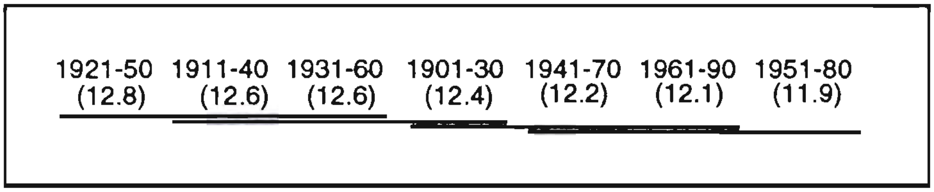


Figure 15. Results of Duncan's multiple range test for seven normal mean minimum temperature periods. Values in parenthesis under each period are the normal mean minimum temperatures in °C.

Frost-free days: Frost-free days are those days for which the minimum daily temperature never equals or drops below 0 °C. Figure 17 shows that differences among the means in the number of frost-free days among normal periods are even greater than those for the minimum temperature and that they correspond very closely to the minimum temperatures. The only real difference is that the seventh (1961-90) and fifth (1941-70) normals have switched places. Even though it appears that the most recent normals are significantly different from the second, third, and fourth normals, the first normal serves to dismiss the significant differences as they might relate to a significant trend.

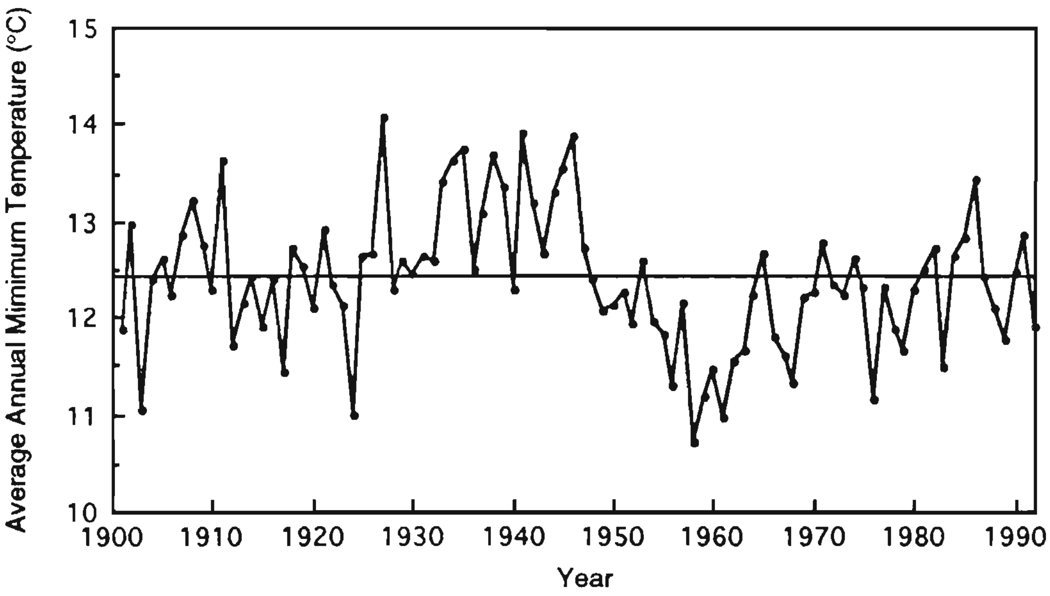


Figure 16. Average annual minimum temperatures (in °C) vs years for Nacogdoches, Texas.

The last ten year period (1980-90) had a minimum of 314 frost-free days and a maximum number of frost-free days of 346 with a mean and standard deviation of 333.9 and 8.4 days, respectively. This is comparable to the last normal period which had a minimum of 308 and a maximum of 346 frost-free days and a mean of 325.9 with a standard deviation of 9.6 days. With a P-value of 0.0854 there are no significant differences between the last two normal periods (1951-80 and 1961-90). The recent long-term period had a maximum of 347 days in both 1939 and 1941. The 90-year minimum was 301 days in 1959. With a P-value of 0.7941 there are no significant differences between the last two long-term periods (1901-80 and 1901-90). Frost-free data are given in Table 34.

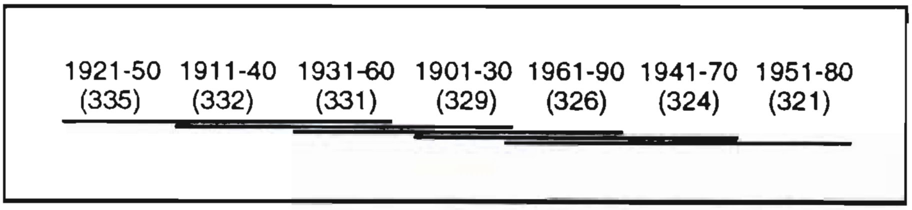


Figure 17. Results of Duncan's multiple range test for seven normal number of frost-free day periods. Values in parenthesis under each period are the normal number of frost-free days.

Growing season: More important than the number of frost-free days is the growing season: a period of time during which no frost (freezing) days occur. Growing seasons are provided in Table 35. It should be noted that the table provides the dates of the last killing frost in the spring and first killing frost in the fall. These dates are one day before and after the season in consideration and not the beginning and ending dates discussed below.

The last decade (1981-90) had a maximum growing season of 291 days beginning on February 14, 1985 and ending on December 1, 1985. A minimum growing season of 191 days began on April 12 and ended on October 19, 1989. With a P-value of 0.6099 there are no significant differences between the last two normal periods (1951-80 and 1961-90). The overall long-term (1901-90) minimum number of days in a growing season was 166 which began on June 1 and continued through November 13 on 1979. The maximum growing season was 291 days in 1985, it lasted from February 12 through December 1. The 90-year average growing season lasted 239 days with a standard deviation of 22 days. The recent long-term average beginning date was March 12 with an average ending date of November 14. With a P-value of 0.9343 there is no significant difference between the last two long-term periods.

Heating degree units: Heating degree units are counted for each degree that the daily mean air temperature drops below a threshold temperature, in this case 18.3 °C. Heating degree units are used by engineers to estimate energy consumption used for heating. In the last ten year period the annual heating degree units ranged from 1490.8 to 1055.8 with a mean of 1229.6 and a standard deviation of 133.3. The last decade differs from the most recent normal period (1961-90) in that the normal ranged from 1537.8 to 1014.4 degree units with a mean of 1253.6 and a standard deviation of 125.6. With a P-value of 0.9276 there is no significant difference between the two normal periods (1951-80 and 1961-90). The 90-year period had extremes of 1537.8 and 863.3 with a mean of 1217.7 and standard deviation of 143.3. With a P-value of .9455 there are no significant differences between the last two long-term periods (1901-80 and 1901-90). The number of heating degree units are given in Table 36 by month and year.

Cooling degree units: Cooling degree units are counted for each degree that the daily mean air temperature exceeds the threshold value of 18.3 °C. Cooling degree units are used by engineers to estimate energy consumption used for cooling. In the last ten year period (1981-90) cooling degree units ranged from 1453.1 to 1131.7 with a mean of 1323.4 and a standard deviation of 96.6. The last decade differs from the last normal period (1961-90) in that the normal annual maximum was 1607.2 cooling degree units and the minimum was 1007.2 cooling degree units with a mean of 1337.6 and standard deviation of 128.4. With a P-value of 0.3318 there is no significant difference between the two normal periods (1951-80 and 1961-90). The 90-year period had extremes of 1607.2 and 973.3 cooling degree units with a mean of 1331.0 and a standard deviation of 119.0. With a P-value of 0.9589 there are no significant differences between the last two long-term periods (1901-80 and 1901-90). The number of cooling degree units are given in Table 37 by month and year.

Table 12. Comparison of All Relevant Temperature Data for the Last Two Normal Periods and the Last Two Long-term Periods

		Normals			Long-term Averages		
		1951-80	1961-90	P-value	1901-80	1901-90	P-value
Mean Temp. (°C)							
	mean	18.6	18.5	0.5576	18.6	18.6	0.9457
	s.d.	0.5	0.5		0.6	0.6	
	max	19.4	19.4		19.7	19.7	
	min	17.5	17.5		17.2	17.2	
Maximum Temp. (°C)							
	mean	25.3	24.9	0.0842	24.8	24.8	0.9019
	s.d.	0.9	0.8		1.0	1.0	
	max	27.5	26.3		27.5	27.5	
	min	23.4	23.1		22.8	22.8	
Hot Days (days)							
	mean	103	93.5	0.0669	91.6	91.3	0.9118
	s.d.	20.6	18.6		21.4	20.7	
	max	145	140		145	145	
	min	62	62		44	44	
Minimum Temp. (°C)							
	mean	11.9	12.1	0.1022	12.4	12.4	0.9525
	s.d.	0.5	0.6		0.7	0.7	
	max	12.8	13.4		14.1	14.1	
	min	10.7	11.0		10.7	10.7	
Frost-free Days (days)							
	mean	321.2	325.9	0.0854	328.0	328.4	0.7941
	s.d.	11.1	9.6		10.9	10.7	
	max	342	346		347	347	
	min	301	308		301	301	
Growing Season (days)							
	mean	232.6	235.5	0.6099	238	239.1	0.9343
	s.d.	20.8	23.9		20.6	21.2	
	max	271	291		290	291	
	min	166	166		166	166	

Table 12. Continued

	Normals			Long-term Averages		
	1951-80	1961-90	P-value	1901-80	1901-90	P-value
Heating Degree Units (°C)						
mean	1256.5	1253.6	0.9276	1216.2	101.5	0.9455
s.d.	126.0	125.6		143.3	141.5	
max	1537.8	1537.8		1537.8	1537.8	
min	1014.4	1014.4		863.3	863.3	
Cooling Degree Units (°C)						
mean	1370.4	1337.6	0.3318	1332.0	1331.0	0.9589
s.d.	130.9	128.4		1122.0	119.0	
max	1607.2	1607.2		1607.2	1607.2	
min	1007.2	1007.2		973.3	973.3	

Climate Fluctuation at Nacogdoches, Texas

The year to year fluctuations of selected climatic variables are reviewed through a plot of their autocorrelation coefficients versus lags zero to 30: these plots are called correlograms. Random processes are revealed by autocorrelation coefficients for all lags being not significantly different form zero. If any lag, k, is significantly different form zero then there may be some non-random process occurring in the data.

Figure 18 clearly reveals that lag two of the annual precipitation series is significantly different from zero at α=0.05. This suggests a tendency of a four year cycle in the annual precipitation. Aguilar (1979) also reported a four year cycle in annual precipitation for Nacogdoches while conducting a similar study using 50 years of data (1921-70) at Nacogdoches. Aguilar (1979) took his study one step farther utilizing spectral analysis and stated that the non-randomness was likely to follow a four year cycle but was not strong enough to be conclusive.

Figure 19 reveals that lag one and two of the annual rain day series are significantly different from zero at α=0.05. In other words there may be some non-randomness in the rainday data. However, by observing the gradual fading out of the autocorrelation coefficients at higher lags, it is not likely that there is a periodic cycle confined in the data series. It may be indicated that a year with a great number of raindays is likely to be followed by a year with a great number of raindays, the so-called autoregression function.

None of the autocorrelation coefficients for the annual mean temperature data are significantly different from zero at α=0.05 (Figure 20). This implies that the data are random with no clear pattern confined in the series.

Figures 17 to 20 reveal that the first few lags of the autocorrelation coefficients are significantly different form zero at α=0.05. They indicate some non-randomness in the annual maximum temperature, annual number of hot days, the annual minimum temperature, and the annual number of frost-free day data series. The patterns of these correlograms are similar to that of the rain day data series Farther investigation by spectral analysis is definitely warranted to define any trends that may be confined in the data.

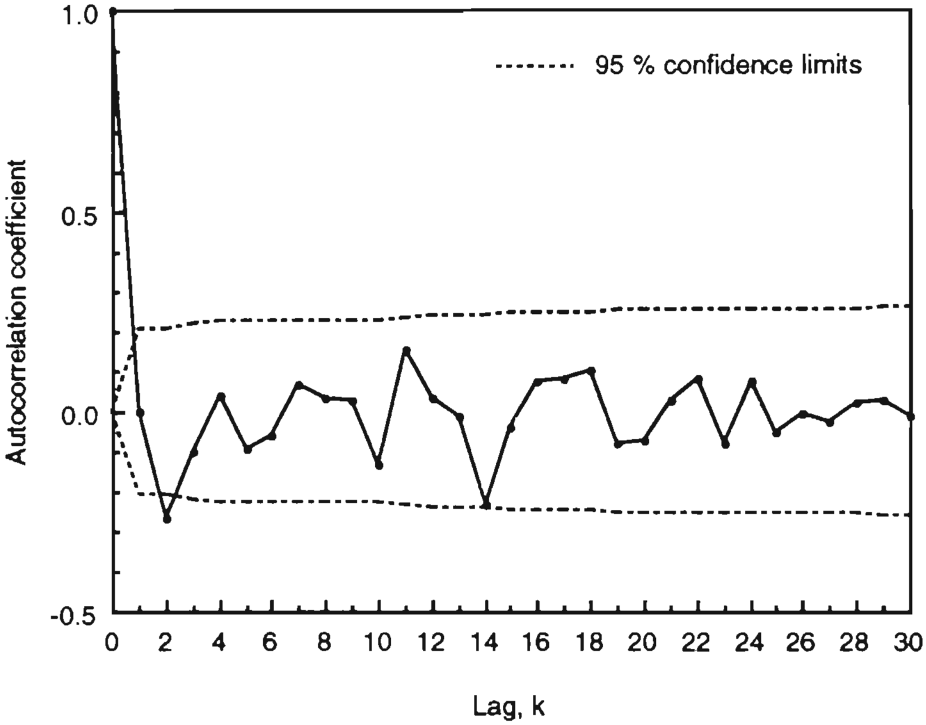


Figure 18. The correlogram of annual precipitation at Nacogdoches, Texas.

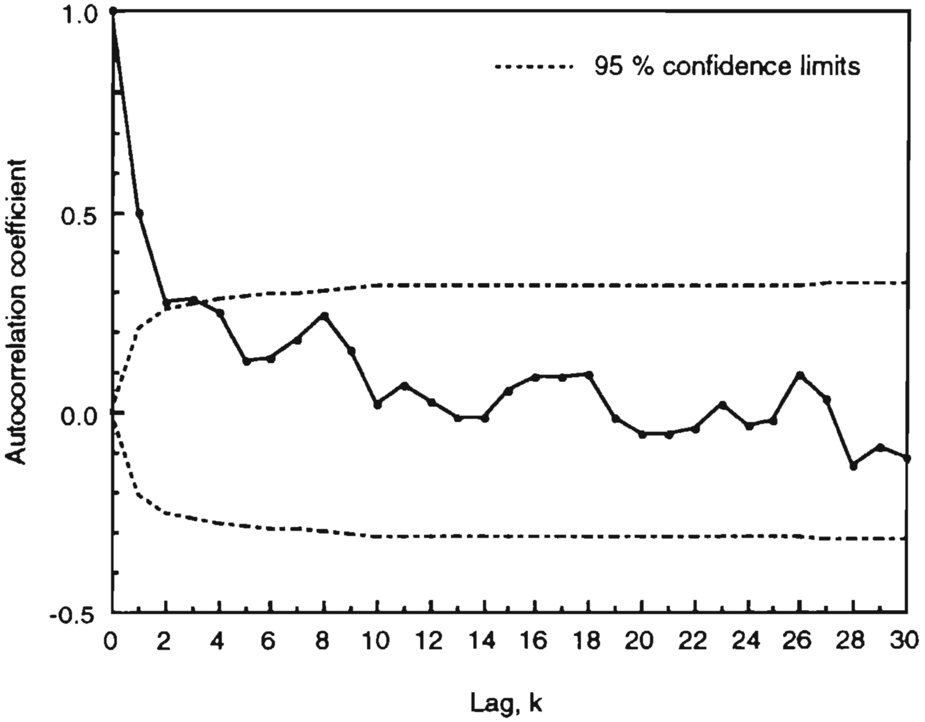


Figure 19. The correlogram of annual number of raindays at Nacogdoches, Texas.

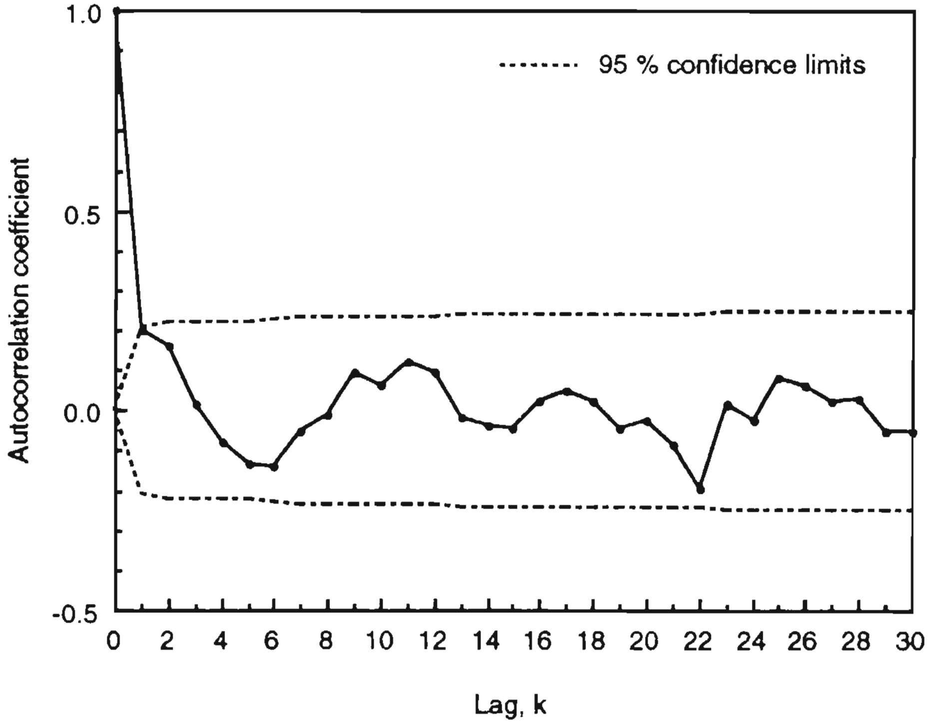


Figure 20. The correlogram of annual mean temperature at Nacogdoches, Texas.

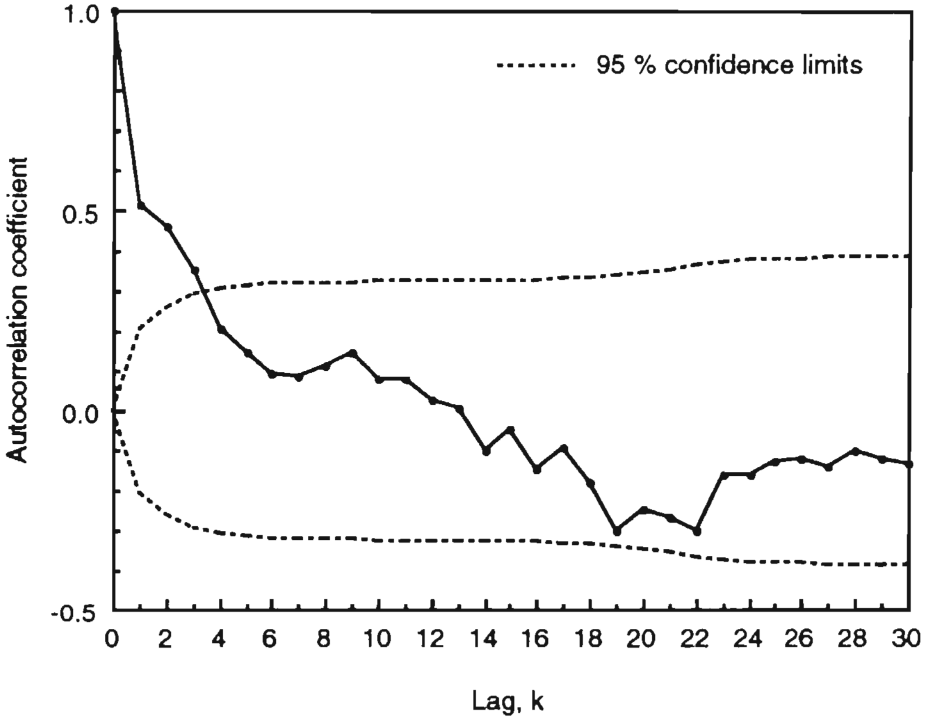


Figure 21. The correlogram of annual mean maximum temperature at Nacogdoches, Texas.

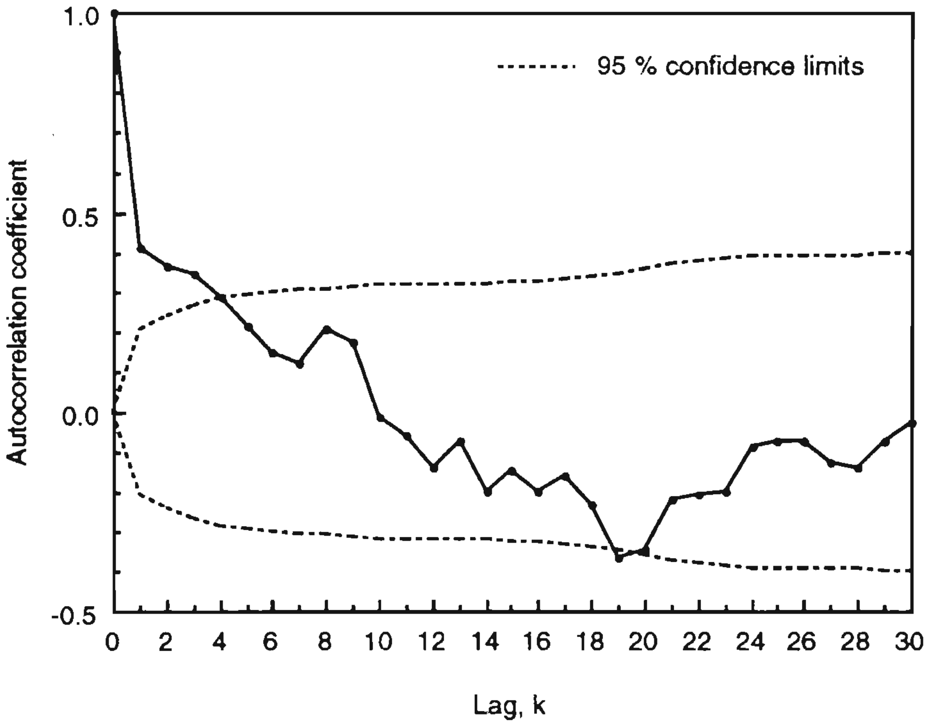


Figure 22. The correlogram of annual number of hot days at Nacogdoches, Texas.

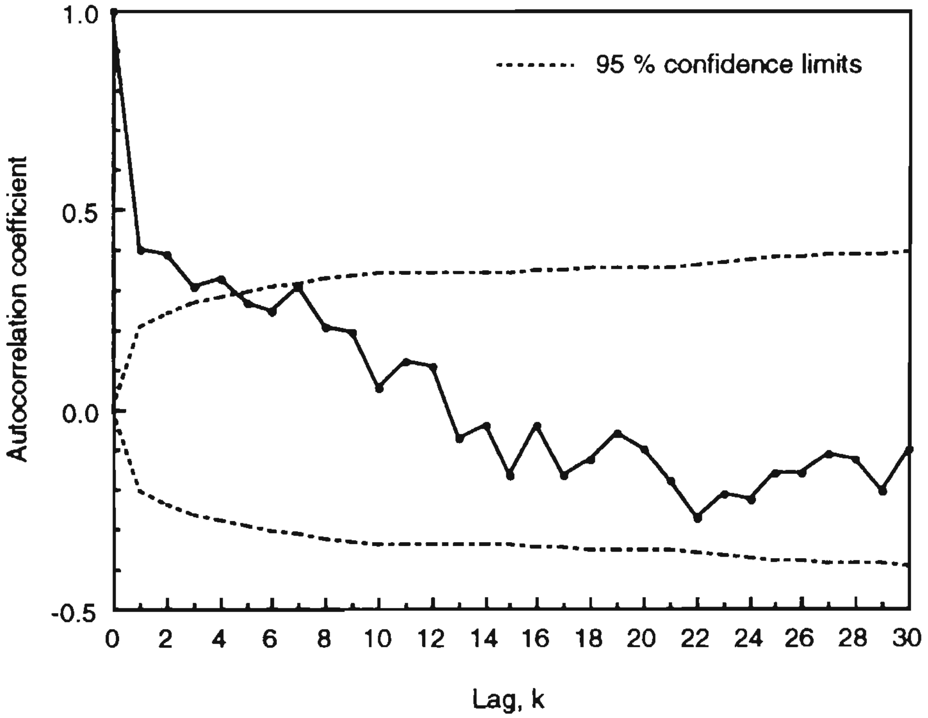


Figure 23. The correlogram of annual mean minimum temperature at Nacogdoches, Texas.

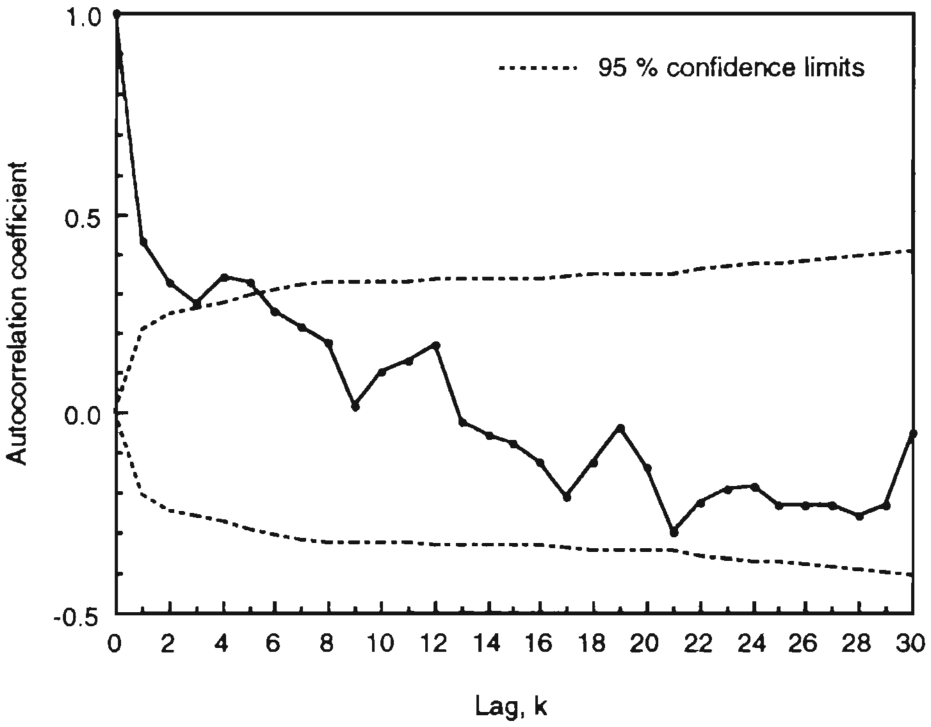


Figure 24. The correlogram of annual number of frost-free days at Nacogdoches, Texas.

Streamflow

All relevant streamflow data are given in Appendix III. Table 38 provides monthly and annual total streamflow in cubic meters per second (cms) while Table 39 provides total monthly and annual streamflow in centimeters (cm). Table 40 provides the maximum monthly and annual stream flow data in cms for La Nana Creek, Nacogdoches, Texas.

Daily streamflow duration

Table 13 provides the necessary data to construct the flow duration curve given in Figure 25, including the distribution of flow classes, frequency of occurrence, and percent of time that the class is equaled or exceeded. The curve shows that the median flow of La Nana Creek is about 0.19 cms and that 20 percent of the time the daily streamflow is 0.9 cms or greater. Construction of these curves destroys the logical or chronological sequence of events. The flow distribution in each year is given in Table 14 where the number of days of occurrence is given by flow class.

The mean daily streamflow of La Nana Creek is 0.92 cms, about 0.23 cms greater than the median flow. The maximum daily streamflow ever recorded in 23 years was 162.2 cms and there were 337 days having daily streamflow equal to or greater than 0.15 cms.

Compared to the flow duration of 1964-84 analyzed by Sayok (1989), there seems to be a greater frequency of lower flows viz. those in flow classes of 16 or less. Interpretation of the flow duration curve reveals that the larger flows, namely those equaled or exceeded 20 percent of the time have remained about the same in volume with the additional five years of flow data at 0.90 cms; compared to 0.93 cms reported by Sayok (1986). The flows equaled or exceeded 50 percent of the time have not changed much either. They have increased from 0.11 cms as reported by Sayok (1986) to 0.18 cms. The lesser volumes equaled or exceeded 90 percent of the time have remained very close to the same at about 0.003 cms.

Table 13. Duration Table of Daily Discharge, Water Years 1965-91, for La Nana Creek, Nacogdoches, Texas

Class	Daily Streamflow (cms)	Total Number of Days		% of Time ≥
		Observed	Accumulated	
0	0.000-0.0029	852	9130	100.0
1	0.003-0.0059	375	8278	90.7
2	0.006-0.0089	267	7903	86.6
3	0.009-0.0149	430	7636	83.6
4	0.015-0.019	253	7206	78.9
5	0.020-0.029	419	6953	76.2
6	0.030-0.039	334	6534	71.6
7	0.040-0.059	458	6200	67.9
8	0.060-0.089	447	5742	62.9
9	0.090-0.149	580	5295	60.0
10	0.150-0.199	337	4715	51.6
11	0.200-0.299	554	4378	48.0
12	0.300-0.399	514	3824	41.9
13	0.400-0.599	779	3310	36.3
14	0.600-0.899	782	2531	27.7
15	0.900-1.499	763	1749	19.2
16	1.500-1.999	259	986	10.8
17	2.000-2.999	244	727	8.0
18	3.000-3.999	94	483	5.3
19	4.000-5.999	138	389	4.3
20	6.000-8.999	88	251	2.7
21	9.000-14.99	82	163	1.8
22	15.000-19.99	25	81	0.9
23	20.000-29.99	33	56	0.6
24	30.000-39.99	14	23	0.3
25	40.000-59.99	5	9	0.1
26	60.000-89.99	2	4	< 0.0
27	90.000-149.99	1	2	< 0.0
28	≥ 150.000	1	1	< 0.0

(Water years 1987-88 are missing)

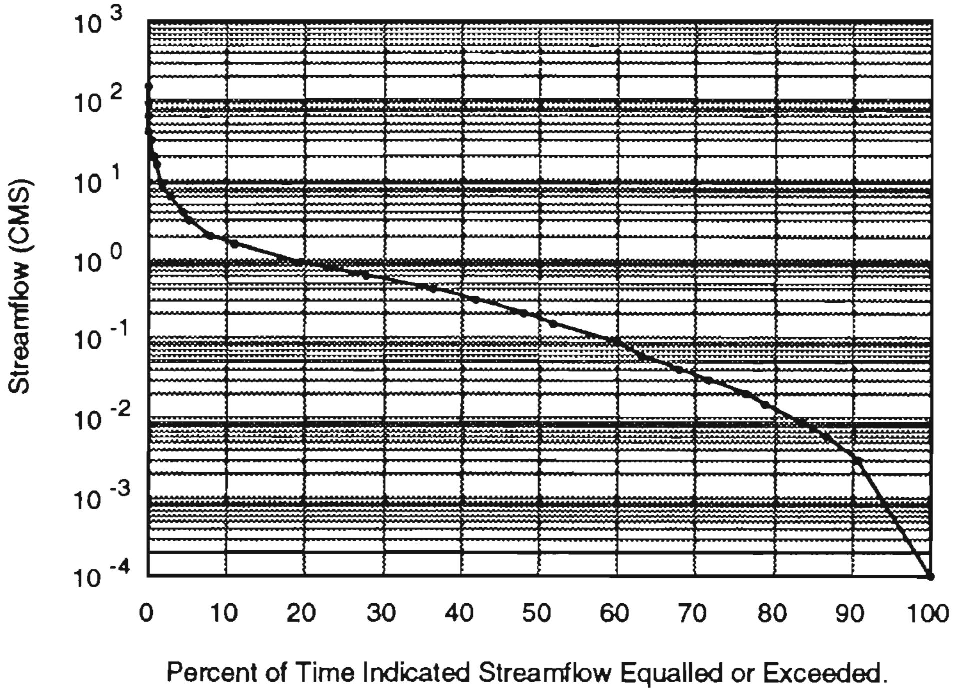


Figure 25. Streamflow duration curve for La Nana Creek, Nacogdoches, Texas, for water years 1965-91.

Table 14. Frequency (days) of daily discharge (cms), by Class and Year for La Nana Creek, Nacogdoches, Texas

Year	Classes of Daily Discharge†																												
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1964	64	7	6	8	1	0	2	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	100	9	20	21	13	5	1	5	14	23	12	26	22	24	20	25	5	6	4	2	6	1	0	1	0	0	0	0	0
1966	29	9	9	27	21	19	18	19	11	20	21	17	15	30	32	34	8	11	3	3	2	3	3	0	1	0	0	0	0
1967	150	12	4	10	7	8	7	17	45	39	24	16	9	6	2	5	0	1	1	0	2	0	0	0	0	0	0	0	0
1968	0	0	0	0	2	4	7	20	21	29	15	23	49	39	37	45	20	22	2	13	6	5	3	2	1	1	0	0	0
1969	66	14	17	39	11	13	10	7	9	9	5	8	7	12	29	52	12	16	6	7	3	6	3	3	1	0	0	0	0
1970	92	14	5	22	17	20	7	22	16	35	14	24	18	22	15	12	4	2	1	3	0	0	0	0	0	0	0	0	0
1971	130	17	6	28	8	21	30	40	18	13	4	18	12	7	4	5	1	2	1	0	0	0	0	0	0	0	0	0	0
1972	4	35	25	19	6	11	15	14	15	29	11	28	33	26	38	27	6	7	6	3	5	3	0	0	0	0	0	0	0
1973	0	0	0	0	2	3	12	9	9	28	19	21	20	31	59	61	23	22	12	14	7	6	1	5	1	0	0	0	0
1974	10	11	14	17	12	6	11	25	13	20	20	18	21	33	42	48	15	9	4	6	3	5	0	1	0	1	0	0	0
1975	0	0	0	0	0	17	28	20	52	24	12	14	15	42	49	49	12	12	5	3	3	4	2	1	0	0	0	1	0
1976	0	9	12	33	17	18	7	9	10	26	20	55	44	48	20	15	8	3	4	5	3	0	0	0	0	0	0	0	0
1977	17	81	13	14	10	37	14	13	8	9	5	11	15	46	34	25	5	2	0	0	3	3	0	0	0	0	0	0	0
1978	125	8	7	9	9	16	16	11	9	13	13	13	21	30	22	21	7	4	2	4	4	1	0	0	0	0	0	0	0
1979	0	6	13	20	11	14	8	15	15	16	10	27	9	19	39	46	24	18	7	18	6	13	3	3	2	1	1	0	1
1980	28	29	31	26	8	11	22	24	9	14	9	15	16	42	29	24	5	11	0	6	1	3	0	2	1	0	0	0	0
1981	13	6	9	10	11	25	21	47	37	38	21	51	23	16	13	4	6	5	4	2	1	1	0	1	0	0	0	0	0
1982	2	29	5	6	7	7	6	11	29	38	7	21	40	52	28	21	15	13	4	9	5	3	3	2	1	1	0	0	0
1983	0	0	4	26	15	24	12	14	8	29	15	21	11	45	49	49	12	7	3	8	5	3	1	3	1	0	0	0	0
1984	1	17	27	14	9	21	12	23	9	19	5	5	7	53	54	51	15	9	4	3	5	1	1	1	0	0	0	0	0
1985	0	18	8	17	8	33	6	13	9	11	7	13	11	43	53	58	19	10	7	7	4	5	1	1	0	1	0	0	0

Table 14. Continued

	Classes of Daily Discharge†																												
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1986	0	0	0	0	0	14	16	16	28	28	14	39	30	28	22	15	7	7	3	2	2	0	0	1	0	0	1	0	0
*1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*1988	5	16	0	2	0	9	5	16	15	8	3	2	3	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	6	18	29	21	22	14	8	12	28	26	31	27	27	28	21	9	14	5	5	2	8	1	1	2	0	0	0	0
1990	16	22	14	31	26	33	9	20	15	12	11	19	20	27	25	20	11	15	3	3	4	4	1	3	1	0	0	0	0
1991	0	0	0	2	1	8	18	19	11	21	13	17	16	29	35	28	10	16	3	10	6	4	2	2	2	0	0	0	0

* Water years 1987-88 data are missing.

† Streamflow in each flow class are given in Table 10.

Annual streamflows

The mean and standard deviation of annual streamflow over the entire period (1964-90) were 35.7 cm and 23.3 cm, respectively. The fluctuation of the annual streamflow is plotted in Figure 26. Total monthly and annual streamflow data in cms are given in Table 38. Table 39 provides the same data however they have been converted to cm for the watershed. The maximum and minimum annual flows did not change the extremes reported by Sayok (1986) with the addition of four more years of data. Figure 27 is a plot of the accumulated streamflow vs accumulated precipitation. The additional years of data appear to be similar to those reported by Sayok (1986) and are consistent since 1981. Even though the trend since 1981 looks consistent, caution should be used in making inferences due to the three missing years.

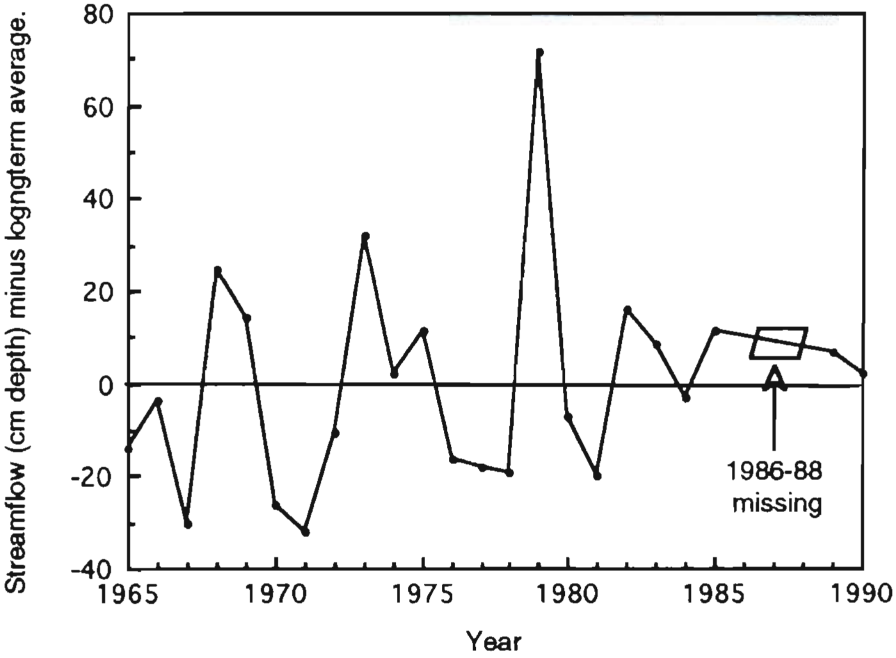


Figure 26. Fluctuation of streamflow (cm) minus long-term average versus year. Calendar years 1986-88 were excluded due to missing streamflow data.

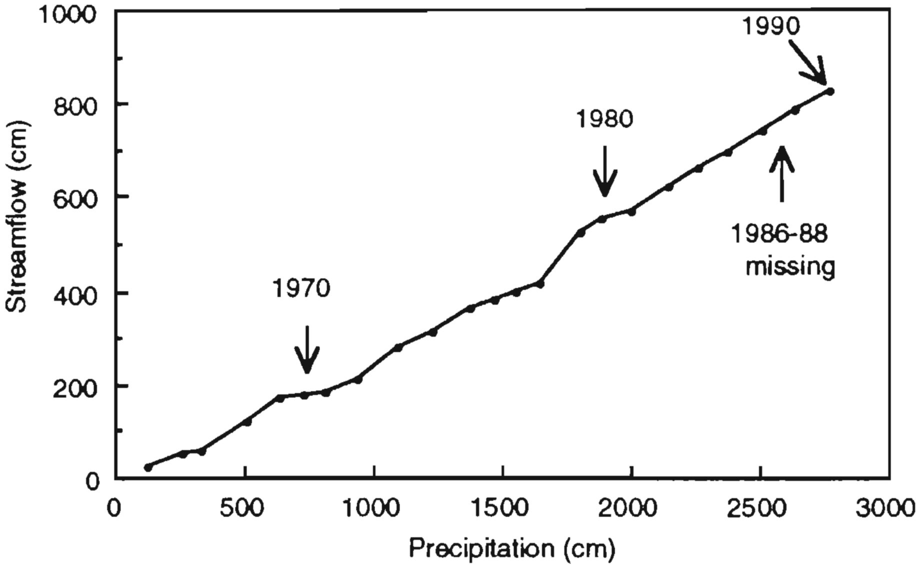


Figure 27 Accumulated annual streamflow versus accumulated annual precipitation, 1965-90 (1986-88, missing) for La Nana Creek, Nacogdoches, Texas.

Probability of occurrence of annual total streamflow

Annual total streamflow values were investigated for independence using autocorrelation coefficient and resulted in lag one having a value of -0.101, lag two had -0.106, lag three had -0.121, and lag four had -0.061. These auto correlation coefficients are small and indicate that the data are independent. Using the Kolmogorof-Smirnov goodness of fit test it was shown that the annual total streamflow values given in Table 38 fit the Gumbel distribution as well as the Lognormal distribution.

For the test statistic of the Gumbel distribution the maximum deviation is 0.110, well outside the rejection region of 0.275 at α =0.05. We therefore fail to reject the null hypothesis and state that the data are adequately described by the Gumbel distribution. For the test statistic of the Lognormal distribution the maximum deviation is 0.080 well outside the rejection region of 0.275 at α =0.05. We therefore fail to reject the null hypothesis and state that the data are adequately described by the Lognormal distribution (Figure 28). However since the test statistic is smaller for the Lognormal distribution it was chosen as the best fit.

It should be noted that the Log-Pearson type III distribution was also investigated. The test statistic for the Log-Pearson type III distribution was 1.800 which is inside the rejection region of 0.275 at α=.05. We therefore reject our null hypothesis and state that the data do not fit the Log-Pearson type III distribution.

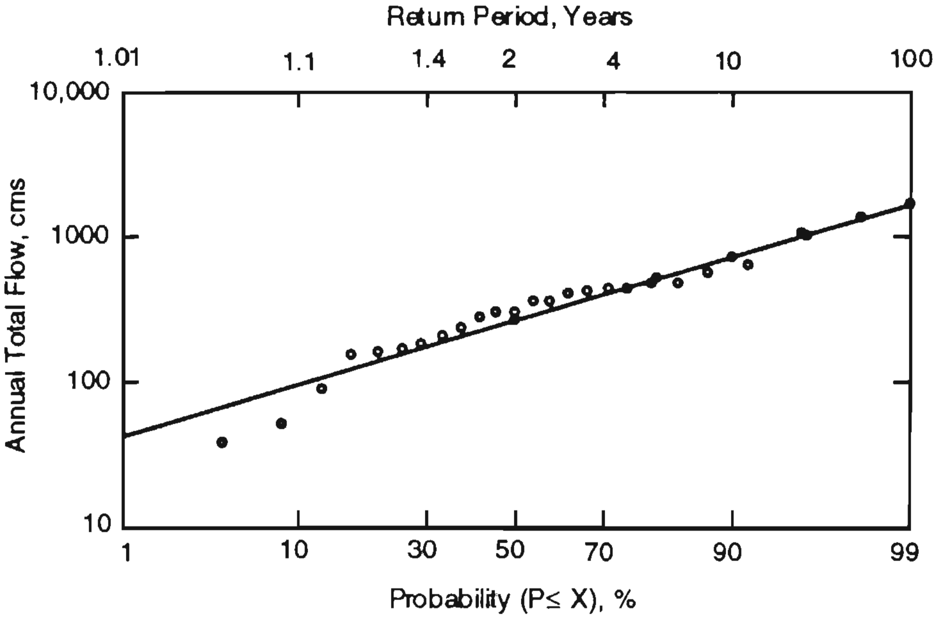


Figure 28. Annual total streamflow (1964-91) as fitted by the Lognormal distribution for La Nana Creek, Nacogdoches, Texas.

Table 15 provides the predicted annual total flows as fitted by the Lognormal distribution. These figures become useful for engineering applications.

Table 15. Predicted Annual Total Flows (cms) by the Lognormal Distribution

Return Period, in Years	2	5	10	25	50	100
Annual Flows (cms)	262.59	509.59	720.80	1043.94	1332.84	1648.88

Probability of occurrence of extreme daily streamflow

Annual extreme daily streamflow values were investigated for independence using autocorrelation coefficients and resulted in lag one having a value of -0.089, lag two had -0.089, lag three had -0.091, and lag four had -0.086. These auto correlation coefficients are small and indicate that the data are independent. It was shown that the annual extreme daily streamflow values given in Table 40 fit the Log-Pearson type III distribution as well as the Lognormal distribution by using the Kolmogorof-Smirnov goodness of fit test.

For the test statistic of the Log-Pearson type III distribution the maximum deviation is 0.240, outside the rejection region of 0.275 at α =0.05. We therefore fail to reject the null hypothesis and state that the data are adequately described by the Log-Pearson type III distribution. For the test statistic of the Lognormal distribution the maximum deviation is 0.255, outside the rejection region of 0.275 at α =0.05. We therefore fail to reject the null hypothesis and state that the data are adequately described by the Lognormal distribution. However since the test statistic is smaller for the Log-Pearson type III it was chosen as the best fit (Figure 29).

It should be noted that the Gumbel distribution was also investigated. The Kolmogorof-Smirnov test statistic for the Gumbel distribution was 0.310 which is inside the rejection region of 0.275 at α=.05. We therefore reject our null hypothesis and state that the data do not fit the Gumbel distribution. Table 16 provides the predicted daily extreme flows as fitted by the Log-Pearson type III distribution. As previously mentioned these figures become useful for engineers trying to make long-term plans. These figures are used in determining the seasonal variation in flows discussed later.

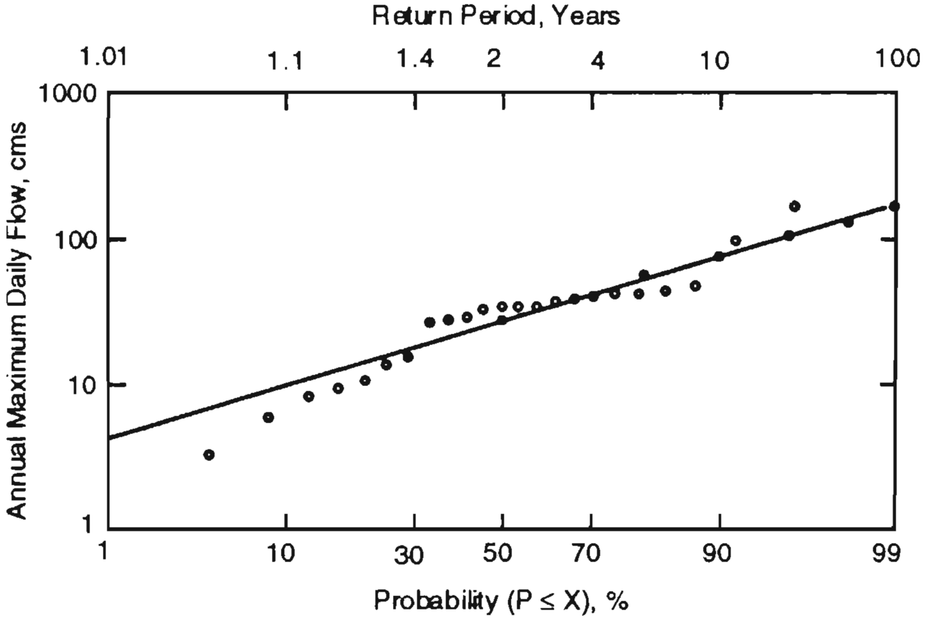


Figure 29. Annual extreme daily streamflow (1964-91) as fitted by the Log-Pearson type III distribution for La Nana Creek, Nacogdoches, Texas.

Table 16. Predicted Extreme Daily Flows (cms) by the Log-Pearson type III Distribution

Month	Return Period, in Years					
	2	5	10	25	50	100
Jan	6.226	8.858	34.328	53.487	68.175	82.410
Feb	7.415	18.961	30.960	52.242	73.240	99.191
Mar	4.839	15.339	26.234	44.290	60.590	79.042
Apr	4.415	17.744	35.545	72.929	114.558	170.394
May	7.245	22.668	40.667	75.136	111.077	157.178
Jun	3.311	16.640	39.478	100.635	185.308	322.988
Jul	0.962	4.952	10.895	23.829	38.403	65.854
Aug	0.283	1.047	1.953	3.764	5.660	8.122
Sep	0.679	3.877	8.886	20.235	33.422	58.921
Oct	0.764	4.443	8.631	14.801	19.301	23.376
Nov	2.038	11.858	22.923	39.111	50.940	61.637
Dec	2.405	9.962	20.291	42.337	67.213	100.889
Annual	26.376	54.987	78.051	110.681	136.887	174.073

Seasonal variation in extreme daily streamflow

Figure 30 is a graphical representation of the seasonal variation in probability of annual maximum daily streamflows occurring in each month. The data used are obtained by comparing the theoretical monthly distributions, obtained above, to the annual theoretical values. For example, there is only a one percent probability that the annual value of a 25 year maximum daily flow will occur in February while the chance that the two-year extreme flow occurring in November would be five percent.

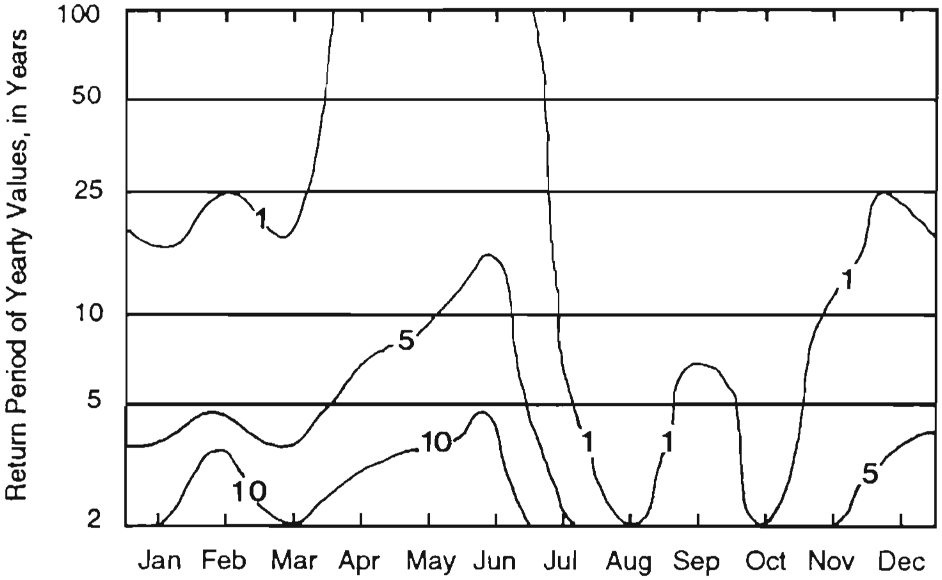


Figure 30. Seasonal probability of extreme daily flow in percent of obtaining a given magnitude in any month of a particular year equal to or exceeding the yearly return period values.

Probability of occurrence of instantaneous peakflows

Annual instantaneous peakflow values were investigated for independence using autocorrelation and resulted in lag one having a value of -0.153, lag two had -0.157, lag three had -0.170, and lag four had -0.138. These auto correlation coefficients are small and indicate that the data are independent. It was shown that the annual instantaneous peakflow values given in Table 17 fit the Log-Pearson type III distribution as well as the Lognormal distribution by using the Kolmogorof-Smirnov goodness of fit test (Figure 31).

For the Kolmogorof-Smirnov test statistic of the Log-Pearson type III distribution the maximum deviation is 0.160, well outside the rejection region of 0.254 at α =0.05. We therefore fail to reject the null hypothesis and state that the data are adequately described by the Log-Pearson type III distribution. For the test statistic of the Lognormal distribution the maximum deviation is 0.123, well outside the rejection region of 0.254 at α =0.05. We therefore fail to reject the null hypothesis and state that the data are adequately described by the Lognormal distribution. However since the test statistic is smaller for the Lognormal it was chosen as the best fit.

It should be noted that the Gumbel distribution was also investigated. The Kolmogorof-Smirnov test statistic for the Gumbel distribution was 0.193 which is also outside the rejection region of 0.254 at α=.05. We therefore fail to reject our null hypothesis and state that the data do adequately fit the Gumbel distribution, however since the Gumbel test statistic is greater than the Lognormal test statistic, the Gumbel distribution will not be used. Table 17 provides the predicted annual instantaneous peakflows as fitted to the Lognormal distribution. Again, these figures are useful for engineering applications.

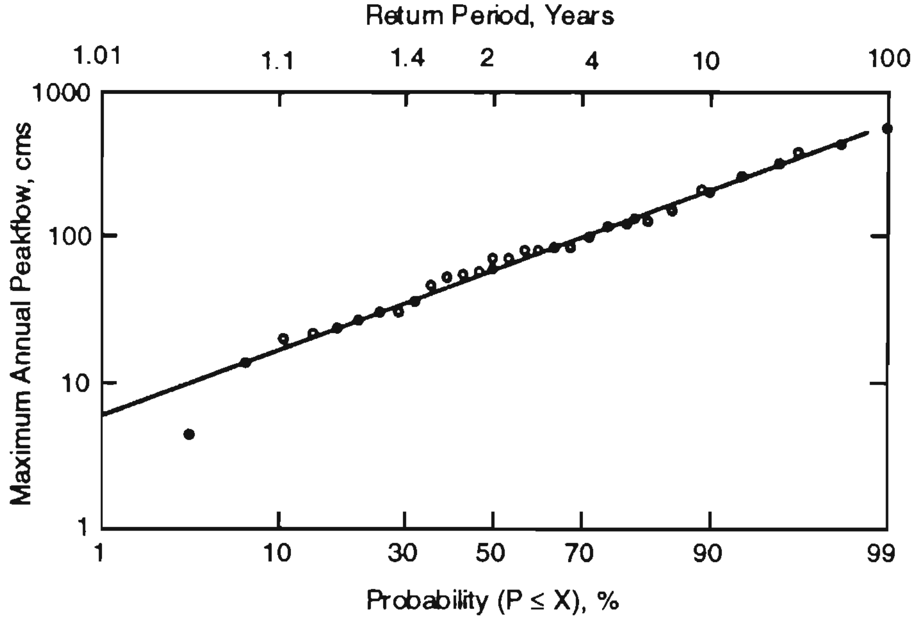


Figure 31. Annual instantaneous peakflows (1964-91) as fitted by the Lognormal distribution for La Nana Creek, Nacogdoches, Texas.

Table 17. Predicted Annual Instantaneous Peakflow (cms) by the Lognormal Distribution

Return Period, in Years	2	5	10	25	50	100
Peakflow, cms	57.69	133.22	199.54	314.82	425.39	552.80

Table 18. Maximum Instantaneous Peakflow for La Nana Creek, Nacogdoches, Texas 1965-92

Year	Date	Peakflow (cms)	Height (meters)
1965	Mar 30	50.94	4.91
1966	Apr 25	77.82	5.23
1967	Jun 2	21.06	3.85
1968	Apr 2	79.52	5.24
1969	May 7	81.22	5.26
1970	May 3	13.36	3.13
1971	Sep 22	4.30	2.55
1972	Jul 4	23.04	4.02
1973	Mar 24	70.75	5.03
1974	Jan 24	55.75	4.77
1975	Feb 1	254.70	6.03
1976	Jul 5	20.01	2.88
1977	Mar 3	26.94	3.46
1978	Apr 17	29.43	3.66
1979	Jun 2	382.05	6.74
1980	May 16	82.92	5.22
1981	Sep 1	69.34	5.22
1982	Apr 17	98.20	5.33
1983	May 21	54.34	4.82
1984	Dec 11	122.54	5.48
1985	Apr 21	45.85	4.61
1986	Jun 9	209.42	5.94
1987		missing	
1988		missing	
1989	May 18	127.63	5.44
1990	May 31	149.71	5.60
1991	May 13	113.48	5.33

Probability of wet year vs dry year

In this study any year with its annual streamflow greater than the long-term average is considered a wet year, otherwise it is a dry year. The probability of a wet year or dry year may be estimated by a binomial distribution.

In order to verify assumptions underlying the binomial distribution, it must be shown that the annual streamflow data are independent. Using the autocorrelation coefficients we obtain the following values of -0.009 for lag one, -0.105 for lag two, -0.121 for lag three, and -0.061 for lag four. These values are small, indicating that one year's streamflow is not dependent on another year's streamflow.

Utilizing the binomial distribution given by:

$$P(y) = \frac{n!}{y!(n-y)!} p^y (1-p)^{n-y}$$

where :

n = number of years

p = probability of success (wet or dry year) on a single trial

1 - p = probability of failure (wet or dry year) on single trial

y = number of successes (wet or dry year) in n trials

n! = n(n - 1)(n - 2) ...(3)(2)(1) in years

Since there were 11 wet years in a total of 23 years, p is assumed to be 0.478. If p = 0.478 it is further assumed to be true that in each trial (year), that there is a

$$\binom{3}{2} (0.478)^2 (1\text{-}0.478)$$

or a 36 percent chance that two out of three years will be wet, but we do not know which two of the three it will be. It can also be estimated that there is $(0.4789)^2$ (1-0.478) or a 12 percent chance that the first two, or last two, consecutive years of three will be wet and the chance that all three years will be wet is $(0.478)^3$ $(1\text{-}0.478)^0$ or 11 percent. We can also state that there is a

$$\binom{3}{2}(1-0.478)^2\,(0.478)$$

or a 39 percent chance that two of three years will be dry however we still do not know their sequence. The chance that the first two or last two consecutive years of the three will be dry is $(1-0.478)^2\,(0.478)$ or 13 percent and the chance that all three years will be dry is $(1-0.478)^3\,(0.478)^0$ or 14 percent. There is a slightly higher probability for a dry year to occur than there is for a wet year.

The probability p of a wet year given that the previous year was wet is P (W/W) = 5/11 or p = 0.4545. The probability q of a dry year given that the previous year was dry is P (D/D) =7/12 or q = 0.5833. Using the conditional probability function, the probability of a dry spell p_r (n) of length n = 3 is p_r (3) = 0.5833^{2} (1-0.5833) or 14 percent and the probability of a wet spell p_r (m)of length m = 3 is p_r (3) = 0.4545^{2} (1-0.4545) or 11 percent. These and probabilities of other durations are compared to the observed data in Figures 32 and 33.

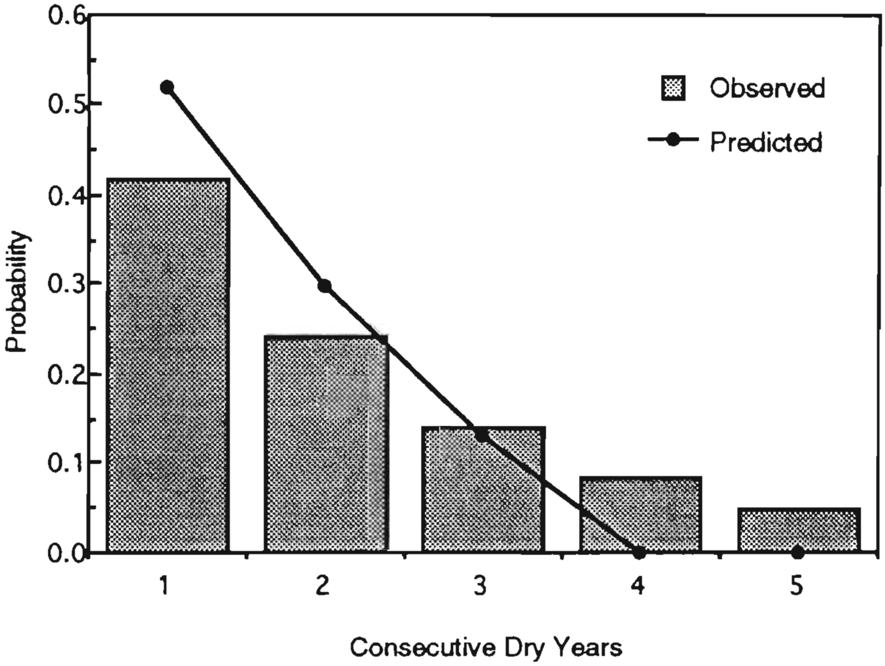


Figure 32. Conditional probability for consecutive dry years at Nacogdoches, Texas.

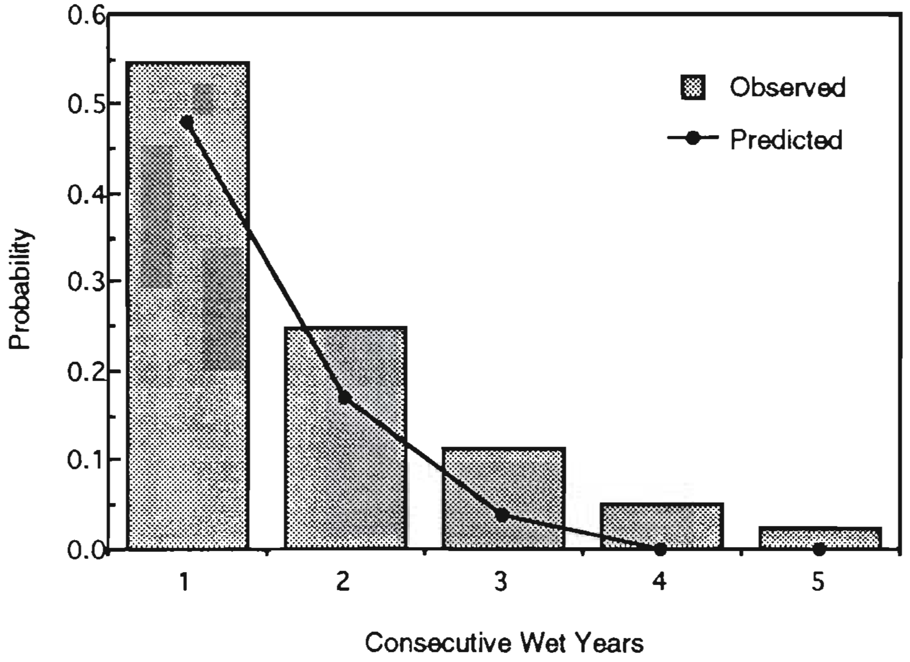


Figure 33. Conditional probability for consecutive wet years at Nacogdoches, Texas.

Utilizing the conditional probability function we obtain the following. The probability of experiencing a dry year following consecutive dry years of length zero through four is 42, 24, 14, 8, and 5 percent, respectively. In other words, any given year has a 42 percent chance of being dry, however the chance of a dry year following a dry year is 24 percent and the chance of a dry year following two consecutive dry years is 14 percent. The probability of receiving a wet year following consecutive wet years of length zero through four is 54, 25, 11, 5, and 2 percent, respectively. In other words, any given year has a 54 percent chance of being wet, however the chance of a wet year following a wet year is 25 percent and the chance of a wet year following two consecutive wet years is 11 percent.

Tornadoes

Looking at the entire period of record (1953-90) for Nacogdoches, Texas, there was only one year that had as many as four reported tornadoes, two occurred on the same day in February and two occurred on different days of May. May of 1989 was the only month having three tornadoes occur on a single day. There were 21 years during which no tornadoes were reported and ten years during which only one tornado was reported. Two tornadoes were reported during each of six different years. Dates for tornado occurrences are given in Table 19.

May had the greatest number of occurrences during the entire period of record, with ten tornadoes reported. May was followed by February which received five tornadoes; November is in third place with four occurrences. June, July and October were the only months which received no tornadoes. Wolford (1960) reported that for Texas, during the entire period of record, April 30 was the day with the most tornadoes followed by May 20. Nacogdoches, during the entire period of record, experienced eight tornadoes from May 10-20. August and September only received one tornado during the entire period of record. June through October could be considered a relatively tornado free period in Nacogdoches; even though June 6 was the day which received the fourth greatest number of occurrences in the State. This is probably explained by the fact that the height of tornado activity has moved northward and out of East Texas by June.

Table 19. Dates of Occurrence of Tornadoes in Nacogdoches County, Texas 1953-91

1-in-a-year	2-in-a-year	3-in-a-year	4-in-a-year
1953	1961	1989	1990
Feb 19	Mar 27	May 17	Feb 2
1954	Nov 22	May 17	Feb 2
Apr 30	1965	May 17	May 3
1968	Feb 11		May 12
Dec 27	Feb 11		
1979	1971		
Nov 21	May 10		
1980	May 10		
Mar 17	1976		
1982	Jan 25		
Apr 19	May 31		
1983	1978		
Dec 10	Sep 11		
1986	Nov 26		
Aug 30	1981		
1987	May 18		
Jan 1	May 18		
1991			
Nov 11			

Five o'clock p.m. was the hour during which most tornadoes occurred; two occurred on the same day in May, three occurred in February and two of those on the same day. Three tornadoes occurred during each of the following hours, 8:00 a.m., 10:00 a.m., 4:00 p.m., and 8:00 p.m. The three that occurred at four o'clock all occurred on the same day (May 17, 1989). The hours of one, two and three o'clock p.m. each received two tornadoes. One tornado was reported for each hour of five, nine, and eleven o'clock a.m. and nine and eleven o'clock p.m. Table 20 gives the number of tornado occurrences during each hour of the day.

Table 20. Occurrence of Tornadoes in Nacogdoches County by Hour of the Day

Time	Number of Occurrences	Time	Number of Occurrences
2:00 a.m.	1	1:00 p.m.	2
3:00 a.m.	0	2:00 p.m.	2
4:00 a.m.	0	3:00 p.m.	2
5:00 a.m.	1	4:00 p.m.	3
6:00 a.m.	1	5:00 p.m.	5
7:00 a.m.	0	6:00 p.m.	0
8:00 a.m.	3	7:00 p.m.	0
9:00 a.m.	1	8:00 p.m.	3
10:00 a.m.	3	9:00 p.m.	1
11:00 a.m.	1	10:00 p.m.	0
12:00 p.m.	0	11:00 p.m.	1

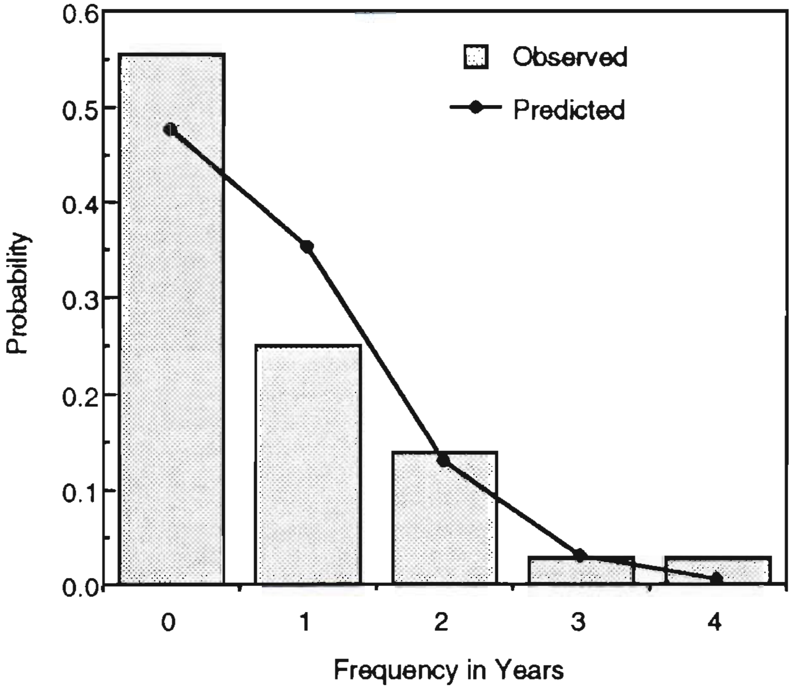


Figure 34. Poisson probability for frequency of tornado occurrence in Nacogdoches County.

Utilizing the Poisson distribution, the prediction equation is given by:

$$P(y) = \frac{0.737^{y} 2.718^{-0.737}}{y!}$$

where:

y = the number of tornadoes occurring in a year

y! = y(y - 1)(y - 2) ...(3)(2)(1)

Consider the test statistic for the Chi-square test of goodness of fit, for the tornado data, of 5.7. This is lower than the rejection region of 7.8 at $\alpha = 0.05$. Therefore we fail to reject our null hypothesis and can state that the data are of the Poison Type distribution.

The Poison distribution with mean 0.737 gives a probability of 48 percent that no tornadoes will occur in any one given year. The probability that one tornado will occur is 35 percent. Probabilities drop off significantly for higher frequencies. The probability of two tornadoes in a single year is 13 percent, the probability of three is three percent, and the probability of four tornadoes is only 0.6 percent. These probabilities are illustrated in Figure 34.

Municipal Water Demand

In East Texas there is generally no shortage of water for municipal needs. Water demand during winter months was found to be significantly different from water demand during summer months at Nacogdoches, Texas. Monthly and annual total water production for the wells and for Lake Nacogdoches are given in Table 41.

Variation in water demand

Total water demand in Nacogdoches each year ranged from just over 11.5 million cubic meters in 1988 to just under 8.9 million cubic meters in 1983 with a mean and standard deviation of 9.7 million cubic meters and 0.73 million cubic meters, respectively. Results of the Duncan multiple range test for differences between the monthly mean of annual water demand are given in Figure 35. Means that do not share a common line are said to be significantly different. The year 1988 is significantly different from all other years of concern. Years 1989 and 1990 are significantly different from 1981 and 1983. Years 1988, 1990, 1989, and 1987 are significantly different from 1983. The year 1984 is not significantly different from any year except 1988. The year 1988 was very dry receiving 300 mm less precipitation than any other year and nearly 500 mm less than the average.

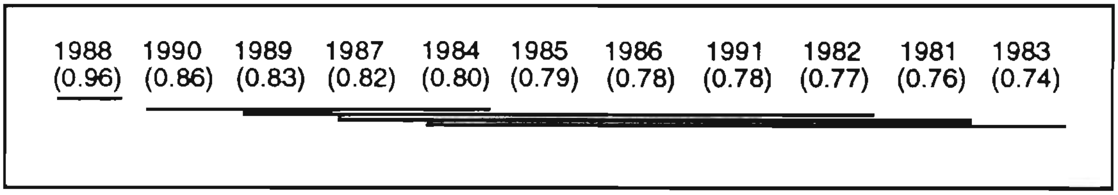


Figure 35. Results of Duncan's multiple range test for differences between mean monthly water production for the years. Values in parenthesis are mean water production values in millions of cubic meters for the normal period.

Results of the Duncan multiple range test for differences in the means of monthly water demand are given in Figure 36. The month of August is the only month that is significantly different from all of the rest of the months in consideration. June, July, August, September, and October are significantly different from November, December, January, February, and March.

The University at Nacogdoches experiences a population decrease during summer months of at least 5,000. If this were not the case, Nacogdoches might utilize enough water to cause the other summer months to become significantly different from the winter months, thereby implying a seasonal effect which seems to be prevalent in dryer climates. If this were the case and September's water demand became significantly different from October's then streamflow may be an important variable to investigate, due to its coincidence with the water year.

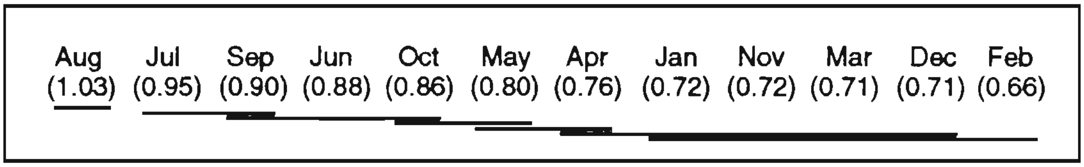


Figure 36. Results of Duncan's multiple range test for differences between the mean monthly water production for the months. Values in parenthesis are mean water production values in millions of cubic meters for the normal period.

The prediction equation

Table 21 provides the correlation matrix of all variables which are chosen for the development of the final prediction model.

Table 21. Pearson's Correlation Coefficients for Selected Variables

Variable	HD	HD35	MAXT	DEF	AE	ST	RD	PE	P-PE	P	1/P
WATER	0.75 (0.00)	0.74 (0.00)	0.71 (0.00)	0.74 (0.00)	0.54 (0.00)	-0.72 (0.00)	-0.39 (0.00)	0.71 (0.00)	-0.66 (0.00)	-0.30 (0.00)	0.41 (0.00)
HD		0.83 (0.00)	0.81 (0.00)	0.77 (0.00)	0.74 (0.00)	-0.62 (0.00)	-0.29 (0.00)	0.88 (0.00)	-0.71 (0.00)	-0.22 (0.01)	0.22 (0.01)
HD35			0.62 (0.00)	0.80 (0.00)	0.46 (0.00)	-0.57 (0.00)	-0.30 (0.00)	0.67 (0.00)	-0.59 (0.00)	-0.24 (0.01)	0.23 (0.01)
MAXT				0.63 (0.00)	0.90 (0.00)	-0.61 (0.00)	-0.29 (0.00)	0.96 (0.00)	-0.69 (0.00)	-0.12 (0.16)	0.15 (0.08)
DEF					0.35 (0.00)	-0.70 (0.00)	-0.37 (0.00)	0.65 (0.00)	-0.71 (0.00)	-0.42 (0.00)	0.43 (0.00)
AE						-0.36 (0.00)	-0.12 0.16	0.94 (0.00)	-0.53 (0.00)	0.08 (0.34)	-0.02 (0.84)
ST							0.43 (0.00)	-0.55 (0.00)	0.65 (0.00)	0.42 (0.00)	-0.22 (0.01)
RD								-0.24 0.01	0.67 (0.00)	0.71 (0.00)	-0.42 (0.00)
PE									-0.69 (0.00)	-0.09 (0.30)	0.14 (0.10)
P-PE										0.78 (0.00)	-0.46 (0.00)
P											-0.51 (0.00)

WATER = total monthly water production in thousands of cubic meters,
MAXT = monthly average of daily maximum temperatures in °C,
HD = number days in each month exceeding 32.2 °C,
HD35 = number days in each month exceeding 35 °C,
P = monthly total precipitation in mm,
1/P = one over monthly total precipitation in mm,
RD = monthly total number of raindays,
PE = Potential evapotranspiration in mm,
P-PE = precipitation minus potential evapotranspiration in mm,
ST = soil moisture storage in mm,
AE = actual evapotranspiration in mm, and
DEF = Soil moisture deficit in mm.
(P-values are given in parenthesis)

The final prediction model is given by:

$$\hat{water} = 558.823054 + 10.67053\ (HD35) + 7.987590\ (MAXT) + 1211.391428\ (1/P)$$

where:

$\hat{water}$ = predicted total monthly water production in thousands of cubic meters

558.823054 = the point at which the line crosses the vertical axis (β_0)

MAXT = average monthly maximum temperature °C (where MAXT is within the range of 9 to 36 °C)

HD35 = number of days in a month that are equal to or exceed 35 °C (where HD35 is within the range of 0 to 25)

1/P = the reciprocal of total monthly precipitation in mm (where P is within the range of 3 to 52 mm)

Since the regression is significant, we must reject the null hypothesis and state that at least one variable is significant for regression. Utilization of the stepwise max-R method provides the following results. The variable HD35 entered in step one and gave an R-square of 54 percent. Step two added MAXT and raised the R-square to 65 percent. Step three entered 1/P and gave an R-square of 71 percent and the standard error of the estimate is 78.5 thousand cubic meters or 10 percent of the mean. Looking at the collinearity diagnostics and variance inflation factors there seems to be very little worry about multicollinearity.

Other models were also investigated including entering over fifteen variables, which never raised the R-square to more than 77.4 percent. The single best one variable model predictor was HD with an R-square of 0.56. This indicates that water demand is highly temperature dependent. The three variable model was chosen because of the simplicity involved in obtaining the variables. Various other data manipulation techniques improved R-square, but only very little. Thornthwaite's variables such as soil moisture storage were also very good predictors of water demand. However, due to the complicated nature in deriving the figures, it was decided to forego a few percentage points with the R-square in order to develop a model that had variables which are easy to obtain. The final variables used in the model are simple to obtain and only require simple manipulation.

SUMMARY AND CONCLUSIONS

Climate Classification

It is of paramount importance that the climate of a place be fully understood. Understanding and applying a climatic classification scheme permits for the systematic comparisons of regional climates. Thornthwaite's scheme allows us to look closely at seasonal variations in the energy and moisture supply or demand of a place. Along with the classification, the monthly water budget reveals the seasonal march of climatic parameters, which can be graphically represented. According to the 1957 Thornthwaite climate classification Nacogdoches is moist subhumid, third mesothermal, with moderate summer water deficiency, and a temperature-efficiency regime equal to a fourth mesothermal climate.

Solar Radiation

Observed data, which were found to be consistent with recent published data, are on the average 62.4 percent lower than the values for total potential radiation as calculated for a horizontal surface at the top of the atmosphere The effect of cloud cover can be easily observed by looking at the observed solar radiation during the wet months and comparing it to the dryer months.

Climate Fluctuation at Nacogdoches, Texas

The climate in the last decade (1981-90) at Nacogdoches, Texas experienced very little change from that in recent periods. The statistics of all climatic variables studied in the most recent normal period (1961-90) are not significantly different from that in the previous normal period (1951-80).

The correlogram analyses of annual precipitation showed a tendency of a four-year cycle. All other variables showed some sort of non-randomness within the data series except for annual mean temperature. Farther investigation utilizing the tools of time series analysis is warranted.

Streamflow

Extreme daily streamflows fit the Log-Pearson type III probability distribution best while annual total and annual peakflows fit the Lognormal distribution better. There is a slightly higher probability that a dry year will occur than that of a wet year. The Probability of receiving the annual extreme daily flow in June is much greater than the probability of receiving it during August.

Tornadoes

It is more probable that Nacogdoches will not experience any tornadoes in a given year than for exactly one tornado to occur. It is even less probable that Nacogdoches will experience more than one tornado in any given year. The highest frequency of occurrence was at five o'clock p.m. The earliest occurrence was at two o'clock a.m. and the latest occurrence was at eleven o'clock p.m. Tornadoes are most frequent during May, while the height of tornado activity has probably moved out of East Texas by June.

Municipal Water Demand

Differences in average monthly water production are very little among the years, except for 1988. Monthly water demand can be estimated by the monthly maximum temperature, monthly number of days with maximum temperature equal to or exceeding 35 °C, and the reciprocal of total monthly precipitation in a multiple regression model with a standard error of estimate 10 percent of the observed mean and an R-square of 0.71. Improvement of the prediction model is possible by using more complicated variables such as those calculated by the Thornthwaite water balance.

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APPENDIX I
(Precipitation Data)

Table 22. Monthly and Annual Precipitation (in mm) for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	46.5	129.8	89.2	147.1	57.2	137.4	117.3	55.4	131.3	114.3	65.8	55.6	1146.8
1902	63.8	91.4	132.3	73.9	115.1	361.2	146.6	12.2	253.7	141.5	157.2	51.8	1600.7
1903	123.4	170.2	128.3	31.2	75.7	75.9	191.0	76.5	3.8	151.9	9.4	131.3	1168.7
1904	47.2	98.0	82.0	112.0	68.8	103.1	140.7	90.4	118.9	8.4	22.4	204.0	1096.0
1905	81.0	101.1	142.7	225.6	228.3	132.3	239.5	93.7	69.6	45.2	258.1	148.8	1766.1
1906	123.2	43.9	41.4	108.2	39.1	118.1	200.9	42.7	44.2	104.6	48.5	91.4	1006.3
1907	75.2	72.1	54.6	115.8	230.4	5.3	59.2	3.8	16.0	163.6	263.9	115.6	1175.5
1908	58.7	161.8	86.4	104.6	72.9	23.4	62.5	99.6	142.0	3.0	75.7	39.6	930.1
1909	11.2	82.3	51.1	99.8	121.7	99.1	110.0	29.2	31.2	73.4	21.6	213.4	943.9
1910	39.6	247.9	22.6	107.2	216.4	125.0	54.4	46.7	23.9	57.7	86.6	123.4	1151.4
mean	67.0	119.9	83.1	112.5	122.6	118.1	132.2	55.0	83.5	86.4	100.9	117.5	1198.5
s.d.	35.5	59.5	41.2	49.8	74.9	96.5	64.1	34.2	78.1	57.8	94.3	60.3	273.8
max	123.4	247.9	142.7	255.6	230.4	361.2	239.5	99.6	253.7	163.6	263.9	213.4	1766.1
min	11.2	43.9	22.6	31.2	39.1	5.3	54.4	3.8	3.8	3.0	9.4	39.6	930.1
1911	0.0	74.4	98.8	244.3	15.5	13.2	283.7	53.1	13.5	46.7	127.0	267.0	1237.2
1912	49.8	90.7	182.4	189.5	239.8	118.4	16.3	58.4	0.0	23.1	20.3	164.8	1153.4
1913	102.6	101.1	117.6	112.3	127.3	40.9	40.4	36.8	314.7	113.3	74.7	156.0	1337.6
1914	31.0	127.8	107.7	103.6	227.6	31.8	6.6	132.6	46.5	17.0	104.4	226.1	1162.6
1915	117.1	81.0	58.4	71.6	72.9	19.1	117.1	199.4	38.9	30.7	77.0	62.0	945.1
1916	194.6	14.7	20.6	134.1	272.8	61.7	90.7	19.3	17.0	32.3	95.3	80.8	1033.8
1917	96.3	108.2	48.5	83.1	82.6	19.6	148.1	1.5	95.0	35.1	17.5	2.8	738.1
1918	36.8	23.4	46.0	177.5	42.4	66.8	57.9	84.1	98.3	114.3	166.4	76.7	990.6
1919	105.7	114.0	63.0	32.8	176.8	221.5	46.2	139.4	61.5	245.1	103.1	38.1	1347.2
1920	176.0	29.7	135.4	125.5	116.1	77.7	120.4	173.5	37.3	89.2	118.4	144.5	1343.7
mean	91.0	76.5	87.8	127.4	137.4	67.1	92.7	89.8	72.3	74.7	90.4	121.9	1128.9
s.d.	62.8	40.4	49.3	62.3	88.3	63.3	81.8	67.7	91.2	70.2	45.9	84.3	201.5
max	194.6	127.8	182.4	244.3	272.8	221.5	283.7	199.4	314.7	245.1	166.4	267.0	1347.2
min	0.0	14.7	20.6	32.8	15.5	13.2	6.6	1.5	0.0	17.0	17.5	2.8	738.1

Table 22. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1921	79.2	54.9	184.9	160.0	43.4	149.9	180.3	81.5	81.8	26.7	15.5	106.7	1164.8
1922	161.5	154.9	212.1	296.2	128.3	69.6	79.0	86.6	26.2	17.8	133.6	98.6	1464.3
1923	95.3	157.5	158.0	251.5	125.0	106.7	36.1	46.7	223.5	68.8	128.8	238.3	1636.0
1924	127.3	131.1	110.5	145.0	240.3	78.0	1.5	0.0	50.0	1.3	54.4	69.9	1009.1
1925	146.6	36.6	25.4	27.9	47.0	7.1	76.7	16.0	66.8	283.0	223.3	23.6	979.9
1926	92.7	15.2	213.1	125.7	61.0	168.1	186.7	44.7	12.7	17.3	88.9	193.3	1219.5
1927	32.3	57.2	180.3	155.7	89.9	189.7	22.6	14.2	63.2	92.7	31.0	112.3	1041.1
1928	20.8	85.9	143.8	62.5	74.2	111.3	130.8	23.9	27.4	58.7	140.5	77.0	956.6
1929	95.5	66.8	76.2	118.6	323.3	83.3	101.1	22.6	37.3	39.4	195.3	187.7	1347.2
1930	163.8	113.3	59.7	12.2	169.2	59.9	44.2	62.2	116.1	139.2	140.5	80.5	1160.8
mean	101.5	87.3	136.4	135.5	130.1	102.4	85.9	39.9	70.5	74.5	115.2	118.8	1197.9
s.d.	49.6	49.7	65.8	90.0	91.3	55.0	63.9	29.6	61.8	84.1	67.8	66.5	224.6
max	163.8	157.5	213.1	296.2	323.3	189.7	186.7	86.6	223.5	283.0	223.3	238.3	1636.0
min	20.8	15.2	25.4	12.2	43.4	7.1	1.5	0.0	12.7	1.3	15.5	23.6	956.6
1931	92.2	145.5	89.4	97.8	75.2	19.8	50.5	162.8	5.6	53.3	105.9	248.2	1146.3
1932	294.9	241.3	86.9	61.5	60.2	24.1	36.3	59.9	23.4	33.5	75.7	174.0	1171.7
1933	48.3	109.7	139.7	103.9	139.7	15.2	323.1	15.2	45.0	18.5	8.9	188.0	1155.2
1934	203.5	123.4	169.7	162.1	111.5	23.6	32.5	24.4	92.5	47.8	240.0	115.6	1346.5
1935	77.0	57.2	60.2	183.6	396.2	69.3	40.9	12.7	87.4	71.9	143.5	140.5	1340.4
1936	45.0	43.7	25.9	77.2	124.2	10.2	103.9	90.2	25.4	73.7	70.9	127.3	817.4
1937	196.9	68.6	99.3	129.8	36.6	98.0	80.0	84.8	75.2	92.7	106.2	130.3	1198.4
1938	104.9	62.7	149.4	135.1	62.5	91.4	96.8	10.9	14.2	43.7	117.9	65.3	954.8
1939	142.7	175.0	47.2	67.1	106.7	35.1	73.2	23.9	14.7	64.8	97.5	229.9	1077.7
1940	47.0	205.5	62.0	169.4	100.6	146.8	20.3	189.5	64.3	17.0	478.8	225.3	1726.4
mean	125.2	123.3	93.0	118.7	121.3	53.4	85.8	67.4	44.8	51.7	144.5	164.4	1193.5
s.d.	83.4	67.8	47.1	43.9	101.7	45.9	88.1	64.6	32.7	24.6	131.4	58.7	246.1
max	294.9	241.3	169.7	183.6	396.2	146.8	323.1	189.5	92.5	92.7	478.8	248.2	1726.4
min	45.0	43.7	25.9	61.5	36.6	10.2	20.3	10.9	5.6	17.0	8.9	65.3	817.4

Table 22. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	57.2	125.7	92.7	40.9	169.2	195.3	192.0	62.5	149.6	324.9	88.1	94.0	1592.1
1942	65.5	38.4	77.2	140.0	107.4	145.8	50.8	103.9	86.4	25.9	49.3	93.2	983.7
1943	74.7	48.3	54.6	16.3	62.5	34.8	98.8	71.1	51.6	66.3	81.0	111.5	771.4
1944	162.1	139.4	166.9	132.8	319.3	91.4	49.0	130.8	52.6	19.3	196.6	225.8	1686.1
1945	152.1	118.9	118.1	144.5	121.9	104.4	176.3	63.8	113.8	171.2	41.1	113.3	1439.4
1946	188.0	141.0	197.6	80.5	223.5	79.8	109.0	120.7	74.2	46.2	232.2	89.2	1581.7
1947	113.0	52.3	128.8	114.0	151.4	83.6	57.9	10.2	20.3	30.2	129.0	131.3	1022.1
1948	100.3	106.7	57.9	131.1	104.1	25.1	79.0	19.3	25.9	26.4	151.9	109.2	937.0
1949	181.9	85.6	110.7	128.3	138.9	62.7	82.0	35.6	83.1	336.3	15.0	141.5	1401.6
1950	150.1	165.4	43.7	135.6	269.5	154.7	121.4	18.3	224.5	27.7	60.2	109.7	1480.8
mean	124.5	102.2	104.8	106.4	166.8	97.8	101.6	63.6	88.2	107.4	104.4	121.9	1289.6
s.d.	48.7	44.1	50.1	45.2	80.5	53.9	49.8	43.6	61.8	125.8	71.1	40.0	327.2
max	188.0	165.4	197.6	144.5	319.3	195.3	192.0	130.8	224.5	336.3	232.2	225.8	1686.1
min	57.2	38.4	43.7	16.3	62.5	25.1	49.0	10.2	20.3	19.3	15.0	89.2	771.4
1951	97.5	90.4	109.5	38.9	35.6	91.2	70.4	11.7	138.4	16.3	77.7	160.0	937.5
1952	70.9	80.3	94.2	130.0	135.6	25.7	106.9	20.8	23.9	0.0	153.7	152.9	994.9
1953	78.5	105.2	192.3	221.2	300.2	137.4	156.2	81.5	49.3	77.5	81.5	152.9	1633.7
1954	91.2	20.8	29.2	68.1	153.4	25.4	27.4	12.2	13.7	134.6	84.8	52.6	713.5
1955	96.5	116.1	51.3	77.7	151.1	20.3	52.6	134.1	37.3	62.5	31.8	61.2	892.6
1956	89.2	116.6	68.1	96.3	77.7	126.5	9.9	95.3	10.9	24.9	90.9	69.1	875.3
1957	144.5	101.3	151.1	354.6	160.8	111.8	82.0	34.3	171.2	253.2	247.1	74.4	1886.5
1958	119.6	61.0	86.1	107.7	93.5	177.0	31.5	106.9	288.3	38.4	65.8	54.1	1229.9
1959	22.1	123.7	46.7	135.4	45.5	86.4	195.8	90.2	95.8	97.3	79.0	165.9	1183.6
1960	90.4	135.4	38.6	86.6	26.2	210.1	112.0	150.4	90.2	103.6	187.7	196.3	1427.5
mean	90.0	95.1	86.7	131.6	118.0	101.2	84.5	73.7	91.9	80.8	110.0	113.9	1177.5
s.d.	31.7	34.0	52.4	92.6	81.9	65.0	59.3	51.0	87.6	74.1	65.5	56.1	373.4
max	144.5	135.4	192.3	354.6	300.2	210.1	195.8	150.4	288.3	253.2	247.1	196.3	1886.5
min	22.1	20.8	29.2	38.9	26.2	20.3	9.9	11.7	10.9	0.0	31.8	52.6	713.5

Table 22. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	206.2	141.5	140.5	30.0	45.5	139.7	78.0	30.2	190.2	72.1	98.8	204.7	1377.4
1962	102.6	40.4	46.2	124.2	122.9	125.7	104.9	30.5	168.7	53.3	121.2	96.8	1137.4
1963	27.7	73.9	16.8	117.9	25.4	171.5	66.3	54.6	48.3	1.0	117.6	64.3	785.1
1964	132.8	61.0	90.4	192.0	86.6	51.8	2.5	61.7	108.5	48.5	56.1	86.1	978.2
1965	99.8	117.1	130.3	47.5	250.7	133.1	76.7	36.6	140.7	7.4	64.8	170.7	1275.3
1966	191.5	112.8	44.5	217.4	181.9	60.5	40.1	153.7	63.5	65.5	27.4	136.1	1294.9
1967	25.1	95.0	51.1	51.1	121.4	74.7	118.4	33.0	17.5	59.9	16.3	134.4	797.8
1968	184.9	85.3	68.1	268.5	209.6	233.9	87.9	35.1	203.2	42.7	164.1	158.5	1741.7
1969	43.2	169.2	214.9	185.9	178.6	19.3	68.3	39.6	62.0	89.7	59.7	108.7	1239.0
1970	39.9	117.9	120.4	68.6	121.7	27.4	0.0	81.8	75.7	175.5	43.4	44.2	916.4
mean	105.4	101.4	92.3	130.3	134.4	103.8	64.3	55.7	107.8	61.6	76.9	120.4	1154.3
s.d.	71.0	38.4	59.6	82.2	71.4	68.8	39.5	38.2	64.5	48.4	46.9	49.8	295.8
max	206.2	169.2	214.9	268.5	250.7	233.9	118.4	153.7	203.2	175.5	164.1	204.7	1741.7
min	25.1	40.4	16.8	30.0	25.4	19.3	0.0	30.2	17.5	1.0	16.3	44.2	785.1
1971	10.7	56.6	14.0	15.7	128.8	44.2	95.3	77.5	108.2	94.7	100.1	140.2	886.0
1972	123.2	23.1	89.4	102.1	37.1	129.0	194.3	46.0	82.6	218.2	95.8	95.5	1236.2
1973	137.7	46.0	194.6	164.1	73.7	178.8	43.7	111.5	169.4	158.0	106.4	124.0	1507.7
1974	247.7	35.8	31.5	108.2	137.7	56.4	109.7	140.7	218.9	70.1	179.8	87.1	1423.7
1975	68.8	325.1	113.8	92.5	172.0	194.6	35.1	49.5	40.1	116.6	109.5	66.0	1383.5
1976	36.3	53.6	107.2	71.1	153.4	126.5	87.4	14.0	61.5	60.5	53.1	125.7	950.2
1977	89.7	58.4	103.4	81.8	30.0	88.6	31.5	96.5	59.9	35.6	71.4	73.9	820.7
1978	169.2	66.3	65.5	90.7	70.4	51.6	27.7	39.9	54.4	22.9	137.2	88.9	884.5
1979	182.9	148.6	165.9	108.7	349.0	127.3	158.5	82.3	123.7	127.5	178.3	90.7	1843.3
1980	101.9	48.0	95.3	113.8	157.0	40.4	40.1	58.2	44.7	57.4	88.6	31.2	876.6
mean	116.8	86.2	98.1	94.9	130.9	103.7	82.3	71.6	96.3	96.2	112.0	92.3	1181.2
s.d.	71.3	90.5	54.7	37.4	92.1	56.1	58.1	37.7	59.2	60.2	41.8	32.0	349.5
max	247.7	325.1	194.6	164.1	349.0	194.6	194.3	140.7	218.9	218.2	179.8	140.2	1843.3
min	10.7	23.1	14.0	15.7	30.0	40.4	27.7	14.0	40.1	22.9	53.1	31.2	820.7

Table 22. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	54.4	94.0	84.6	28.2	139.7	112.0	203.5	38.4	156.7	150.1	83.3	16.8	1161.5
1982	78.2	55.4	108.0	273.8	87.6	183.6	73.4	5.8	67.3	141.7	160.3	221.7	1456.9
1983	36.6	146.6	118.4	22.9	192.5	130.3	29.2	73.7	54.4	30.7	106.9	179.6	1121.7
1984	46.0	146.6	89.4	42.2	60.7	28.4	105.4	22.1	82.0	338.6	73.7	69.6	1104.6
1985	93.0	119.9	111.5	176.3	117.9	23.9	116.8	69.6	89.9	213.6	188.0	56.6	1376.9
1986	11.2	64.8	7.6	123.4	196.1	238.0	72.9	75.2	82.8	153.2	180.6	137.4	1343.2
1987	32.0	148.3	52.6	12.7	49.0	135.4	92.7	32.3	71.9	53.6	195.6	132.3	1008.4
1988	35.3	41.4	108.0	35.6	10.9	3.6	106.9	123.4	51.8	67.8	55.4	78.2	718.3
1989	259.3	53.3	159.8	22.6	164.3	261.6	98.0	26.4	103.1	52.8	51.8	42.7	1295.9
1990	194.3	108.7	129.5	65.3	274.8	106.7	76.2	29.2	35.1	91.9	79.8	105.7	1297.2
mean	8.4	97.9	96.9	80.3	129.4	122.4	97.5	49.6	79.5	129.4	117.5	104.1	1188.5
s.d.	80.3	42.1	42.3	85.7	80.3	88.0	44.8	35.2	33.7	93.4	57.4	64.1	216.2
max	259.3	148.3	159.8	273.8	274.8	261.6	203.5	123.4	156.7	338.6	195.6	221.7	1456.9
min	11.2	41.4	7.6	12.7	10.9	3.6	29.2	5.8	35.1	30.7	51.8	16.8	718.3
1991	312.9	151.6	53.3	262.9	243.1	72.1	21.3	200.7	36.6	80.5	123.7	178.8	1737.6
1992	126.2	246.1	171.5	56.1	96.8	51.8	35.1	57.2	81.5	52.8	154.2	184.7	1313.9

Table 22. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	86.5	94.6	102.4	125.2	130.0	95.8	103.6	61.6	75.4	78.5	102.2	119.4	1175.1
s.d.	51.0	52.2	56.8	67.7	82.3	74.4	71.1	50.1	75.4	69.2	70.3	68.6	229.4
max	194.6	247.9	213.1	296.2	323.3	361.2	283.7	199.4	314.7	283.0	263.9	267.0	1766.1
min	0.0	14.7	20.6	12.2	15.5	5.3	1.5	0.0	0.0	1.3	9.4	2.8	738.1
1911-40													
mean	105.9	95.7	105.7	127.2	129.6	74.3	88.1	65.7	62.5	66.9	116.7	135.0	1173.4
s.d.	66.0	55.8	57.2	66.1	90.9	57.2	75.9	58.5	65.3	63.5	89.1	71.4	219.3
max	294.9	241.3	213.1	296.2	396.2	221.5	323.1	199.4	314.7	283.0	478.8	267.0	1726.4
min	0.0	14.7	20.6	12.2	15.5	7.1	1.5	0.0	0.0	1.3	8.9	2.8	738.1
1921-50													
mean	117.1	104.3	111.4	120.2	139.4	84.5	91.1	57.0	67.8	77.9	121.4	135.0	1227.0
s.d.	61.5	55.0	56.2	62.4	90.6	54.8	67.1	48.1	55.0	88.5	93.0	58.2	264.0
max	294.9	241.3	213.1	296.2	396.2	195.3	323.1	189.5	224.5	336.3	478.8	248.2	1726.4
min	20.8	15.2	25.4	12.2	36.6	7.1	1.5	0.0	5.6	1.3	8.9	23.6	771.4
1931-60													
mean	113.3	106.8	94.8	118.9	135.4	84.1	90.6	68.3	74.9	80.0	119.7	133.4	1220.2
s.d.	59.1	50.4	48.8	63.3	88.4	57.9	65.8	52.1	66.1	85.7	92.6	55.2	312.8
max	294.9	241.3	197.6	354.6	396.2	210.1	323.1	189.5	288.3	336.3	478.8	248.2	1886.5
min	22.1	20.8	25.9	16.3	26.2	10.2	9.9	10.2	5.6	0.0	8.9	52.6	713.5
1941-70													
mean	106.6	99.5	94.6	122.8	139.7	100.9	83.5	64.3	96.0	83.3	97.1	118.8	1207.1
s.d.	53.1	37.8	52.9	74.4	78.1	60.7	50.9	43.7	70.3	87.8	61.6	47.5	327.5
max	206.2	169.2	214.9	354.6	319.3	233.9	195.8	153.7	288.3	336.3	247.1	225.8	1886.5
min	22.1	20.8	16.8	16.3	25.4	19.3	0.0	10.2	10.9	0.0	15.0	44.2	713.5

Table 22. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951-80													
mean	104.1	94.2	92.4	118.9	127.8	102.9	77.0	67.0	98.7	79.5	99.7	108.9	1171.0
s.d.	59.8	58.3	53.9	74.1	79.7	61.3	52.0	42.1	69.4	61.3	53.2	47.1	329.4
max	247.7	325.1	214.9	354.6	349.0	233.9	195.8	153.7	288.3	253.2	247.1	204.7	1886.5
min	10.7	20.8	14.0	15.7	25.4	19.3	0.0	11.7	10.9	0.0	16.3	31.2	713.5
1961-90													
mean	102.1	95.1	95.8	101.8	131.6	109.9	81.4	59.0	94.6	95.7	102.2	105.6	1174.7
s.d.	73.0	59.9	50.9	72.6	78.9	70.2	48.4	37.0	53.6	73.2	50.8	50.0	282.5
max	259.3	325.1	214.9	273.8	349.0	261.6	203.5	153.7	218.9	338.6	195.6	221.7	1884.3
min	10.7	23.1	7.6	12.7	10.9	3.6	0.0	5.8	17.5	1.0	16.3	16.8	718.3

Table 23. Maximum Daily Precipitation (mm) by Month and Year for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	26.7	42.9	44.2	128.3	23.6	50.8	57.2	18.8	53.3	101.1	32.0	34.3	128.3
1902	30.5	53.3	47.8	23.4	71.1	361.2	34.8	10.7	106.9	112.3	40.6	16.0	361.2
1903	48.3	39.9	22.4	31.2	25.4	23.9	50.8	53.8	3.8	71.6	9.4	68.8	71.6
1904	16.0	25.1	20.8	39.4	30.5	27.9	30.7	58.9	45.2	6.9	15.2	110.5	110.5
1905	22.1	57.7	34.8	43.7	73.4	35.3	56.4	75.4	49.0	28.4	153.7	24.6	153.7
1906	83.8	38.4	17.0	74.2	18.8	30.2	152.9	10.7	17.8	58.9	19.6	38.9	152.9
1907	35.8	43.2	31.0	41.9	56.4	5.3	20.3	3.8	16.0	61.0	100.3	61.5	100.3
1908	26.2	55.6	42.7	40.6	20.3	9.7	20.3	45.7	63.5	3.0	21.3	18.8	63.5
1909	5.3	30.0	29.5	46.5	51.6	45.5	101.6	15.7	19.1	64.0	5.1	58.7	101.6
1910	17.3	96.5	10.7	48.3	49.0	48.3	24.6	17.8	9.7	36.6	58.4	40.5	96.5
1911	0.0	42.7	38.1	52.6	10.7	6.6	69.9	28.4	13.5	19.6	73.7	62.5	73.7
1912	24.9	38.1	50.8	63.2	98.0	43.9	10.2	26.2	0.0	10.2	7.4	38.1	98.0
1913	40.1	35.6	39.1	44.5	43.2	18.3	23.6	20.3	70.6	29.2	35.6	40.4	70.6
1914	20.3	34.5	35.6	36.3	59.4	23.9	2.0	41.1	37.3	14.2	29.7	49.8	59.4
1915	48.5	19.8	38.1	34.5	63.0	13.2	41.7	73.7	23.1	15.7	30.7	15.2	73.7
1916	76.2	14.7	20.6	53.3	111.0	18.8	18.3	7.1	5.8	32.3	77.2	37.8	111.0
1917	25.9	30.0	30.0	23.4	47.2	19.6	35.3	1.5	41.9	35.1	10.2	2.8	47.2
1918	18.5	7.1	16.0	54.6	33.8	26.9	37.3	27.2	45.7	41.1	77.5	32.8	77.5
1919	49.5	26.7	17.3	24.1	35.8	48.5	20.6	49.0	26.2	69.9	44.7	15.2	69.9
1920	50.8	20.3	70.1	82.3	41.9	18.8	61.0	85.6	12.7	26.7	43.7	76.2	85.6
1921	26.4	22.9	65.0	35.1	34.3	48.3	66.3	57.4	28.7	15.2	10.7	34.5	66.3
1922	42.4	42.9	96.5	172.2	39.4	21.3	24.9	31.8	11.4	8.6	61.5	41.1	172.2
1923	59.2	61.0	57.2	77.5	47.0	33.0	9.7	24.9	51.8	45.7	54.1	57.2	77.5
1924	44.2	47.2	27.4	72.9	64.8	24.1	1.5	0.0	26.9	1.3	34.3	20.3	72.9
1925	35.6	13.7	9.9	15.2	15.2	5.1	29.2	7.6	33.0	78.7	94.0	6.6	94.0

Table 23. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1926	27.7	8.4	47.5	78.0	12.2	47.8	58.9	12.7	6.6	10.4	31.0	43.2	78.0
1927	24.6	25.1	48.8	96.5	46.2	47.8	6.9	8.6	45.2	35.6	22.1	43.4	96.5
1928	15.7	40.6	64.8	17.8	58.4	24.9	29.0	15.7	7.6	32.3	62.2	33.0	64.8
1929	32.0	13.2	27.7	49.8	51.3	39.4	49.8	17.0	30.5	27.2	59.9	99.1	99.1
1930	35.6	37.6	17.3	7.1	38.1	48.8	27.9	18.8	39.1	51.8	70.4	35.1	70.4
1931	33.0	29.7	27.9	49.5	25.4	10.2	17.8	43.2	5.6	42.2	20.6	48.3	49.5
1932	85.3	105.4	47.0	37.8	45.7	13.0	22.9	26.9	7.6	23.1	47.8	36.8	105.4
1933	29.2	38.6	48.3	29.0	61.0	8.9	208.3	6.1	26.9	11.2	5.3	73.7	208.3
1934	54.4	43.7	64.8	69.1	38.9	23.6	10.7	11.9	24.6	46.2	114.3	38.6	114.3
1935	41.9	17.5	35.3	55.9	190.0	19.8	10.7	5.8	54.1	48.5	51.3	116.1	190.0
1936	27.7	11.7	6.9	23.9	47.0	9.7	45.7	55.1	10.2	29.0	24.6	58.2	58.2
1937	36.8	30.0	18.0	44.7	34.3	33.3	41.4	30.7	25.4	42.9	43.9	54.6	54.6
1938	37.1	37.3	56.6	61.5	33.3	62.2	58.7	4.1	8.9	20.3	64.3	22.4	64.3
1939	28.7	26.4	39.4	38.4	36.8	15.2	46.5	5.3	7.1	40.4	34.0	149.9	149.9
1940	18.0	61.0	33.3	56.4	76.7	74.4	9.9	71.6	59.2	7.4	224.8	70.6	224.8
1941	23.6	71.4	37.3	14.2	50.0	62.5	55.6	18.0	66.0	231.9	43.9	25.9	231.9
1942	32.3	16.8	21.1	52.3	45.5	28.4	22.1	56.6	67.1	10.4	27.9	54.6	67.1
1943	33.5	33.8	24.4	8.4	15.5	10.9	25.4	52.8	12.2	37.1	40.1	30.7	52.8
1944	30.5	32.3	58.2	54.9	75.4	54.4	20.1	84.3	37.3	19.1	56.1	48.8	84.3
1945	47.8	40.4	26.4	69.3	49.3	42.4	47.8	29.2	44.7	52.8	29.7	42.4	69.3
1946	57.9	34.3	73.7	33.3	82.0	41.7	50.8	38.6	35.8	15.2	56.6	24.6	82.0
1947	24.1	21.1	48.8	45.5	73.4	40.1	46.0	6.1	14.5	24.4	33.0	59.9	73.4
1948	16.3	38.9	26.7	66.5	36.1	19.1	35.1	6.4	14.7	15.7	54.6	65.5	66.5
1949	67.1	20.1	39.9	35.1	108.7	42.4	23.4	21.6	31.2	97.3	15.0	24.6	108.7
1950	43.9	60.7	13.2	55.9	90.2	50.8	32.5	11.9	99.6	23.1	52.1	101.6	101.6

Table 23. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951	51.8	34.0	43.4	14.0	25.4	41.7	53.8	5.1	73.7	5.8	31.2	60.7	73.7
1952	45.0	18.3	37.8	50.5	64.3	10.2	32.3	20.6	19.1	0.0	80.8	67.6	80.8
1953	56.6	26.9	65.8	149.9	94.5	74.4	80.3	40.6	47.2	77.5	31.2	64.3	149.9
1954	25.9	16.3	11.4	25.9	51.3	13.2	12.2	5.8	8.9	73.4	47.5	35.6	73.4
1955	29.5	41.1	20.3	38.1	69.6	10.7	23.4	50.8	14.2	41.9	20.6	26.4	69.6
1956	49.0	48.3	17.8	62.0	31.5	70.6	9.9	51.1	10.9	7.6	34.3	18.3	70.6
1957	40.6	30.5	35.6	99.1	39.1	21.6	41.1	21.1	50.8	104.1	55.1	33.3	104.1
1958	47.2	22.4	27.9	34.5	44.5	84.6	21.8	50.5	122.7	15.0	20.3	22.9	122.7
1959	10.2	45.0	13.5	36.6	24.6	23.6	116.8	43.2	44.7	49.0	50.8	69.3	116.8
1960	28.4	29.7	27.2	48.8	18.5	45.2	36.8	44.5	57.9	26.4	55.1	40.1	57.9
1961	57.7	57.7	51.8	18.0	32.5	34.0	18.3	16.0	120.4	55.1	32.5	65.0	120.4
1962	37.6	14.2	17.5	37.1	85.6	50.3	50.8	10.7	86.6	16.3	31.0	32.5	86.6
1963	16.3	46.2	11.4	53.6	10.9	55.6	20.6	24.9	19.3	1.0	46.5	26.9	55.6
1964	31.0	28.4	33.5	66.3	45.7	30.5	2.5	25.9	66.0	24.1	23.1	36.8	66.3
1965	72.4	27.7	80.0	38.6	93.5	39.1	57.2	16.0	43.2	7.4	50.8	44.7	93.5
1966	104.6	50.3	16.5	94.2	65.8	23.1	16.8	64.0	13.2	24.6	7.6	30.5	104.6
1967	11.2	48.3	24.6	33.5	68.6	41.1	26.7	20.6	9.1	33.0	8.9	34.0	68.6
1968	80.0	26.9	21.8	95.0	69.9	48.5	34.0	13.2	109.0	27.2	34.8	61.5	109.0
1969	15.5	43.7	72.9	39.6	73.9	15.5	43.7	20.3	36.6	59.9	40.1	44.2	73.9
1970	23.1	39.6	32.3	29.5	50.8	8.9	0.0	45.7	27.2	44.2	20.6	19.8	50.8
1971	5.1	15.5	7.4	6.6	73.9	14.5	31.2	53.3	47.2	41.1	69.9	33.3	73.9
1972	58.4	11.2	29.5	72.6	11.9	55.6	82.0	24.6	23.6	73.2	32.0	29.5	82.0
1973	60.5	17.3	88.1	58.2	30.2	46.5	13.0	47.2	70.6	40.1	28.7	71.9	88.1
1974	102.9	24.1	15.5	45.7	50.8	23.1	51.1	52.1	54.9	44.2	39.9	34.0	102.9
1975	24.4	193.8	35.3	46.5	35.6	63.0	14.0	17.8	20.6	46.7	43.7	36.1	193.8

Table 23. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1976	21.6	24.1	22.9	51.6	51.6	57.4	34.5	4.6	21.8	36.1	18.3	47.0	57.4
1977	42.9	39.4	49.5	24.1	18.3	36.1	11.9	46.5	16.8	20.3	34.3	30.2	49.5
1978	35.8	21.8	25.9	45.5	30.0	38.4	10.9	33.0	11.2	40.2	58.9	30.2	58.9
1979	45.0	43.2	38.5	18.5	52.3	66.5	78.0	15.5	69.9	90.2	83.1	30.5	90.2
1980	36.8	32.5	30.7	50.0	76.5	40.4	39.9	36.3	11.7	28.4	26.7	19.6	76.5
1981	29.0	43.9	31.8	9.4	24.1	42.7	72.4	21.3	83.3	51.6	40.9	4.8	83.3
1982	29.2	19.1	51.8	85.3	71.1	113.5	34.0	5.3	37.6	50.8	60.2	53.6	113.5
1983	14.2	29.7	39.4	9.9	59.4	69.1	14.5	24.9	24.1	21.1	61.2	52.8	69.1
1984	25.9	81.8	39.1	31.0	32.0	20.8	61.2	10.4	65.0	87.1	31.0	22.9	87.1
1985	41.4	45.0	23.4	63.2	31.0	22.9	35.6	30.5	29.0	47.5	88.1	34.8	88.1
1986	5.6	46.2	3.8	45.7	54.9	117.6	57.2	25.4	22.9	71.6	37.6	30.2	117.6
1987	14.5	30.7	29.2	7.6	14.2	31.2	33.5	17.8	23.1	44.5	96.3	51.3	96.3
1988	15.5	21.1	48.3	22.9	7.6	1.8	42.2	84.8	21.8	19.1	25.4	30.5	84.8
1989	66.5	24.6	86.9	13.2	44.7	77.7	39.6	9.7	82.0	22.4	25.9	18.0	86.9
1990	47.5	40.6	62.2	22.6	137.4	85.9	24.6	17.0	15.7	43.4	54.4	60.7	137.4
1991	131.8	34.5	17.0	86.6	104.1	27.9	8.4	78.7	21.3	54.1	37.8	31.8	131.8
1992	30.7	74.4	105.7	41.9	46.0	24.4	33.0	47.8	35.8	35.6	31.2	95.5	105.7

Table 24. Monthly and Annual Precipitation (in mm) departures from 90 year average for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	-56.7	28.8	-8.8	30.8	-76.0	41.5	26.9	-9.0	50.2	30.0	-42.9	-65.2	-43.2
1902	-39.4	-9.6	34.3	-42.4	-18.1	265.3	56.1	-52.2	172.6	57.1	48.6	-69.0	410.7
1903	20.3	69.2	30.3	-85.0	-57.4	-19.9	100.5	12.1	-77.3	67.6	-99.3	10.5	-21.3
1904	-55.9	-3.0	-16.0	-4.3	-64.3	7.3	50.2	26.1	37.7	-76.0	-86.3	83.1	-94.0
1905	-22.2	0.1	44.8	109.3	95.2	36.5	149.0	29.4	-11.6	-39.1	149.4	28.0	576.1
1906	20.0	-57.1	-56.6	-8.1	-94.0	22.2	110.4	-21.7	-37.0	20.3	-60.2	-29.4	-183.7
1907	-28.0	-28.9	-43.4	-0.4	97.2	-90.5	-31.3	-60.6	-65.1	79.2	155.2	-5.3	-14.5
1908	-44.5	60.8	-11.6	-11.6	-60.2	-72.5	-28.0	35.2	60.8	-81.3	-33.0	-81.2	-259.9
1909	-92.0	-18.7	-46.9	-16.4	-11.5	3.2	19.5	-35.2	-49.9	-10.9	-87.1	92.5	-246.1
1910	-63.6	146.9	-75.4	-9.1	83.3	29.1	-36.1	-17.6	-57.3	-26.7	-22.1	2.6	-38.6
1911	-103.0	-26.6	0.8	128.1	-118	-82.7	193.2	-11.3	-67.7	-37.6	18.3	146.1	47.2
1912	-53.4	-10.3	84.4	73.2	106.6	22.5	-74.2	-5.9	-81.1	-61.2	-88.3	44.0	-36.6
1913	-0.6	0.1	19.6	-4.0	-5.9	-55.0	-50.1	-27.5	233.6	28.9	-34.0	35.1	147.6
1914	-72.2	26.7	9.7	-12.6	94.5	-64.1	-83.9	68.2	-34.7	-67.3	-4.3	105.2	-27.4
1915	13.9	-20.0	-39.6	-44.6	-60.2	-76.8	26.6	135.0	-42.3	-53.6	-31.7	-58.8	-244.9
1916	91.4	-86.3	-77.4	17.8	139.7	-34.2	0.2	-45.1	-64.1	-52.1	-13.4	-40.0	-156.2
1917	-6.9	7.2	-49.5	-33.2	-50.6	-76.3	57.6	-62.8	13.8	-49.3	-91.1	-118	-451.9
1918	-66.4	-77.7	-52.0	61.3	-90.7	-29.1	-32.6	19.7	17.2	30.0	57.7	-44.1	-199.4
1919	2.5	13.0	-35.0	-83.5	43.7	125.6	-44.3	75.1	-19.7	160.8	-5.5	-82.7	157.2
1920	72.8	-71.3	37.4	9.2	-17.1	-18.1	29.9	109.1	-43.8	4.8	9.7	23.7	153.7

Table 24. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1921	-23.9	-46.2	86.9	43.8	-89.7	54.0	89.9	17.2	0.6	-57.7	-93.2	-14.1	-25.2
1922	58.4	53.9	114.1	179.9	-4.9	-26.3	-11.5	22.3	-55.0	-66.6	24.9	-22.3	274.3
1923	-7.9	56.5	60.0	135.2	-8.2	10.8	-54.4	-17.6	142.4	-15.5	20.1	117.4	446.0
1924	24.1	30.0	12.5	28.8	107.2	-17.9	-89.0	-64.4	-31.1	-83.1	-54.3	-51.0	-180.9
1925	43.4	-64.4	-72.6	-88.3	-86.1	-88.8	-13.8	-48.4	-14.3	198.6	114.6	-97.2	-210.1
1926	-10.5	-85.8	115.1	9.5	-72.2	72.3	96.2	-19.7	-68.4	-67.1	-19.8	72.5	29.5
1927	-70.9	-43.9	82.3	39.4	-43.2	93.9	-67.9	-50.1	-17.9	8.4	-77.7	-8.6	-148.9
1928	-82.4	-15.2	45.8	-53.8	-59.0	15.4	40.3	-40.5	-53.7	-25.7	31.8	-43.9	-233.4
1929	-7.7	-34.2	-21.8	2.3	190.2	-12.6	10.6	-41.8	-43.8	-45.0	86.7	66.9	157.2
1930	60.6	12.3	-38.3	-104.0	36.0	-35.9	-46.3	-2.1	34.9	54.9	31.8	-40.3	-29.2
1931	-11.0	44.5	-8.6	-18.5	-57.9	-76.1	-39.9	98.5	-75.6	-31.0	-2.7	127.3	-43.7
1932	191.7	140.3	-11.1	-54.8	-72.9	-71.7	-54.2	-4.4	-57.8	-50.8	-33.0	53.2	-18.3
1933	-54.9	8.7	41.7	-12.4	6.6	-80.6	232.6	-49.1	-36.2	-65.8	-99.8	67.1	-34.8
1934	100.3	22.4	71.7	45.8	-21.6	-72.3	-58.0	-40.0	11.3	-36.6	131.4	-5.3	156.5
1935	-26.2	-43.9	-37.8	67.4	263.1	-26.5	-49.6	-51.7	6.2	-12.5	34.8	19.6	150.4
1936	-58.2	-57.3	-72.1	-39.1	-8.9	-85.7	13.4	25.8	-55.7	-10.7	-37.8	6.4	-372.6
1937	93.7	-32.4	1.3	13.5	-96.6	2.2	-10.5	20.5	-6.0	8.4	-2.5	9.5	8.4
1938	1.7	-38.3	51.4	18.9	-70.6	-4.4	6.3	-53.4	-66.9	-40.7	9.2	-55.5	-235.2
1939	39.6	74.0	-50.8	-49.2	-26.4	-60.8	-17.3	-40.5	-66.4	-19.6	-11.1	109.0	-112.3
1940	-56.2	104.5	-36.0	53.1	-32.5	50.9	-70.2	125.1	-16.9	-67.3	370.1	104.5	536.4

Table 24. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	-46.0	24.7	-5.3	-75.4	36.0	99.5	101.5	-1.9	68.5	240.5	-20.5	-26.8	402.1
1942	-37.7	-62.7	-20.8	23.7	-25.7	49.9	-39.7	39.5	5.2	-58.4	-59.4	-27.6	-206.3
1943	-28.5	-52.8	-43.4	-100.0	-70.6	-61.1	8.3	6.8	-29.6	-18.0	-27.6	-9.3	-418.6
1944	58.9	38.4	68.9	16.6	186.1	-4.4	-41.5	66.4	-28.6	-65.0	87.9	105.0	496.1
1945	49.0	17.8	20.1	28.3	-11.2	8.5	85.8	-0.6	32.6	86.9	-67.5	-7.5	249.4
1946	84.8	39.9	99.6	-35.8	90.4	-16.1	18.5	56.3	-7.0	-38.1	123.5	-31.7	391.7
1947	9.8	-48.7	30.8	-2.2	18.3	-12.3	-32.6	-54.2	-60.8	-54.1	20.4	10.5	-167.9
1948	-2.9	5.7	-40.1	14.8	-29.0	-70.7	-11.5	-45.1	-55.2	-57.9	43.2	-11.6	-253.0
1949	78.7	-15.4	12.7	12.0	5.8	-33.1	-8.4	-28.8	1.9	252.0	-93.7	20.7	211.6
1950	46.9	64.3	-54.3	19.4	136.4	58.8	30.9	-46.1	143.4	-56.7	-48.5	-11.1	290.8
1951	-5.7	-10.6	11.5	-77.4	-97.6	-4.7	-20.1	-52.7	57.3	-68.1	-30.9	39.2	-252.5
1952	-32.3	-20.8	-3.8	13.8	2.5	-70.2	16.4	-43.5	-57.3	-84.3	45.0	32.1	-195.1
1953	-24.7	4.1	94.3	105.0	167.1	41.5	65.7	17.2	-31.9	-6.9	-27.1	32.1	443.7
1954	-12.0	-80.2	-68.8	-48.2	20.3	-70.5	-63.1	-52.2	-67.4	50.3	-23.8	-68.2	-476.5
1955	-6.7	15.1	-46.7	-38.5	18.0	-75.6	-37.9	69.8	-43.8	-21.9	-76.9	-59.6	-297.4
1956	-14.0	15.6	-29.9	-20.0	-55.4	30.6	-80.6	30.9	-70.2	-59.4	-17.7	-51.7	-314.7
1957	41.3	0.3	53.1	238.3	27.7	15.9	-8.4	-30.1	90.0	168.9	138.5	-46.4	696.5
1958	16.4	-40.1	-11.9	-8.6	-39.7	81.2	-59.0	42.6	207.1	-46.0	-42.9	-66.7	39.9
1959	-81.1	22.7	-51.3	19.1	-87.7	-9.5	105.3	25.8	14.6	12.9	-29.7	45.0	-6.4
1960	-12.8	34.4	-59.4	-29.7	-107	114.2	21.5	86.0	9.0	19.3	79.0	75.5	237.5

Table 24. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	103.1	40.5	42.5	-86.3	-87.7	43.8	-12.5	-34.1	109.1	-12.2	-9.9	83.9	187.4
1962	-0.6	-60.6	-51.8	7.9	-10.2	29.9	14.4	-33.9	87.5	-31.0	12.5	-24.0	-52.6
1963	-75.5	-27.1	-81.2	1.6	-108.0	75.6	-24.2	-9.8	-32.9	-83.3	8.9	-56.6	-404.9
1964	29.7	-40.1	-7.6	75.8	-46.5	-44.1	-87.9	-2.6	27.3	-35.8	-52.5	-34.7	-211.8
1965	-3.4	16.1	32.3	-68.8	117.6	37.2	-13.8	-27.8	59.6	-77.0	-43.9	49.9	85.3
1966	88.3	11.8	-53.5	101.2	48.7	-35.4	-50.4	89.3	-17.6	-18.8	-81.2	15.3	104.9
1967	-78.0	-6.0	-46.9	-65.2	-11.7	-21.2	27.9	-31.3	-63.6	-24.4	-92.4	13.5	-392.2
1968	81.7	-15.7	-29.9	152.2	76.4	138.1	-2.6	-29.3	122.1	-41.7	55.4	37.7	551.7
1969	-60.0	68.1	116.9	69.7	45.4	-76.6	-22.2	-24.7	-19.2	5.3	-49.0	-12.1	49.0
1970	-63.3	16.8	22.4	-47.7	-11.5	-68.4	-90.5	17.4	-5.5	91.2	-65.2	-76.6	-273.6
1971	-92.5	-44.4	-84.0	-101.0	-4.4	-51.7	4.8	13.1	27.1	10.4	-8.6	19.4	-304.0
1972	20.0	-77.9	-8.6	-14.2	-96.0	33.2	103.8	-18.4	1.4	133.8	-12.9	-25.3	46.2
1973	34.5	-55.0	96.6	47.8	-59.5	82.9	-46.8	47.1	88.3	73.6	-2.2	3.1	317.7
1974	144.5	-65.2	-66.5	-8.1	4.5	-39.5	19.2	76.4	137.8	-14.2	71.2	-33.7	233.7
1975	-34.4	224.1	15.8	-23.8	38.8	98.7	-55.4	-14.8	-41.0	32.2	0.8	-54.8	193.5
1976	-66.9	-47.4	9.2	-45.1	20.3	30.6	-3.1	-50.4	-19.7	-23.9	-55.6	4.9	-239.8
1977	-13.5	-42.6	5.4	-34.5	-103.0	-7.2	-59.0	32.2	-21.2	-48.8	-37.3	-46.9	-369.3
1978	66.0	-34.7	-32.5	-25.6	-62.8	-44.3	-62.8	-24.5	-26.8	-61.4	28.5	-31.9	-305.5
1979	79.7	47.6	67.9	-7.6	215.9	31.4	68.0	17.9	42.6	43.2	69.6	-30.1	653.3
1980	-1.3	-53.0	-2.7	-2.5	23.8	-55.5	-50.4	-6.2	-36.4	-26.9	-20.0	-89.6	-313.4

Table 24. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	-48.8	-7.0	-13.4	-88.1	6.6	16.1	113.0	-26.0	75.6	65.8	-25.4	-104.0	-28.5
1982	-25.0	-45.7	10.0	157.5	-45.5	87.8	-17.1	-58.5	-13.8	57.4	51.6	100.9	266.9
1983	-66.6	45.5	20.4	-93.4	59.4	34.4	-61.3	9.3	-26.8	-53.6	-1.7	58.8	-68.3
1984	-57.2	45.5	-8.6	-74.1	-72.4	-67.4	14.9	-42.3	0.9	254.2	-35.0	-51.2	-85.4
1985	-10.2	18.9	13.5	60.0	-15.3	-72.0	26.4	5.2	8.8	129.3	79.3	-64.2	186.9
1986	-92.0	-36.3	-90.4	7.2	63.0	142.1	-17.6	10.8	1.7	68.8	71.9	16.6	153.2
1987	-71.2	47.3	-45.4	-104.0	-84.1	39.5	2.2	-32.1	-9.3	-30.7	86.9	11.5	-181.6
1988	-67.9	-59.6	10.0	-80.7	-122	-92.3	16.4	59.1	-29.3	-16.5	-53.3	-42.6	-471.7
1989	156.1	-47.7	61.8	-93.7	31.2	165.7	7.6	-37.9	22.0	-31.5	-56.8	-78.1	105.9
1990	91.1	7.7	31.5	-51.0	141.7	10.8	-14.3	-35.2	-46.1	7.6	-28.9	-15.2	107.2
1991	209.7	50.6	-44.7	146.6	109.9	-23.7	-69.2	136.3	-44.6	-3.8	15.0	58.0	547.6
1992	23.1	145.1	73.5	-60.1	-36.4	-44.1	-55.4	-7.2	0.4	-31.5	45.5	63.8	123.9
Mean	103.2	101.0	98.0	116.3	133.1	95.9	90.5	64.4	81.1	84.3	108.7	120.8	1190.0

Table 25. Raindays at Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	4	8	6	3	6	7	8	4	5	2	5	3	61
1902	8	6	9	5	4	1	16	2	9	4	11	4	79
1903	8	14	14	1	6	8	12	5	1	6	1	5	81
1904	7	6	7	7	3	8	9	4	5	2	3	4	65
1905	8	6	10	11	9	8	10	3	4	4	4	11	88
1906	4	2	7	8	6	9	7	7	5	4	6	7	72
1907	7	4	4	9	13	1	6	1	1	9	6	3	64
1908	3	9	5	5	6	4	5	9	6	1	9	4	66
1909	3	5	3	5	6	6	3	4	3	2	5	10	55
1910	3	5	3	4	7	7	6	4	4	4	5	8	60
mean	5.5	6.5	6.8	5.8	6.6	5.9	8.2	4.3	4.3	3.8	5.5	5.9	69.1
s.d.	2.3	3.3	3.5	3.0	2.8	2.9	3.8	2.3	2.4	2.3	2.8	2.9	10.6
max	8	14	14	11	13	9	16	9	9	9	11	11	88
min	3	2	3	1	3	1	3	1	1	1	1	3	55
1911	0	5	4	11	3	3	12	4	1	3	3	11	60
1912	3	4	9	9	6	7	3	5	0	3	4	9	62
1913	6	5	6	4	6	4	4	5	17	11	3	8	79
1914	3	11	9	6	15	3	5	11	4	2	8	11	88
1915	7	7	4	10	3	2	4	10	4	4	6	7	68
1916	9	1	1	6	7	7	10	4	5	1	5	5	61
1917	8	7	4	7	6	1	8	1	4	1	2	1	50
1918	4	5	6	8	3	4	3	9	5	8	9	7	71
1919	7	10	7	5	14	17	8	7	6	14	8	6	109
1920	14	6	8	6	6	12	11	14	5	7	8	11	108
mean	6.1	6.1	5.8	7.2	6.9	6.0	6.8	7.0	5.1	5.4	5.6	7.6	75.6
s.d.	3.9	2.9	2.6	2.3	4.3	5.0	3.4	3.9	4.6	4.5	2.5	3.2	20.3
max	14	11	9	11	15	17	12	14	17	14	9	11	109
min	0	1	1	4	3	1	3	1	0	1	2	1	50
1921	7	7	7	14	3	9	9	5	8	3	4	10	86
1922	17	9	12	11	13	9	9	8	5	4	8	10	115
1923	8	11	13	14	10	7	5	5	9	5	7	18	112
1924	8	10	7	9	10	6	1	0	5	1	5	9	71
1925	9	5	5	2	5	3	7	4	7	14	14	6	81
1926	11	3	14	5	8	10	8	8	4	5	6	11	93
1927	6	6	10	7	6	11	7	3	5	5	4	6	76
1928	2	11	8	11	3	9	9	2	8	7	8	6	84
1929	11	13	10	6	14	4	6	2	4	3	11	6	90
1930	11	11	7	3	9	2	3	8	10	7	7	9	87
mean	9.0	8.6	9.3	8.2	8.1	7.0	6.4	4.5	6.5	5.4	7.4	9.1	89.5
s.d.	3.9	3.2	3	4.3	3.8	3.1	2.7	2.8	2.2	3.5	3.1	3.7	14.2
max	17	13	14	14	14	11	9	8	10	14	14	18	115
min	2	3	5	2	3	2	1	0	4	1	4	6	71

Table 25. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1931	11	10	8	5	6	4	10	9	1	5	13	16	98
1932	16	10	5	5	5	4	4	7	6	5	6	18	91
1933	6	10	7	7	6	2	13	4	6	3	3	10	77
1934	12	7	9	9	8	1	8	3	8	3	9	12	89
1935	6	6	6	11	8	10	10	5	6	3	10	7	88
1936	6	7	11	8	10	2	7	5	6	7	6	10	85
1937	22	9	13	4	2	8	7	8	6	5	8	10	102
1938	11	3	10	7	5	8	10	6	5	4	6	11	86
1939	15	14	7	7	8	10	7	10	3	4	8	10	103
1940	4	12	3	12	8	9	7	11	3	5	12	11	97
mean	10.9	8.8	7.9	7.5	6.6	5.8	8.3	6.8	5.0	4.4	8.1	11.5	91.6
s.d.	5.6	3.2	3.0	2.6	2.3	3.6	2.5	2.7	2.1	1.3	3.0	3.2	8.3
max	22	14	13	12	10	10	13	11	8	7	13	18	103
min	4	3	3	4	2	1	4	3	1	3	3	7	77
1941	8	8	9	9	12	11	10	11	12	9	9	9	117
1942	7	6	8	10	10	12	8	10	4	7	7	9	98
1943	7	5	13	4	8	9	11	4	10	2	5	10	88
1944	13	13	8	10	12	7	6	9	6	2	11	10	107
1945	8	9	16	9	5	10	11	9	11	10	8	10	116
1946	15	10	9	5	16	8	7	9	4	9	13	10	115
1947	18	9	10	9	10	6	5	6	3	3	13	9	101
1948	15	17	12	8	7	4	7	8	2	3	14	4	101
1949	15	11	10	11	5	8	16	8	6	15	1	14	120
1950	18	12	8	11	11	6	9	4	7	4	2	3	95
mean	12.4	10.0	10.3	8.6	9.6	8.1	9.0	7.8	6.5	6.4	8.3	8.8	105.8
s.d.	4.5	3.5	2.6	2.4	3.4	2.5	3.2	2.4	3.5	4.3	4.6	3.2	10.8
max	18	17	16	11	16	12	16	11	12	15	14	14	120
min	7	5	8	4	5	4	5	4	2	2	1	3	88
1951	9	8	7	8	3	7	5	3	12	3	6	13	84
1952	6	9	9	7	9	5	7	2	4	0	10	11	79
1953	7	14	12	7	10	2	11	8	2	1	9	12	95
1954	13	3	8	4	7	3	4	3	4	9	3	6	67
1955	11	7	5	8	7	7	12	8	7	2	5	3	82
1956	7	8	7	6	7	11	1	3	1	6	7	8	72
1957	14	11	7	16	11	11	8	4	9	5	17	5	118
1958	6	8	11	12	8	9	4	7	13	7	9	6	100
1959	6	14	5	9	3	10	9	10	9	5	4	11	95
1960	12	7	6	5	3	8	8	14	5	7	9	13	97
mean	9.1	8.9	7.7	8.2	6.8	7.3	6.9	6.2	6.6	4.5	7.9	8.8	88.9
s.d.	3.1	3.3	2.4	3.5	2.9	3.2	3.4	3.9	4.1	2.9	4.0	3.6	15.1
max	14	14	12	16	11	11	12	14	13	9	17	13	118
min	6	3	5	4	3	2	1	2	1	0	3	3	67

Table 25. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	9	10	11	4	4	11	13	7	5	4	9	10	97
1962	13	8	8	8	3	10	3	5	7	5	8	9	87
1963	5	7	3	7	4	8	10	6	8	1	9	6	74
1964	11	10	7	8	6	7	1	5	10	4	9	10	88
1965	5	11	13	3	16	9	5	6	6	1	5	10	90
1966	9	9	3	8	10	5	4	10	7	5	7	11	88
1967	8	7	5	3	7	2	10	4	6	3	5	16	76
1968	13	12	9	11	6	11	7	5	9	4	9	8	104
1969	7	8	9	8	9	2	5	4	5	7	4	6	74
1970	6	8	10	5	6	6	0	7	10	9	3	8	78
mean	8.6	9.0	7.8	6.5	7.1	7.1	5.8	5.9	7.3	4.3	6.8	9.4	85.6
s.d.	3.0	1.7	3.3	2.6	3.8	3.3	4.2	1.8	1.9	2.5	2.3	2.9	10.1
max	13	12	13	11	16	11	13	10	10	9	9	16	104
min	5	7	3	3	3	2	0	4	5	1	3	6	74
1971	3	7	7	5	7	8	7	8	11	7	4	12	86
1972	10	4	9	5	7	5	10	10	10	7	8	11	96
1973	10	7	12	10	8	11	6	12	9	10	7	7	109
1974	18	4	6	3	7	8	5	14	11	4	15	9	104
1975	11	8	10	8	12	13	6	8	6	7	5	7	101
1976	5	5	14	7	9	5	8	6	8	5	5	9	86
1977	6	5	6	8	3	4	5	8	6	3	5	8	67
1978	13	9	9	5	8	2	4	4	10	6	6	7	83
1979	15	13	9	11	8	7	9	11	6	2	7	7	105
1980	10	7	15	6	12	1	2	3	9	5	5	3	78
mean	10.1	6.9	9.7	6.8	8.1	6.4	6.2	8.4	8.6	5.6	6.7	8.0	91.5
s.d.	4.6	2.7	3.1	2.5	2.6	3.8	2.4	3.5	2.0	2.3	3.2	2.5	13.6
max	18	13	15	11	12	13	10	14	11	10	15	12	109
min	3	4	6	3	3	1	2	3	6	2	4	3	67
1981	6	5	8	5	12	8	9	3	5	10	5	5	81
1982	11	5	9	14	6	6	8	2	6	10	8	13	98
1983	8	7	7	7	9	12	6	7	5	4	5	14	91
1984	5	8	9	4	4	4	5	4	5	16	7	7	78
1985	8	9	9	6	8	2	8	6	7	11	9	4	87
1986	5	4	5	6	11	14	3	9	10	9	12	13	101
1987	7	13	9	5	8	11	8	5	6	4	7	10	93
1988	6	10	9	5	5	3	6	6	6	7	6	10	79
1989	16	7	10	4	9	14	6	6	5	6	6	5	94
1990	16	11	10	7	6	4	10	4	9	6	6	12	101
mean	8.8	7.9	8.5	6.3	7.8	7.8	6.9	5.2	6.4	8.3	7.1	9.3	90.3
s.d.	4.2	2.9	1.5	2.9	2.6	4.6	2.1	2.0	1.8	3.7	2.1	3.8	8.7
max	16	13	10	14	12	14	10	9	10	16	12	14	101
min	5	4	5	4	4	2	3	2	5	4	5	4	78

Table 25. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1991	11	12	8	14	14	11	7	11	8	5	11	16	128
1992	15	12	10	4	9	8	6	6	5	4	14	18	111

Table 25. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	6.9	7.1	7.3	7.1	7.2	6.3	7.1	5.3	5.3	4.9	6.2	7.5	78.1
s.d.	3.7	3.2	3.3	3.3	3.6	3.7	3.3	3.2	3.2	3.5	2.9	3.4	17.3
max	17	14	14	14	15	17	16	14	17	14	14	18	115
min	0	1	1	1	3	1	1	0	0	1	1	1	50
1911-40													
mean	8.7	7.8	7.7	7.6	7.2	6.3	7.2	6.1	5.5	5.1	7.0	9.4	85.6
s.d.	4.8	3.2	3.1	3.1	3.5	3.9	2.9	3.3	3.1	3.3	3.0	3.6	16.2
max	22	14	14	14	15	17	13	14	17	14	14	18	115
min	0	1	1	2	2	1	1	0	0	1	2	1	50
1921-50													
mean	10.8	9.1	9.2	8.1	8.1	7.0	7.9	6.4	6.0	5.4	7.9	9.8	95.6
s.d.	4.8	3.2	2.9	3.1	3.4	3.1	2.9	2.9	2.7	3.3	3.6	3.5	13.2
max	22	17	16	14	16	12	16	11	12	15	14	18	120
min	2	3	3	2	2	1	1	0	1	1	1	3	71
1931-60													
mean	10.8	9.2	8.6	8.1	7.7	7.1	8.1	6.9	6.0	5.1	8.1	9.7	95.4
s.d.	4.6	3.3	2.8	2.8	3.1	3.1	3.1	3	3.3	3.1	3.8	3.5	13.6
max	22	17	16	16	16	12	16	14	13	15	17	18	120
min	4	3	3	4	2	1	1	2	1	0	1	3	67
1941-70													
mean	10.0	9.3	8.6	7.8	7.8	7.5	7.2	6.6	6.8	5.1	7.7	9.0	93.4
s.d.	3.9	2.9	3.0	2.9	3.5	2.9	3.7	2.9	3.2	3.4	3.7	3.1	14.8
max	18	17	16	16	16	12	16	14	13	15	17	16	120
min	5	3	3	3	3	2	0	2	1	0	1	3	67
1951-80													
mean	9.3	8.3	8.4	7.2	7.3	6.9	6.3	6.8	7.5	4.8	7.1	8.7	88.7
s.d.	3.6	2.8	3.0	2.9	3.1	3.3	3.3	3.3	2.9	2.6	3.2	3.0	12.9
max	18	14	15	16	16	13	13	14	13	10	17	16	118
min	3	3	3	3	3	1	0	2	1	0	3	3	67
1961-90													
mean	9.2	7.9	8.7	6.5	7.7	7.1	6.3	6.5	7.4	6.1	6.9	8.9	89.1
s.d.	3.9	2.6	2.8	2.6	3.0	3.9	3.0	2.8	2.0	3.3	2.5	3.1	10.9
max	18	13	15	14	16	14	13	14	11	16	15	16	109
min	3	4	3	3	3	1	0	2	5	1	3	3	67

Table 26. Maximum Monthly and Annual Wet Spells (in days) at Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	3	3	2	1	3	2	2	3	4	1	2	2	4
1902	4	3	6	2	2	1	2	9	4	2	5	1	9
1903	3	3	7	1	2	3	4	7	1	3	1	2	7
1904	1	4	2	2	2	3	4	2	3	1	2	2	4
1905	3	2	3	3	3	4	3	1	1	1	1	4	4
1906	2	1	3	2	1	4	2	3	3	2	4	3	4
1907	2	2	2	4	4	1	4	1	1	3	2	1	4
1908	1	3	2	3	1	2	2	3	3	1	2	2	3
1909	2	1	2	1	2	3	2	2	2	1	2	3	3
1910	1	2	1	2	4	3	2	1	1	3	3	3	4
1911	0	1	2	3	1	2	6	1	1	1	1	3	6
1912	1	2	3	3	2	2	1	3	0	2	1	3	3
1913	2	1	3	2	3	2	2	1	11	5	2	3	11
1914	2	3	4	4	5	3	3	3	3	1	5	4	5
1915	1	2	2	6	2	1	3	4	2	2	2	2	6
1916	3	1	1	1	2	2	4	1	2	1	2	2	4
1917	3	2	1	2	2	1	2	1	2	1	1	1	3
1918	1	2	3	2	1	1	1	3	2	2	3	2	3
1919	4	4	2	2	5	9	5	4	4	9	2	2	9
1920	4	2	3	3	2	4	2	7	2	3	2	3	7
1921	3	4	2	4	2	3	4	3	3	1	3	3	4
1922	7	4	7	4	4	6	4	3	2	1	4	4	7
1923	3	4	5	3	3	4	2	3	3	2	3	7	7
1924	2	4	2	3	2	5	1	0	2	1	2	2	5
1925	4	2	2	1	2	1	2	2	3	5	6	3	6
1926	4	2	4	1	2	3	3	1	3	2	2	5	5
1927	3	2	3	2	2	3	3	1	2	3	2	2	3
1928	1	4	4	3	1	3	6	1	2	2	2	3	6
1929	3	3	3	2	4	1	4	1	2	1	6	1	6
1930	7	4	2	2	2	1	1	2	4	3	2	2	7
1931	2	2	2	2	2	2	4	3	1	2	5	5	5
1932	4	5	1	2	3	2	2	2	3	2	3	5	5
1933	2	3	2	2	2	2	5	1	4	1	1	4	5
1934	3	2	5	2	6	1	3	2	3	1	4	3	6
1935	7	3	3	3	4	3	3	3	3	1	4	2	7
1936	2	2	4	2	4	1	2	3	3	2	2	2	4
1937	7	4	3	2	1	2	3	5	2	2	3	2	7
1938	4	2	3	3	2	3	7	3	3	1	2	6	7
1939	5	4	2	2	4	5	2	5	2	2	5	6	6
1940	1	5	2	3	4	2	3	3	3	2	6	5	6

Table 26. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	3	3	2	5	4	3	6	2	3	3	4	3	6
1942	2	3	2	4	2	7	2	2	3	2	2	4	7
1943	3	3	3	2	2	2	4	2	4	1	3	4	4
1944	4	6	2	3	6	3	3	1	6	1	5	5	6
1945	2	3	4	5	2	3	6	4	5	4	3	2	6
1946	5	3	4	3	4	4	2	7	4	4	6	4	7
1947	8	2	3	3	5	5	1	1	2	2	3	4	8
1948	5	6	3	4	3	1	2	7	2	1	5	1	7
1949	8	4	3	2	2	4	6	3	3	5	1	7	8
1950	6	8	2	2	3	2	2	2	2	2	1	1	8
1951	3	3	3	2	2	2	2	2	3	1	4	3	4
1952	2	3	2	2	2	2	5	1	2	0	3	6	6
1953	4	4	4	2	8	2	5	4	1	1	2	5	8
1954	4	2	4	2	3	1	1	3	2	8	2	3	8
1955	5	4	4	5	2	3	6	3	4	1	1	2	6
1956	3	4	4	1	4	9	1	2	2	2	3	3	9
1957	2	16	1	6	5	4	7	2	3	3	6	3	16
1958	3	3	4	5	11	4	3	2	8	2	6	2	11
1959	2	5	1	5	1	3	4	3	3	2	2	4	5
1960	3	2	2	3	1	3	6	5	3	4	3	7	7
1961	4	6	2	1	2	7	5	2	2	2	4	4	7
1962	7	3	3	2	1	2	3	3	5	1	4	6	7
1963	2	2	1	2	1	2	6	2	3	1	5	3	6
1964	3	3	2	2	3	3	1	2	4	2	2	3	4
1965	2	7	4	2	5	4	2	3	5	1	2	6	7
1966	2	2	2	4	3	2	2	2	3	1	4	3	4
1967	4	2	3	1	2	4	4	1	2	1	3	4	4
1968	5	3	4	3	3	9	4	2	4	1	3	2	9
1969	2	5	4	3	4	1	1	1	1	4	3	3	5
1970	2	3	2	1	2	4	0	2	4	2	1	2	4
1971	1	2	2	3	2	3	3	4	3	3	2	3	4
1972	2	4	2	2	3	4	2	3	4	2	3	8	8
1973	3	2	3	3	3	4	3	4	4	7	2	3	7
1974	4	1	3	2	2	3	2	3	4	3	4	1	4
1975	8	5	4	2	4	6	3	3	3	5	2	3	8
1976	1	2	5	2	2	2	2	1	3	1	2	5	5
1977	2	2	2	2	3	4	2	6	3	2	2	4	6
1978	4	4	3	2	3	1	1	2	5	3	1	2	5
1979	5	5	3	6	3	4	5	3	4	1	3	3	6
1980	3	3	7	2	7	1	1	2	2	3	2	3	7

Table 26. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	3	2	2	3	3	4	3	1	4	5	2	2	5
1982	3	2	2	5	2	3	5	1	3	4	4	5	5
1983	3	2	2	2	3	3	2	2	3	1	1	5	5
1984	2	2	2	1	2	2	2	1	2	5	2	2	5
1985	5	3	2	2	3	1	4	1	4	4	4	3	5
1986	4	2	2	4	3	8	1	3	3	4	4	6	8
1987	3	5	4	3	1	5	2	2	3	2	3	4	5
1988	2	5	2	4	2	1	2	2	2	5	2	3	5
1989	5	3	4	3	5	4	2	3	2	2	2	1	5
1990	6	4	3	3	1	2	3	3	3	2	2	4	6
1991	3	7	2	5	4	3	1	7	4	1	4	5	7
1992	3	4	3	2	4	3	3	2	3	2	3	5	5

All wet spells are reported for the month in which they end.

Table 27. Maximum Monthly Annual Dry Spells (in days) at Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	9	11	8	10	19	19	7	23	13	12	21	16	23
1902	21	12	8	9	8	40	8	12	18	15	9	9	40
1903	10	6	5	32	13	6	12	10	18	15	*	32	32
1904	11	7	24	10	3	29	10	18	9	17	24	18	29
1905	8	10	14	6	6	24	9	17	10	16	14	9	24
1906	9	16	8	7	13	13	9	6	18	7	33	12	33
1907	10	19	14	6	8	2	36	22	25	16	7	8	36
1908	20	6	13	17	10	15	15	12	19	27	9	14	27
1909	24	6	12	24	19	11	24	15	13	22	13	5	24
1910	11	13	11	5	28	12	5	17	16	2	29	10	29
1911	*	41	18	5	10	27	11	13	3	41	16	8	41
1912	11	14	9	6	13	11	14	12	*	53	16	7	53
1913	6	10	9	13	9	18	17	11	6	5	22	7	22
1914	24	4	7	12	6	16	18	15	22	18	23	9	24
1915	8	8	15	17	19	17	15	12	20	8	21	8	21
1916	9	12	40	8	12	15	10	10	19	18	21	11	40
1917	7	8	10	7	13	6	28	20	16	39	22	11	39
1918	30	11	17	7	6	17	16	7	13	10	12	14	30
1919	9	8	8	19	5	6	17	12	13	12	14	6	19
1920	16	13	7	12	12	7	6	4	9	15	10	6	16
1921	7	11	13	4	12	19	7	17	10	14	19	6	19
1922	5	9	6	4	8	7	11	12	6	16	4	18	18
1923	11	9	6	5	4	10	9	23	8	12	11	3	23
1924	7	8	11	8	7	16	33	*	37	31	9	10	37
1925	12	13	13	19	10	11	14	23	10	7	5	6	23
1926	13	16	6	7	10	7	6	19	13	7	8	14	19
1927	15	12	7	7	8	13	14	12	16	21	8	15	21
1928	22	5	9	11	8	12	11	20	8	10	9	9	22
1929	17	5	6	9	9	16	16	13	12	23	6	6	23
1930	7	6	10	24	5	13	20	6	7	12	8	6	24
1931	7	6	8	17	11	9	8	6	12	24	14	6	24
1932	5	6	18	15	7	25	15	10	13	11	12	7	25
1933	10	6	6	8	19	11	22	15	11	18	7	21	22
1934	6	7	8	9	9	10	26	15	12	14	15	9	26
1935	9	16	6	21	9	5	8	11	14	21	14	9	21
1936	9	9	6	7	10	19	7	23	11	14	13	8	23
1937	2	14	4	15	2	30	18	10	16	10	14	7	30
1938	10	17	13	9	10	14	7	8	16	13	11	8	17
1939	4	4	16	9	9	8	18	11	19	13	15	13	19
1940	8	9	17	6	8	9	14	8	23	12	9	6	23

Table 27. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	7	13	8	12	5	6	11	11	4	10	12	7	13
1942	10	9	11	11	5	11	6	17	10	14	6	5	17
1943	10	10	4	15	18	6	4	17	9	12	19	7	19
1944	9	5	4	7	14	15	13	16	19	8	22	14	22
1945	10	11	4	10	11	12	9	10	7	11	13	5	13
1946	7	7	9	19	2	8	9	16	27	10	8	9	27
1947	4	6	6	5	11	16	11	12	14	36	2	15	36
1948	6	5	5	8	13	13	10	23	8	26	3	10	26
1949	12	8	6	7	16	13	6	7	6	13	11	21	21
1950	5	7	7	8	5	7	13	10	14	10	12	16	16
1951	12	6	12	9	6	24	12	17	15	15	17	5	24
1952	16	8	6	6	8	16	14	10	13	*	47	9	47
1953	13	4	5	10	5	41	12	11	14	36	9	6	41
1954	12	15	13	11	12	16	17	20	15	11	10	25	25
1955	5	12	22	7	13	7	8	9	9	8	27	1	27
1956	44	9	16	11	10	10	21	36	29	16	7	17	44
1957	14	11	6	5	4	6	21	13	7	20	10	11	21
1958	13	11	6	9	14	8	19	8	5	13	8	10	19
1959	7	4	8	7	19	8	7	6	10	15	6	16	19
1960	6	11	10	14	14	10	17	7	20	9	10	12	20
1961	10	9	6	13	12	13	6	7	4	18	7	11	18
1962	17	18	7	11	14	8	17	14	9	7	9	22	22
1963	15	8	9	13	10	20	10	9	9	17	19	7	20
1964	14	6	5	13	21	10	27	20	11	15	9	5	27
1965	12	13	6	18	9	7	16	15	16	11	30	18	30
1966	8	7	14	15	6	12	17	10	14	13	14	5	17
1967	6	9	19	14	13	*	29	19	10	13	16	3	29
1968	7	11	6	9	5	14	16	5	17	10	9	9	17
1969	12	5	8	11	11	4	32	8	11	17	13	16	32
1970	7	8	7	7	13	19	*	39	12	9	6	27	39
1971	14	12	8	18	14	13	19	9	4	10	27	12	27
1972	8	4	18	11	13	16	11	6	10	19	5	10	19
1973	6	8	6	5	11	7	13	8	10	10	10	7	13
1974	7	8	15	15	9	6	15	3	9	16	4	6	16
1975	6	10	7	8	8	8	17	13	9	23	16	7	23
1976	8	10	12	7	9	14	8	12	12	8	12	4	14
1977	13	11	8	10	*	41	23	14	14	19	19	14	41
1978	5	9	6	10	15	4	37	14	6	14	8	11	37
1979	5	6	10	8	11	17	10	6	11	30	10	16	30
1980	7	12	4	9	5	29	30	15	7	16	17	10	30

Table 27. Continued.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	26	11	8	13	4	12	14	26	11	19	16	13	26
1982	7	16	7	5	8	19	12	9	36	11	8	6	36
1983	14	10	11	8	9	7	8	11	8	13	16	3	16
1984	13	5	5	16	10	14	12	9	17	11	6	13	17
1985	9	11	9	20	7	14	17	7	17	13	8	13	20
1986	14	9	20	20	6	8	11	12	8	8	11	12	20
1987	10	7	7	5	19	6	6	16	10	21	12	10	21
1988	12	3	12	18	8	16	7	11	8	22	9	12	22
1989	4	10	14	13	8	14	16	6	20	22	9	14	22
1990	7	6	9	10	8	21	8	15	5	10	13	9	21
1991	4	10	9	7	5	5	9	14	14	18	7	5	18
1992	4	5	7	13	9	14	18	8	17	12	5	10	18

All dry spells are reported for the month in which they end.
* Dry spell continues to the next month.

APPENDIX II
(Temperature Data)

Table 28. Mean Monthly and Annual Temperature (in °C) for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	10.9	9.0	14.1	16.5	21.8	26.8	28.1	28.3	23.5	18.7	13.5	7.8	18.3
1902	7.1	8.3	15.0	20.4	24.5	26.6	26.6	28.5	23.4	19.1	16.5	9.2	18.8
1903	8.1	9.2	14.8	18.0	20.4	22.1	26.0	26.9	22.7	17.2	12.4	8.4	17.2
1904	6.8	13.0	17.1	17.3	22.0	25.7	26.1	27.3	25.6	20.2	13.5	9.7	18.7
1905	6.0	5.0	17.3	18.4	24.0	26.7	25.8	27.4	25.2	18.9	15.7	5.5	18.0
1906	9.1	9.0	12.4	19.2	22.2	26.0	26.4	26.2	25.3	15.9	14.4	12.2	18.2
1907	9.1	12.1	20.1	16.1	20.3	25.9	27.7	28.4	25.8	19.6	11.6	10.5	18.9
1908	9.4	10.1	18.8	20.0	22.6	26.4	26.7	26.6	24.1	16.9	14.4	11.7	19.0
1909	11.2	12.1	15.1	18.0	21.4	25.9	28.7	28.8	25.4	19.7	17.8	6.3	19.2
1910	10.0	8.8	17.3	17.4	21.3	24.9	26.9	28.2	26.3	19.9	14.4	9.3	18.7
mean	8.8	9.6	16.2	18.1	22.1	25.7	26.9	27.7	24.7	18.6	14.4	9.0	18.5
s.d.	1.7	2.3	2.3	1.4	1.4	1.4	1.0	0.9	1.2	1.4	1.9	2.2	0.6
max	11.2	13.0	20.1	20.4	24.5	26.8	28.7	28.8	26.3	20.2	17.8	12.2	19.2
min	6.0	5.0	12.4	16.1	20.3	22.1	25.8	26.2	22.7	15.9	11.6	5.5	17.2
1911	13.1	14.7	16.5	18.2	21.6	27.7	26.5	27.3	27.7	19.5	11.3	8.5	19.4
1912	6.9	7.2	11.7	18.3	22.2	24.0	28.0	27.0	25.0	19.8	11.9	7.6	17.5
1913	9.2	8.8	12.4	17.4	21.5	24.8	27.9	27.8	22.6	17.4	17.4	8.9	18.0
1914	11.3	8.3	12.6	18.1	22.2	27.6	29.2	26.8	24.5	18.5	12.9	5.5	18.1
1915	6.3	10.4	8.1	17.4	22.7	27.3	27.1	25.7	24.7	19.2	14.9	9.9	17.8
1916	11.4	10.2	15.6	17.1	22.0	26.3	28.0	27.8	24.6	19.2	13.0	10.3	18.8
1917	10.5	11.2	14.1	17.2	18.9	26.2	29.1	28.7	24.5	17.0	12.4	7.1	18.1
1918	4.2	12.9	18.0	17.8	23.4	28.4	28.5	27.7	22.7	20.4	12.6	12.3	19.1
1919	8.6	10.8	15.9	19.3	21.6	25.1	27.9	28.3	25.8	23.3	15.9	9.1	19.3
1920	9.3	12.5	14.9	18.8	24.4	25.9	28.0	26.6	26.5	18.9	11.2	8.4	18.8
mean	9.1	10.7	14.0	18.0	22.1	26.3	28.0	27.4	24.9	19.3	13.3	8.8	18.5
s.d.	2.7	2.3	2.9	0.7	1.4	1.4	0.8	0.9	1.5	1.7	2.1	1.9	0.7
max	13.1	14.7	18.0	19.3	24.4	28.4	29.2	28.7	27.7	23.3	17.4	12.3	19.4
min	4.2	7.2	8.1	17.1	18.9	24.0	26.5	25.7	22.6	17.0	11.2	5.5	17.5

Table 28. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1921	11.5	11.2	17.6	15.8	21.6	26.2	27.7	28.4	27.3	19.0	17.3	13.0	19.7
1922	7.8	13.5	14.5	19.7	23.5	26.6	27.7	27.7	26.4	19.5	14.6	13.2	19.6
1923	13.7	10.3	11.5	17.8	21.3	26.3	27.7	28.5	24.7	18.6	12.1	12.0	18.7
1924	6.5	9.0	11.7	18.1	20.2	26.8	28.2	30.1	24.0	19.5	14.0	7.7	18.0
1925	6.6	11.5	14.2	19.1	20.4	27.4	28.7	27.7	26.4	18.1	12.0	6.8	18.2
1926	7.2	12.4	11.2	15.5	20.7	24.7	26.1	27.5	26.6	21.7	11.7	10.3	18.0
1927	10.5	13.5	13.6	20.0	23.6	25.0	26.8	28.0	25.3	20.4	18.2	7.6	19.4
1928	8.9	9.8	14.3	15.0	21.8	24.8	27.1	27.9	23.5	20.9	12.3	8.5	17.9
1929	9.6	5.7	15.8	20.1	21.1	25.3	26.6	27.5	25.0	19.6	9.8	9.1	17.9
1930	5.1	13.3	11.9	20.2	22.0	25.0	28.2	27.8	24.7	17.7	12.9	7.3	18.0
mean	8.7	11.0	13.6	18.1	21.6	25.8	27.5	28.1	25.4	19.5	13.5	9.6	18.5
s.d.	2.6	2.4	2.1	2.0	1.2	1.0	0.8	0.8	1.2	1.3	2.6	2.4	0.7
max	13.7	13.5	17.6	20.2	23.6	27.4	28.7	30.1	27.3	21.7	18.2	13.2	19.7
min	5.1	5.7	11.2	15.0	20.2	24.7	26.1	27.5	23.5	17.7	9.8	6.8	17.9
1931	8.8	11.6	10.5	16.2	19.2	25.8	28.4	25.7	26.5	21.6	16.4	11.2	18.5
1932	11.1	15.0	11.8	18.8	21.7	25.7	28.2	27.0	23.6	17.1	9.5	7.1	18.1
1933	11.2	8.2	14.0	16.5	22.7	24.6	26.7	26.9	26.3	19.8	14.1	13.8	18.7
1934	9.7	11.3	13.6	19.9	22.0	27.2	28.7	29.2	24.3	21.9	15.5	8.8	19.3
1935	10.5	10.2	17.9	18.2	21.5	25.6	27.9	28.5	24.0	21.2	13.4	8.0	18.9
1936	8.3	8.3	16.7	17.4	22.3	27.1	27.0	28.3	25.8	17.7	11.8	10.8	18.4
1937	10.9	11.2	12.0	17.2	22.4	26.7	27.6	28.3	24.3	18.3	11.0	9.2	18.3
1938	9.1	14.2	18.0	17.8	22.1	26.0	27.3	27.3	24.9	21.2	12.9	9.9	19.2
1939	10.8	11.1	15.5	17.9	22.1	26.5	28.9	28.5	27.0	20.6	12.0	11.8	19.4
1940	2.5	9.4	15.0	18.0	21.0	24.2	26.8	25.7	22.7	19.8	13.3	12.2	17.6
mean	9.3	11.0	14.5	17.8	21.7	25.9	27.8	27.5	24.9	19.9	13.0	10.3	18.6
s.d.	2.6	2.2	2.6	1.1	1.0	1.0	0.8	1.2	1.4	1.7	2.0	2.1	0.6
max	11.2	15.0	18.0	19.9	22.7	27.2	28.9	29.2	27.0	17.1	16.4	13.8	19.4
min	2.5	8.2	10.5	16.2	19.2	24.2	26.7	25.7	22.7	21.9	9.5	7.1	17.6

Table 28. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	10.8	8.5	11.7	19.0	22.5	25.5	27.1	27.8	25.8	22.4	12.1	11.0	18.7
1942	7.6	9.1	13.8	18.9	21.9	26.0	27.1	27.7	23.4	19.6	15.8	10.4	18.4
1943	9.1	12.5	13.1	19.6	23.8	27.5	28.0	28.3	23.3	18.1	11.8	8.7	18.7
1944	8.5	13.8	14.7	18.4	21.6	26.7	28.1	28.4	24.6	19.6	14.0	7.5	18.8
1945	7.9	13.3	18.6	19.5	22.1	26.9	27.5	27.8	26.2	18.6	16.8	9.1	19.5
1946	8.8	11.8	16.8	21.0	22.5	25.4	27.7	27.6	24.5	20.4	15.9	12.9	19.6
1947	9.3	7.6	11.7	20.0	22.2	26.6	27.3	29.3	26.9	23.9	13.0	11.3	19.1
1948	5.8	11.0	15.6	20.9	23.2	27.2	28.4	28.8	24.5	19.1	12.8	11.3	19.0
1949	8.1	11.7	13.8	16.8	23.8	26.3	27.4	25.9	24.0	19.2	13.9	10.7	18.5
1950	13.0	12.4	13.1	16.9	23.3	25.3	26.3	26.7	23.6	20.4	12.2	8.7	18.5
mean	8.9	11.2	14.3	19.1	22.7	26.3	27.5	27.8	24.7	20.1	13.8	10.2	18.9
s.d.	1.9	2.1	2.2	1.4	0.8	0.8	0.6	1.0	1.2	1.8	1.8	1.6	0.4
max	13.0	13.8	18.6	21.0	23.8	27.5	28.4	29.3	26.9	23.9	16.8	12.9	19.6
min	5.8	7.6	11.7	16.8	21.6	25.3	26.3	25.9	23.3	18.1	11.8	7.5	18.4
1951	9.1	10.0	14.6	17.7	22.6	26.6	28.6	29.8	25.1	20.6	12.1	10.8	19.0
1952	13.7	12.0	13.0	16.7	21.8	27.2	27.6	28.6	24.6	16.6	13.1	8.5	18.6
1953	10.9	10.1	17.6	17.6	23.3	28.4	27.1	27.2	25.0	20.8	12.3	7.5	19.0
1954	9.7	13.7	13.0	20.2	20.2	26.3	29.6	29.6	26.7	21.3	12.5	9.9	19.4
1955	8.2	9.8	15.7	20.5	24.2	25.3	28.4	27.6	26.8	19.2	13.0	9.8	19.1
1956	9.0	11.7	14.0	17.7	24.3	26.3	29.5	29.3	25.4	21.2	12.1	12.0	19.4
1957	9.3	14.5	13.0	18.5	23.3	26.5	29.0	28.3	24.1	17.6	13.0	10.9	19.0
1958	7.1	6.9	11.2	17.8	23.1	26.8	28.2	28.2	24.8	19.0	14.2	7.9	17.9
1959	6.3	11.0	12.8	17.2	24.6	26.6	28.0	28.1	25.7	19.9	10.1	10.2	18.4
1960	7.9	6.9	10.0	19.3	22.3	26.7	28.7	28.5	25.3	21.4	14.5	7.3	18.2
mean	9.1	10.7	13.5	18.3	23.0	26.7	28.5	28.5	25.4	19.8	12.7	9.5	18.8
s.d.	2.1	2.5	2.2	1.3	1.3	0.8	0.8	0.9	0.9	1.6	1.2	1.6	0.5
max	13.7	14.5	17.6	20.5	24.6	28.4	29.6	29.8	26.8	21.4	14.5	12.0	19.4
min	6.3	6.9	10.0	16.7	20.2	25.3	27.1	27.2	24.1	16.6	10.8	7.3	17.9

Table 28. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	5.9	11.8	16.4	16.6	22.6	25.0	27.1	26.8	25.2	18.7	12.4	9.4	18.2
1962	5.7	14.3	11.9	17.9	23.9	26.5	28.7	29.1	25.5	21.3	13.1	8.6	18.9
1963	4.1	9.1	15.8	21.6	24.3	27.3	28.7	28.6	25.5	22.1	15.4	5.2	19.0
1964	7.9	7.6	14.4	20.6	24.1	27.0	29.0	29.3	25.2	18.0	15.3	10.2	19.1
1965	10.8	8.3	10.1	21.5	23.8	26.6	28.8	28.3	25.8	18.5	17.6	11.0	19.3
1966	6.6	8.8	14.0	19.2	22.7	25.7	29.5	27.2	24.5	18.1	15.5	8.7	18.4
1967	8.5	8.5	17.0	22.4	21.9	27.0	26.9	27.5	23.5	18.3	14.0	10.0	18.8
1968	7.4	7.0	12.4	19.0	22.6	25.6	27.1	28.0	23.3	19.5	12.1	8.9	17.7
1969	9.7	10.0	10.3	19.2	22.5	26.5	30.1	28.8	25.4	20.4	12.9	9.9	18.8
1970	5.7	9.6	12.7	20.1	22.4	26.3	28.1	29.2	26.8	18.0	11.6	13.7	18.7
mean	7.2	9.5	13.5	19.8	23.1	26.3	28.4	28.3	25.1	19.3	14.0	9.6	18.7
s.d.	2.0	2.2	2.4	1.8	0.8	0.7	1.1	0.9	1.1	1.5	1.9	2.1	0.5
max	10.8	14.3	17.0	22.4	24.3	27.3	30.1	29.3	26.8	22.1	17.6	13.7	19.3
min	4.1	7.0	10.1	16.6	21.9	25.0	26.9	26.8	23.3	18.0	11.6	5.2	17.7
1971	10.7	10.6	13.5	18.2	22.0	27.6	28.7	27.0	25.5	21.5	14.0	13.2	19.4
1972	10.2	10.7	16.2	19.8	22.5	26.8	26.7	27.8	27.0	18.8	11.1	7.2	18.7
1973	5.9	9.3	16.1	16.6	22.0	25.2	27.6	26.2	24.8	20.6	17.9	9.5	18.5
1974	9.0	11.4	17.6	18.5	23.8	24.7	27.4	26.7	21.3	19.3	13.0	9.2	18.5
1975	10.8	10.0	14.1	18.0	23.0	25.3	26.8	27.0	22.7	19.3	13.3	9.6	18.3
1976	8.3	14.2	15.2	18.8	19.8	24.3	26.4	26.5	23.7	15.1	9.6	8.0	17.5
1977	3.5	10.2	14.8	18.5	23.3	26.9	28.7	27.8	25.7	19.2	14.2	9.4	18.5
1978	2.5	4.4	12.6	19.3	23.1	26.4	29.1	28.1	25.2	19.2	15.7	9.5	17.9
1979	3.3	7.7	14.3	18.3	22.7	25.3	27.2	26.8	23.0	20.3	11.4	9.6	17.5
1980	9.4	8.7	12.9	16.7	22.4	27.5	29.6	28.7	27.2	17.8	12.2	10.3	18.6
mean	7.4	9.7	14.7	18.3	22.5	26.0	27.8	27.3	24.6	19.1	13.2	9.5	18.3
s.d.	3.2	2.5	1.6	1.0	1.1	1.2	1.1	0.8	1.9	1.8	2.4	1.5	0.6
max	10.8	14.2	17.6	19.8	23.8	27.6	29.6	28.7	27.2	21.5	17.9	13.2	19.4
min	2.5	4.4	12.6	16.6	19.8	24.3	26.4	26.2	21.3	15.1	9.6	7.2	17.5

Table 28. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	7.7	10.1	13.7	21.5	21.3	26.7	28.1	27.7	23.3	18.6	14.5	9.1	18.5
1982	8.2	8.4	15.9	17.2	22.8	26.1	27.6	28.7	25.0	18.2	13.5	10.9	18.5
1983	7.5	9.4	12.9	15.9	21.2	24.3	27.2	27.5	24.0	19.6	14.0	4.1	17.3
1984	5.6	10.8	14.2	18.4	22.9	26.0	28.1	28.3	24.1	20.4	13.3	14.8	18.9
1985	4.9	8.5	16.8	19.8	22.7	26.6	27.5	28.6	25.5	20.4	16.5	6.9	18.7
1986	10.0	12.8	15.3	19.7	22.1	26.3	28.3	26.9	26.1	18.9	14.1	8.3	19.1
1987	7.8	11.1	13.4	18.1	23.5	25.8	27.5	29.2	23.8	18.2	14.7	10.4	18.6
1988	6.0	9.4	14.0	18.8	22.1	26.4	27.8	28.2	25.4	19.0	14.8	10.2	18.5
1989	11.0	8.3	14.5	19.3	23.9	24.0	26.4	27.0	23.3	18.8	14.5	4.2	17.9
1990	11.0	13.0	14.9	18.0	22.9	27.6	27.7	28.5	26.3	18.5	15.4	8.8	19.4
mean	8.0	10.2	14.6	18.7	22.5	26.0	27.6	28.1	24.7	19.1	14.5	8.8	18.6
s.d.	2.2	1.7	1.2	1.6	0.9	1.1	0.5	0.8	1.1	0.8	0.9	3.2	0.6
max	11.0	13.0	16.8	21.5	23.9	27.6	28.3	29.2	26.3	20.4	16.5	14.8	19.4
min	4.9	8.3	12.9	15.9	21.2	24.0	26.4	26.9	23.3	18.2	13.3	4.1	17.3
1991	6.5	10.9	15.1	19.6	23.6	27.2	28.9	28.0	24.0	20.6	10.5	10.9	18.8
1992	7.7	11.6	14.7	18.0	21.1	25.4	28.0	25.7	24.3	19.3	10.9	9.4	18.0

Table 28. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	8.9	10.5	14.6	18.1	21.9	25.9	27.5	27.7	25.0	19.1	13.8	9.1	18.5
s.d.	2.3	2.3	2.6	1.4	1.3	1.3	1.0	0.9	1.3	1.5	2.2	2.1	0.6
max	13.7	14.7	20.1	20.4	24.5	28.4	29.2	30.1	27.7	23.3	18.2	13.2	19.7
min	4.2	5.0	8.1	15.0	18.9	22.1	25.8	25.7	22.6	15.9	9.8	5.5	17.2
1911-40													
mean	9.0	10.9	14.0	18.0	21.8	26.0	27.7	27.7	25.1	19.6	13.3	9.5	18.6
s.d.	2.6	2.2	2.5	1.4	1.2	1.1	0.8	1.0	1.4	1.5	2.2	2.1	0.7
max	13.7	15.0	18.0	20.2	24.4	28.4	29.2	30.1	27.7	23.3	18.2	13.8	19.7
min	2.5	5.7	8.1	15.0	18.9	24.0	26.1	25.7	22.6	17.0	9.5	5.5	17.5
1921-50													
mean	9.0	11.1	14.1	18.3	22.0	26.0	27.6	27.8	25.0	19.9	13.4	10.0	18.7
s.d.	2.3	2.2	2.3	1.6	1.1	0.9	0.7	1.0	1.3	1.6	2.1	2.0	0.6
max	13.7	15.0	18.6	21.0	23.8	27.5	28.9	30.1	27.3	23.9	18.2	13.8	19.7
min	2.5	5.7	10.5	15.0	19.2	24.2	26.1	25.7	22.7	17.1	9.5	6.8	17.6
1931-60													
mean	9.1	11.0	14.1	18.4	22.5	26.3	27.9	28.0	25.0	19.9	13.2	10.0	18.8
s.d.	2.2	2.2	2.3	1.3	1.2	0.9	0.8	1.1	1.2	1.7	1.7	1.7	0.5
max	13.7	15.0	18.6	21.0	24.6	28.4	29.6	29.8	27.0	23.9	16.8	13.8	19.6
min	2.5	6.9	10.0	16.2	19.2	24.2	26.3	25.7	22.7	16.6	9.5	7.1	17.6
1941-70													
mean	8.4	10.4	13.8	19.1	22.9	26.5	28.1	28.2	25.0	19.7	13.5	9.7	18.8
s.d.	2.1	2.3	2.2	1.6	1.0	0.7	0.9	0.9	1.1	1.6	1.7	1.8	0.5
max	13.7	14.5	18.6	22.4	24.6	28.4	30.1	29.8	26.9	23.9	17.6	13.7	19.6
min	4.1	6.9	10.0	16.6	20.2	25.0	26.3	25.9	23.3	16.6	10.1	5.2	17.7

Table 28. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951-80													
mean	7.9	10.0	13.9	18.8	22.8	26.3	28.2	28.0	25.0	19.4	13.3	9.5	18.6
s.d.	2.6	2.4	2.1	1.5	1.1	0.9	1.0	1.0	1.3	1.6	1.9	1.7	0.5
max	13.7	14.5	17.6	22.4	24.6	28.4	30.1	29.8	27.2	22.1	17.9	13.7	19.4
min	2.5	4.4	10.0	16.6	19.8	24.3	26.4	26.2	21.3	15.1	9.6	5.2	17.5
1961-90													
mean	7.5	9.8	14.3	18.9	22.7	26.1	27.9	27.9	24.8	19.1	13.9	9.3	18.5
s.d.	2.5	2.1	1.8	1.6	1.0	1.0	1.0	0.9	1.4	1.4	1.9	2.3	0.5
max	11.0	14.3	17.6	22.4	24.3	27.6	30.1	29.3	27.2	22.1	17.9	14.8	19.4
min	2.5	4.4	10.1	15.9	19.8	24.0	26.4	26.2	21.3	15.1	9.6	4.1	17.3

Table 29. Mean Maximum Monthly and Annual Temperature (in °C) for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	17.1	14.5	21.3	23.4	28.0	33.1	33.7	34.7	29.6	26.1	20.0	14.2	24.6
1902	13.6	13.4	21.1	26.1	29.6	33.0	31.3	34.2	29.6	25.8	21.4	15.4	24.5
1903	14.0	13.7	19.4	24.4	25.7	28.1	31.6	32.3	30.3	24.2	19.7	16.3	23.3
1904	13.8	18.8	23.4	23.0	28.1	31.8	32.0	32.3	31.4	28.0	21.5	15.8	25.0
1905	11.4	10.1	23.0	23.6	29.0	31.7	30.9	32.8	31.2	24.6	21.3	10.9	23.4
1906	15.8	15.4	18.1	25.1	28.2	31.8	31.7	31.8	30.7	22.3	21.0	17.5	24.1
1907	15.8	19.4	25.7	21.5	25.9	31.5	33.5	35.1	32.8	24.9	17.6	16.1	25.0
1908	15.3	16.0	23.9	25.0	27.7	31.5	32.3	31.8	29.7	24.6	21.7	17.4	24.8
1909	16.5	18.9	21.8	24.2	27.2	31.4	34.3	35.4	33.4	28.3	24.4	12.1	25.7
1910	16.5	14.7	25.3	24.3	27.0	30.5	32.4	33.9	33.8	27.6	21.1	12.1	24.9
mean	15.0	15.5	22.3	24.1	27.6	31.4	32.4	33.4	31.3	25.6	21.0	14.8	24.5
s.d.	1.8	2.9	2.4	1.3	1.2	1.4	1.1	1.4	1.6	1.9	1.7	2.3	0.7
max	17.1	19.4	25.7	26.1	29.6	33.1	34.3	35.4	33.8	28.3	24.4	17.5	25.7
min	11.4	10.1	18.1	21.5	25.7	28.1	30.9	31.8	29.6	22.3	17.6	10.9	23.3
1911	18.6	20.0	23.3	22.9	28.3	34.4	30.9	32.4	34.4	25.5	17.4	13.6	25.1
1912	12.6	13.7	16.8	23.8	27.3	28.7	33.6	32.4	31.7	26.8	19.4	12.0	23.2
1913	14.5	15.3	18.5	24.3	27.4	30.5	34.1	34.7	27.4	23.0	23.3	13.2	23.8
1914	17.9	14.1	18.8	24.3	27.2	33.7	36.0	31.4	30.8	24.4	18.8	18.9	23.9
1915	11.6	16.0	13.1	24.2	28.3	33.1	32.7	30.7	30.4	26.4	21.7	16.5	23.7
1916	16.6	16.7	22.8	22.9	27.3	32.0	33.7	33.9	32.1	27.5	20.4	16.5	25.2
1917	15.6	18.0	20.5	23.2	25.0	32.9	34.6	36.1	31.5	25.8	21.2	12.6	24.7
1918	11.2	19.2	24.6	23.6	29.2	34.8	36.7	34.5	30.0	25.9	17.9	17.5	25.4
1919	14.9	17.3	23.1	27.1	27.8	31.0	34.2	34.8	32.3	28.3	22.9	18.9	26.1
1920	15.1	18.6	21.5	26.6	31.0	33.2	35.1	32.8	34.0	26.4	17.9	13.7	25.5
mean	14.9	16.9	20.3	24.3	27.9	32.4	34.2	33.4	31.5	26.0	20.1	14.3	24.7
s.d.	2.5	2.1	3.5	1.5	1.6	1.9	1.6	1.7	2.0	1.5	2.1	3.0	0.9
max	18.6	20.0	24.6	27.1	31.0	34.8	36.7	36.1	34.4	28.3	23.3	18.9	26.1
min	11.2	13.7	13.1	22.9	25.0	28.7	30.9	30.7	27.4	23.0	17.4	8.9	23.2

Table 29. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1921	16.9	17.5	22.2	21.2	28.2	32.4	33.9	36.1	34.3	28.9	25.7	20.5	26.5
1922	13.1	19.4	21.6	26.9	30.0	33.4	34.9	35.4	35.2	29.7	21.9	19.9	26.8
1923	20.8	15.8	17.1	24.2	27.1	33.2	35.1	36.5	31.6	25.9	19.4	16.9	25.3
1924	13.6	14.7	18.4	25.0	27.1	33.5	37.0	39.6	31.1	27.2	20.3	11.8	24.9
1925	12.5	17.6	20.7	24.6	26.9	33.5	34.5	33.8	31.7	21.9	16.6	11.9	23.9
1926	11.8	18.6	16.6	20.2	25.9	30.0	31.0	33.0	32.3	27.4	17.4	15.2	23.3
1927	15.4	18.4	18.6	24.7	28.2	29.5	32.3	34.4	31.6	27.4	23.8	11.9	24.7
1928	14.4	14.5	20.1	20.1	28.0	29.6	32.4	33.9	29.7	27.3	17.8	14.2	23.5
1929	15.0	9.4	21.4	25.4	25.3	30.4	31.7	34.2	31.6	26.1	14.3	14.6	23.3
1930	9.6	18.1	17.4	27.1	26.2	31.1	34.8	34.4	30.4	23.1	18.2	12.4	23.6
mean	14.3	16.4	19.4	23.9	27.3	31.7	33.8	35.1	32.0	26.5	19.5	14.9	24.6
s.d.	3.1	3.0	2.1	2.6	1.4	1.7	1.8	1.9	1.7	2.4	3.5	3.3	1.3
max	20.8	19.4	22.2	27.1	30.0	33.5	37.0	39.6	35.2	29.7	25.7	20.5	26.8
min	9.6	9.4	16.6	20.1	25.3	29.5	31.0	33.0	29.7	21.9	14.3	11.8	23.3
1931	14.5	16.9	16.3	22.1	25.0	32.1	34.4	31.7	33.4	28.4	21.9	15.6	24.4
1932	16.1	20.4	17.8	25.0	27.1	31.0	33.8	32.3	28.8	23.7	15.4	11.0	23.5
1933	15.7	12.6	18.9	22.1	27.1	31.1	31.3	32.5	31.9	25.6	20.4	19.8	24.1
1934	13.4	16.7	19.5	25.8	27.7	33.2	35.3	35.4	30.6	28.8	21.2	13.3	25.1
1935	15.2	14.7	23.3	22.4	26.2	30.1	33.4	34.9	29.4	27.8	19.0	12.9	24.1
1936	15.2	14.2	23.1	24.1	27.2	33.2	32.0	34.6	31.4	23.8	18.0	15.8	24.4
1937	15.1	16.3	17.2	22.4	28.5	32.1	33.1	34.1	30.0	24.1	16.1	12.0	23.4
1938	12.8	19.1	23.2	22.4	27.2	31.4	32.6	32.8	32.1	29.0	19.4	15.3	24.8
1939	16.3	16.5	21.7	23.7	28.0	31.4	35.2	35.1	34.3	27.6	17.5	17.8	25.4
1940	7.5	14.4	21.0	23.0	26.4	28.6	31.8	30.8	28.5	27.0	18.1	16.9	22.8
mean	14.2	16.2	20.2	23.3	27.0	31.4	33.3	33.4	31.0	26.6	18.7	15.0	24.2
s.d.	2.6	2.3	2.6	1.3	1.0	1.4	1.4	1.6	1.9	2.1	2.1	2.7	0.8
max	16.3	20.4	23.3	25.8	28.5	33.2	35.3	35.4	34.3	29.0	21.9	19.8	25.4
min	7.5	12.6	16.3	22.1	25.0	28.6	31.3	30.8	28.5	23.7	15.4	11.0	22.8

Table 29. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	15.9	12.9	16.4	24.1	27.3	30.1	31.9	32.8	30.3	26.3	18.1	15.5	23.5
1942	13.3	13.5	19.7	23.7	26.5	30.6	32.1	32.7	28.5	26.2	21.7	15.9	23.7
1943	14.4	18.8	18.7	25.8	29.7	33.3	34.0	34.9	29.0	25.1	18.9	13.1	24.6
1944	13.2	18.2	19.9	23.7	26.6	32.1	34.3	34.8	30.3	27.8	19.0	12.5	24.4
1945	13.0	19.3	24.6	25.7	28.3	32.4	32.6	33.8	32.6	25.4	23.5	14.7	25.5
1946	13.5	18.1	23.2	27.4	27.8	30.7	33.3	33.4	30.2	26.8	21.1	18.7	25.3
1947	13.5	14.4	17.9	25.6	28.4	32.1	34.3	36.4	34.4	31.9	19.4	17.0	25.5
1948	11.6	16.5	22.2	27.5	29.0	33.5	34.7	36.5	32.0	27.3	19.7	18.0	25.7
1949	13.6	17.9	20.5	22.7	30.3	32.5	33.4	32.8	31.1	24.7	22.4	16.7	24.9
1950	18.2	18.4	20.1	23.0	29.3	30.9	32.0	33.8	29.8	27.6	20.0	15.3	24.9
mean	14.0	16.8	20.3	24.9	28.3	31.8	33.3	34.2	30.8	26.9	20.4	15.7	24.8
s.d.	1.8	2.3	2.5	1.7	1.3	1.2	1.1	1.4	1.8	2.0	1.7	2.0	0.8
max	18.2	19.3	24.6	27.5	30.3	33.5	34.7	36.5	34.4	31.9	23.5	18.7	25.7
min	11.6	12.9	16.4	22.7	26.5	30.1	31.9	32.7	28.5	24.7	18.1	12.5	23.5
1951	15.9	16.5	21.3	24.2	29.1	32.4	35.6	37.5	31.9	27.5	18.6	17.6	25.7
1952	19.8	18.2	19.8	23.2	27.9	33.4	33.7	35.5	32.6	25.9	19.6	14.6	25.4
1953	17.7	16.3	23.7	24.2	28.7	34.9	32.3	32.7	32.5	28.7	19.3	13.8	25.4
1954	16.1	21.9	20.1	26.2	26.0	32.9	36.6	37.4	36.2	29.1	21.5	18.0	26.9
1955	14.2	16.9	23.1	27.4	30.8	32.7	35.1	33.9	34.3	28.9	21.1	17.0	26.3
1956	17.3	18.7	22.1	25.4	31.1	33.0	37.0	37.6	35.1	31.2	21.2	19.8	27.5
1957	15.7	21.0	20.8	25.0	29.6	31.8	35.9	35.4	31.1	25.1	19.2	19.4	25.9
1958	15.1	13.7	19.7	25.4	30.4	33.4	34.7	35.4	30.3	26.3	22.0	15.7	25.2
1959	13.6	17.7	22.3	24.1	30.9	33.1	34.7	34.7	32.5	27.7	18.5	17.2	25.6
1960	13.9	14.5	16.8	26.8	29.8	33.5	35.1	34.2	32.7	28.5	21.2	12.9	25.0
mean	15.9	17.6	21.0	25.2	29.4	33.1	35.1	35.4	32.9	27.9	20.2	16.6	25.9
s.d.	1.9	2.6	2.0	1.3	1.6	0.8	1.4	1.7	1.8	1.8	1.3	2.3	0.8
max	19.8	21.9	23.7	27.4	31.1	34.9	37.0	37.6	36.2	31.2	22.0	19.8	27.5
min	13.6	13.7	16.8	23.2	26.0	31.8	32.3	32.7	30.2	25.1	18.5	12.9	25.0

Table 29. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	12.8	19.3	24.4	24.6	29.9	30.6	32.9	34.7	32.3	27.0	19.0	16.7	25.4
1962	13.7	22.5	19.7	25.3	30.8	33.1	35.4	36.8	32.3	28.8	20.7	15.3	26.2
1963	10.8	17.2	24.5	28.3	31.3	34.5	35.3	36.7	32.2	31.6	22.0	11.7	26.3
1964	15.2	14.2	21.7	27.4	30.3	32.9	36.3	35.9	31.1	26.5	22.5	17.2	25.9
1965	18.1	14.1	16.1	28.3	29.1	32.9	35.5	35.8	32.3	26.0	24.0	18.4	25.9
1966	11.9	15.6	20.8	25.9	28.4	32.1	35.8	33.1	31.1	26.3	23.0	15.4	24.9
1967	15.4	15.8	24.8	28.6	28.9	33.3	33.0	34.7	30.7	27.7	22.0	17.0	26.0
1968	12.1	13.8	18.9	25.1	29.1	31.2	32.8	34.4	30.2	27.1	19.1	16.1	24.2
1969	15.2	15.9	16.0	25.4	28.8	33.0	36.7	35.6	32.8	27.5	21.1	16.9	25.4
1970	11.4	16.4	18.9	26.2	29.1	32.6	34.3	35.7	32.6	24.4	19.3	20.3	25.1
mean	13.7	16.5	20.6	26.5	29.6	32.6	34.8	35.3	31.8	27.3	21.3	16.5	25.5
s.d.	2.3	2.7	3.3	1.5	1.0	1.1	1.5	1.1	0.9	1.9	1.7	2.2	0.7
max	18.1	22.5	24.8	28.6	31.3	34.5	36.7	36.8	32.8	31.6	24.0	20.3	26.3
min	10.8	13.8	16.0	24.6	28.4	30.6	32.8	33.1	30.2	24.4	19.0	11.7	24.2
1971	17.2	17.8	20.9	25.5	28.4	34.0	35.0	33.3	31.3	28.2	21.6	18.4	26.0
1972	16.1	17.5	23.6	26.6	29.5	33.3	32.5	34.2	33.3	25.3	16.4	13.5	25.1
1973	11.8	15.2	22.4	22.6	29.4	30.5	33.4	32.8	30.4	26.9	24.4	16.7	24.7
1974	13.9	18.1	23.2	24.8	29.0	30.8	33.9	32.8	26.3	25.8	18.8	15.0	24.4
1975	16.7	16.5	19.5	23.5	28.2	31.1	32.5	32.9	29.3	26.6	20.3	15.2	24.4
1976	15.5	20.8	20.7	25.1	25.7	30.0	31.8	33.4	30.1	22.2	15.9	14.5	23.8
1977	9.3	17.4	21.2	24.7	29.4	32.9	35.0	33.4	31.2	26.2	20.0	15.7	24.7
1978	7.0	9.5	19.3	25.5	29.2	32.9	36.4	34.6	30.0	26.4	21.6	15.6	24.0
1979	7.8	12.1	20.9	23.5	28.9	30.9	32.3	32.6	28.9	28.0	18.4	16.1	23.4
1980	14.1	14.7	19.2	23.5	27.8	33.5	36.8	35.6	33.7	25.3	18.7	16.4	25.0
mean	12.9	16.0	21.1	24.5	28.5	32.0	34.0	33.5	30.5	26.1	19.6	15.7	24.5
s.d.	3.8	3.2	1.6	1.2	1.1	1.5	1.8	1.0	2.1	1.7	2.5	1.3	0.7
max	17.2	20.8	23.6	26.6	29.5	34.0	36.8	35.6	33.7	28.2	24.4	18.4	26.0
min	7.0	9.5	19.2	22.6	25.7	30.0	31.8	32.6	26.3	22.2	15.9	13.5	23.4

Table 29. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	13.7	16.1	20.1	27.3	26.9	31.9	33.5	34.3	29.8	24.5	21.6	14.9	24.5
1982	14.8	13.5	20.8	22.6	28.2	32.0	33.4	35.2	32.0	24.6	18.9	16.3	24.3
1983	12.2	14.5	19.5	21.6	27.5	29.5	32.8	33.3	30.6	26.4	20.2	9.6	23.1
1984	11.7	18.0	20.4	25.6	29.4	31.9	34.7	35.1	30.3	25.7	19.4	19.8	25.2
1985	10.3	13.6	22.3	26.2	28.9	32.9	33.4	35.5	32.4	25.3	21.5	13.4	24.6
1986	16.3	18.9	22.8	25.2	27.4	31.4	34.0	33.3	30.9	24.7	18.4	12.9	24.7
1987	13.7	15.8	20.2	26.1	29.5	31.4	33.3	35.6	30.2	25.4	20.8	16.0	24.8
1988	11.4	15.5	20.7	26.0	29.1	33.4	33.6	34.3	31.8	25.6	21.4	16.1	24.9
1989	15.8	13.2	20.4	25.3	29.9	29.1	31.7	32.8	30.1	27.2	22.0	12.0	24.1
1990	17.5	20.2	21.3	25.2	28.7	34.1	34.4	35.7	33.0	26.7	23.1	15.8	26.3
mean	13.7	15.9	20.9	25.1	28.5	31.8	33.5	34.5	31.1	25.6	20.7	14.7	24.7
s.d.	2.4	2.4	1.0	1.7	1.0	1.6	0.8	1.1	1.1	0.9	1.5	2.8	0.8
max	17.5	20.2	22.8	27.3	29.9	34.1	34.7	35.7	33.0	27.2	23.1	19.8	26.3
min	10.3	13.2	19.5	21.6	26.9	29.1	31.7	32.8	29.8	24.5	18.4	9.6	23.1
1991	11.2	17.8	22.1	25.1	28.3	32.5	34.7	33.7	30.0	28.5	17.4	16.1	24.8
1992	13.6	18.1	21.8	24.5	26.6	30.7	33.4	31.9	30.2	27.4	17.3	14.3	24.2

Table 29. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	14.7	16.3	20.7	24.1	27.6	31.8	33.4	34.0	31.6	26.0	20.2	14.7	24.6
s.d.	2.4	2.7	2.9	1.8	1.4	1.7	1.7	1.8	1.7	1.9	2.5	2.8	1.0
max	20.8	20.0	25.7	27.1	31.0	34.8	37.0	39.6	35.2	29.7	25.7	20.5	26.8
min	9.6	9.4	13.1	20.1	25.0	28.1	30.9	30.7	27.4	21.9	14.3	8.9	23.2
1911-40													
mean	14.5	16.5	20.0	23.9	27.4	31.8	33.7	34.0	31.5	26.4	19.4	14.8	24.5
s.d.	2.7	2.4	2.7	1.8	1.3	1.7	1.6	1.9	1.8	2.0	2.6	2.9	1.0
max	20.8	20.4	24.6	27.1	31.0	34.8	37.0	39.6	35.2	29.7	25.7	20.5	26.8
min	7.5	9.4	13.1	20.1	25.0	28.6	30.9	30.7	27.4	21.9	14.3	8.9	22.8
1921-50													
mean	14.2	16.5	20.0	24.1	27.6	31.6	33.4	34.3	31.3	26.7	19.5	15.2	24.5
s.d.	2.5	2.5	2.3	2.0	1.3	1.4	1.4	1.8	1.8	2.1	2.6	2.6	1.0
max	20.8	20.4	24.6	27.5	30.3	33.5	37.0	39.6	35.2	31.9	25.7	20.5	26.8
min	7.5	9.4	16.3	20.1	25.0	28.6	31.0	30.8	28.5	21.9	14.3	11.0	22.8
1931-60													
mean	14.7	16.8	20.5	24.5	28.3	32.1	33.9	34.3	34.6	27.1	19.8	15.8	25.0
s.d.	2.2	2.4	2.3	1.6	1.6	1.3	1.5	1.7	2.0	2.0	1.9	2.4	1.0
max	19.8	21.9	24.6	27.5	31.1	34.9	37.0	37.6	36.2	31.9	23.5	19.8	27.5
min	7.5	12.6	16.3	22.1	25.0	28.6	31.3	30.8	28.5	23.7	15.4	11.0	22.8
1941-70													
mean	14.5	16.9	20.6	25.5	29.1	32.5	34.4	35.0	31.8	27.4	20.6	16.3	25.4
s.d.	2.2	2.5	2.6	1.6	1.4	1.1	1.5	1.5	1.7	1.9	1.6	2.1	0.8
max	19.8	22.5	24.8	28.6	31.3	34.9	37.0	37.6	36.2	31.9	24.0	20.3	27.5
min	10.8	12.9	16.0	22.7	26.0	30.1	31.9	32.7	28.5	24.4	18.1	11.7	23.5

Table 29. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951-80													
mean	14.2	16.7	20.9	25.4	29.2	32.6	34.6	34.8	31.7	27.1	20.4	16.3	25.3
s.d.	3.0	2.8	2.3	1.5	1.3	1.2	1.6	1.5	1.9	1.9	2.0	2.0	0.9
max	19.8	22.5	24.8	28.6	31.3	34.9	37.0	37.6	36.2	31.6	24.4	20.3	27.5
min	7.0	9.5	16.0	22.6	25.7	30.0	31.8	32.6	26.3	22.2	15.9	11.7	23.4
1961-90													
mean	13.4	16.1	20.8	25.4	28.9	32.1	34.1	34.5	31.1	26.3	20.5	15.6	24.9
s.d.	2.8	2.7	2.1	1.7	1.1	1.4	1.5	1.3	1.5	1.7	2.0	2.3	0.8
max	18.1	22.5	24.8	28.6	31.3	34.5	36.8	36.8	33.7	31.6	24.4	20.3	26.3
min	7.0	9.5	16.0	21.6	25.7	29.1	31.7	32.6	26.3	22.2	15.9	9.6	23.1

Table 30. Maximum Daily Temperature (°C) by Month and Year for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	23.9	26.7	29.4	30.6	32.2	37.8	38.3	38.9	34.4	32.8	26.7	24.4	38.9
1902	21.7	22.8	28.9	30.6	32.2	36.7	33.9	36.7	35.0	31.7	27.2	25.0	36.7
1903	27.2	23.3	26.7	30.0	30.6	34.4	35.0	35.6	35.0	30.6	29.4	23.3	35.6
1904	22.8	28.9	32.2	29.4	32.8	35.0	34.4	36.7	35.6	35.0	27.8	27.2	36.7
1905	23.3	23.9	28.9	30.0	31.7	35.0	33.9	35.0	35.0	33.3	28.3	16.7	35.0
1906	25.6	23.9	26.7	29.4	33.3	35.0	34.4	33.3	34.4	27.8	28.3	26.7	35.0
1907	24.2	26.7	30.6	29.4	33.3	33.3	36.1	38.3	37.2	34.4	26.1	26.1	38.3
1908	23.9	24.4	31.7	30.0	31.1	34.4	35.6	35.6	35.6	29.4	28.9	26.1	35.6
1909	27.8	27.2	30.6	30.0	31.1	34.4	36.7	42.8	39.4	35.6	29.4	26.7	42.8
1910	25.0	22.2	31.7	29.4	31.1	33.9	36.1	37.2	36.1	33.9	29.4	24.8	37.2
1911	28.9	27.8	33.3	30.6	35.6	37.8	35.6	36.1	38.9	35.6	30.6	21.1	38.9
1912	24.4	25.6	27.2	31.7	32.8	33.3	38.9	35.6	36.1	33.3	27.2	21.1	38.9
1913	23.3	27.2	29.4	30.6	31.7	35.0	38.3	38.3	36.1	31.1	26.7	22.8	38.3
1914	26.1	23.3	26.1	31.1	31.7	38.3	38.3	35.6	34.4	32.2	28.3	20.0	38.3
1915	21.7	22.8	27.8	30.0	36.1	37.2	35.6	36.7	32.8	32.2	29.4	24.4	37.2
1916	25.6	26.1	32.2	28.9	32.2	34.4	36.7	37.2	36.1	32.8	28.9	26.7	37.2
1917	26.7	29.4	29.4	29.4	33.9	38.3	40.6	40.6	37.8	35.0	27.8	29.4	40.6
1918	26.1	32.2	32.2	31.1	33.3	43.3	41.7	40.6	37.2	32.8	26.7	25.0	43.3
1919	21.1	25.0	28.9	32.2	32.2	35.6	37.2	37.8	36.7	33.3	29.4	27.8	37.8
1920	26.1	26.1	28.3	33.9	35.6	36.7	38.9	35.0	37.8	33.3	28.9	21.1	38.9
1921	22.2	26.1	27.2	25.6	36.7	36.1	37.2	40.0	36.7	35.6	32.8	27.8	40.0
1922	25.6	29.4	29.4	31.7	33.9	37.2	38.9	39.4	38.9	35.6	31.1	29.4	39.4
1923	26.1	28.3	27.2	31.1	35.0	35.6	40.0	40.6	36.7	35.6	26.1	27.8	40.6
1924	23.9	27.8	29.4	32.2	33.3	36.7	41.1	41.7	39.4	32.8	28.3	28.3	41.7
1925	20.0	24.4	27.8	31.7	32.8	36.7	37.8	40.0	37.8	33.3	26.7	22.8	40.0

Table 30. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1926	20.0	25.0	26.7	28.3	32.8	33.3	35.0	36.1	35.0	32.8	26.1	25.0	36.1
1927	25.0	26.1	27.2	29.4	33.3	32.8	35.6	38.3	37.8	31.7	28.9	26.7	38.3
1928	25.0	22.8	30.6	26.7	33.9	32.8	36.1	36.1	34.4	33.9	25.6	24.4	36.1
1929	23.9	20.6	31.1	35.6	30.6	34.4	35.6	36.7	35.0	31.7	26.1	23.9	36.7
1930	21.1	27.2	24.4	32.2	31.1	37.2	38.3	38.3	34.4	28.9	26.1	19.4	38.3
1931	21.7	21.7	26.1	28.3	29.4	35.0	37.2	34.4	36.1	33.3	27.2	26.1	37.2
1932	25.6	28.3	28.9	29.4	31.7	35.6	38.9	38.3	36.7	30.6	23.3	20.6	38.9
1933	23.3	25.0	26.1	30.6	32.2	36.1	37.2	34.4	35.0	30.6	26.7	26.1	37.2
1934	21.7	21.7	27.2	29.4	32.2	36.7	38.9	37.8	35.0	31.7	28.9	20.6	38.9
1935	25.6	23.9	31.1	28.9	30.0	32.2	36.7	40.0	35.0	31.7	29.4	20.0	40.0
1936	25.6	25.6	28.9	31.1	29.4	39.4	35.6	40.0	34.4	31.1	28.9	22.8	40.0
1937	23.9	26.7	25.6	28.3	31.7	37.2	36.7	37.8	35.0	31.7	25.6	21.7	37.8
1938	23.3	25.0	28.3	28.9	31.1	34.4	35.0	36.7	35.6	37.2	28.9	25.0	37.2
1939	23.9	23.9	28.3	31.1	31.7	35.0	40.0	39.4	37.8	33.3	25.0	26.1	40.0
1940	21.7	29.4	28.3	29.4	30.6	32.2	35.0	34.4	33.3	31.1	25.6	22.2	35.0
1941	21.7	21.1	26.7	29.4	31.1	32.8	33.9	35.0	33.9	31.1	25.0	23.3	35.0
1942	23.9	23.3	29.4	28.9	31.1	33.9	35.6	36.1	32.8	31.1	28.3	26.1	36.1
1943	28.3	25.0	27.2	31.1	32.8	36.1	38.9	39.4	35.0	29.4	28.3	25.0	39.4
1944	22.2	25.0	26.7	30.0	31.1	35.0	39.4	37.8	34.4	32.2	27.8	22.2	39.4
1945	21.7	28.3	29.4	30.0	32.2	36.1	35.0	37.2	36.1	29.4	30.0	23.3	37.2
1946	23.9	24.4	33.9	31.7	31.1	35.0	37.2	37.2	34.4	30.0	27.8	25.0	37.2
1947	26.7	26.7	26.1	30.6	33.3	34.4	37.2	42.2	40.6	35.0	28.3	23.9	42.2
1948	24.4	28.9	28.3	32.2	32.2	36.1	37.2	40.0	37.8	33.3	30.6	26.7	40.0
1949	26.7	27.2	28.3	31.1	33.9	35.6	37.2	36.1	35.6	31.7	29.4	25.6	37.2
1950	28.9	28.3	30.6	28.9	32.2	34.4	33.9	36.1	34.4	31.1	30.0	27.2	36.1

Table 30. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951	25.6	27.8	28.9	31.7	35.0	35.0	38.9	41.1	40.0	32.8	30.6	27.8	41.1
1952	27.8	26.7	28.9	28.3	32.8	36.1	36.1	37.8	36.7	33.9	28.9	25.6	37.8
1953	24.4	25.6	31.1	29.4	33.9	38.3	35.6	36.7	37.8	36.7	26.7	27.8	38.3
1954	26.7	28.3	30.6	30.6	32.2	36.1	41.7	43.3	39.4	36.7	26.7	26.7	43.3
1955	22.8	25.6	32.8	32.8	35.0	36.7	38.9	38.3	36.7	35.0	31.1	28.9	38.9
1956	28.3	28.9	30.0	30.6	34.4	37.2	39.4	42.2	39.4	36.1	28.9	29.4	42.2
1957	27.8	30.6	27.2	30.0	32.8	35.0	40.0	38.3	36.7	32.2	29.4	25.0	40.0
1958	22.2	23.9	27.2	31.1	37.8	36.7	37.2	41.1	36.1	32.2	29.4	23.3	41.1
1959	23.9	27.8	27.8	32.2	34.4	36.7	37.2	37.2	35.6	33.3	26.7	22.8	37.2
1960	25.6	27.8	30.6	32.2	35.0	39.4	38.9	37.8	37.2	32.8	28.9	24.4	39.4
1961	24.4	27.2	30.6	31.7	33.3	33.9	36.1	37.8	37.8	32.2	30.0	25.6	37.8
1962	25.6	28.9	28.9	30.0	34.4	35.6	37.2	39.4	36.7	35.0	28.9	25.6	39.4
1963	25.6	26.1	30.6	34.4	35.6	38.3	39.4	39.4	38.3	35.6	29.4	23.3	39.4
1964	23.3	22.8	26.7	31.7	35.0	36.1	40.0	41.7	37.2	30.6	28.3	26.7	41.7
1965	26.7	22.2	25.6	32.2	32.8	36.1	37.8	39.4	37.8	32.8	30.6	23.9	39.4
1966	23.3	22.2	28.9	31.1	33.3	35.0	38.9	36.7	35.0	33.3	27.2	26.7	38.9
1967	24.4	25.6	32.8	31.7	34.4	36.7	36.7	38.3	35.0	33.3	28.9	26.1	38.3
1968	22.2	23.9	26.7	30.0	33.3	35.6	35.0	35.6	33.9	32.2	29.4	23.3	35.6
1969	26.7	25.6	27.2	30.0	34.4	36.7	38.9	40.6	36.7	34.4	30.0	23.9	40.6
1970	26.7	26.1	25.6	31.1	32.2	37.2	38.3	39.4	36.1	32.8	26.7	26.7	39.4
1971	28.9	25.6	31.1	30.6	32.8	37.2	39.4	36.7	36.7	32.8	30.0	27.2	39.4
1972	27.8	26.7	28.9	32.2	33.9	36.1	36.1	36.7	37.2	32.8	31.7	23.3	37.2
1973	25.0	23.9	30.0	28.9	33.9	33.9	36.1	34.4	32.8	32.8	29.4	25.6	36.1
1974	25.0	26.7	31.1	31.7	32.2	34.4	37.2	36.1	32.8	29.4	27.8	23.9	37.2
1975	27.2	26.1	27.2	30.6	32.2	33.3	36.7	35.6	35.6	32.8	28.3	25.6	36.7

Table 30. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1976	25.0	26.7	28.3	28.9	30.6	33.3	33.9	35.6	34.4	30.0	25.0	21.1	35.6
1977	22.8	29.4	28.3	27.8	33.9	36.1	37.8	36.7	33.3	33.3	28.3	26.1	37.8
1978	25.6	22.2	27.2	30.0	33.3	35.6	39.4	37.8	33.9	32.5	28.9	25.0	39.4
1979	20.0	23.3	28.7	29.4	33.3	34.4	35.0	34.4	33.9	33.3	26.7	23.9	35.0
1980	22.2	28.3	28.3	30.6	33.3	37.2	39.4	40.0	37.8	32.2	29.4	23.9	40.0
1981	23.3	27.2	29.4	31.7	31.7	33.9	37.2	38.3	32.8	33.9	27.2	25.6	38.3
1982	25.0	28.9	30.6	29.4	33.3	33.9	36.1	37.8	37.2	32.2	28.9	26.7	37.8
1983	21.7	23.9	27.8	28.9	33.3	32.8	35.6	36.1	36.1	30.0	28.3	25.0	36.1
1984	23.3	23.9	30.6	30.6	33.9	36.7	37.2	40.0	37.2	30.0	29.4	25.6	40.0
1985	20.0	26.1	28.3	30.6	33.9	36.1	36.7	38.3	40.0	32.2	27.2	23.3	40.0
1986	25.0	32.2	27.8	29.4	32.2	35.0	38.3	39.4	33.3	32.8	28.3	20.6	39.4
1987	23.9	23.9	27.8	33.9	32.8	33.9	36.7	38.3	35.0	30.6	28.3	24.4	38.3
1988	22.2	26.1	27.8	31.1	33.3	37.2	37.2	37.8	35.0	30.0	28.3	23.9	37.8
1989	25.6	26.1	30.0	30.6	33.9	33.9	35.6	36.7	38.3	34.4	31.1	26.1	38.3
1990	25.0	26.7	27.8	33.3	33.3	37.2	38.3	40.0	38.9	34.4	27.8	25.6	40.0
1991	21.1	24.4	31.7	31.1	33.3	35.0	37.2	37.8	35.0	33.9	26.7	25.6	37.8
1992	20.0	24.4	28.9	30.0	31.1	34.4	35.6	36.7	33.9	31.7	29.4	21.1	36.7

Table 31. Number of Days Exceeding 32.2 °C (90 °F) at Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	0	0	0	0	1	20	28	27	11	1	0	0	88
1902	0	0	0	0	3	21	21	31	9	0	0	0	85
1903	0	0	0	0	0	7	19	21	11	0	0	0	58
1904	0	0	1	0	4	18	17	22	14	7	0	0	83
1905	0	0	0	0	0	18	9	23	17	2	0	0	69
1906	0	0	0	0	5	18	15	18	15	0	0	0	71
1907	0	0	0	0	1	16	28	28	20	4	0	0	97
1908	0	0	0	0	0	11	22	15	10	0	0	0	58
1909	0	0	0	0	0	8	27	27	19	8	0	0	89
1910	0	0	0	0	0	8	20	25	30	8	0	0	91
mean	0.0	0.0	0.1	0.0	1.4	14.5	20.6	23.7	15.6	3.0	0.0	0.0	78.9
s.d.	0.0	0.0	0.3	0.0	1.9	5.4	6.1	4.9	6.3	3.5	0.0	0.0	13.9
max	0	0	1	0	5	21	28	31	30	8	0	0	97
min	0	0	0	0	0	7	9	15	9	0	0	0	58
1911	0	0	3	0	5	27	6	20	26	6	0	0	93
1912	0	0	0	0	2	3	26	21	19	6	0	0	77
1913	0	0	0	0	0	14	26	29	7	0	0	0	76
1914	0	0	0	0	0	23	30	17	18	1	0	0	89
1915	0	0	0	0	6	19	23	13	11	1	0	0	73
1916	0	0	1	0	1	19	29	29	18	4	0	0	101
1917	0	0	0	0	2	23	28	31	11	5	0	0	100
1918	0	1	1	0	6	27	30	25	12	3	0	0	105
1919	0	0	0	1	2	14	26	28	17	9	0	0	97
1920	0	0	0	3	19	22	28	23	25	3	0	0	123
mean	0.0	0.1	0.5	0.4	4.3	19.1	25.2	23.6	16.4	3.8	0.0	0.0	93.4
s.d.	0.0	0.3	1.0	1.0	5.6	7.3	7.1	5.9	6.2	2.8	0.0	0.0	15.4
max	0	1	3	3	19	27	30	31	26	9	0	0	123
min	0	0	0	0	0	3	6	13	7	0	0	0	73
1921	0	0	0	0	10	20	28	29	25	5	3	0	120
1922	0	0	0	0	13	22	28	27	27	12	0	0	129
1923	0	0	0	0	3	25	29	28	16	4	0	0	105
1924	0	0	0	1	2	25	27	31	16	1	0	0	103
1925	0	0	0	0	1	21	29	21	20	2	0	0	94
1926	0	0	0	0	1	7	14	25	22	4	0	0	73
1927	0	0	0	0	4	5	21	28	20	0	0	0	78
1928	0	0	0	0	4	5	22	29	10	8	0	0	78
1929	0	0	0	1	0	4	15	28	13	0	0	0	61
1930	0	0	0	1	0	13	30	28	14	0	0	0	86
mean	0.0	0.0	0.0	0.3	3.8	14.7	24.3	27.4	18.3	3.6	0.3	0.0	92.7
s.d.	0.0	0.0	0.0	0.5	4.4	8.8	6.0	2.7	5.4	3.9	0.9	0.0	21.6
max	0	0	0	1	13	25	30	31	27	12	3	0	129
min	0	0	0	0	0	4	14	21	10	0	0	0	61

Table 31. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1931	0	0	0	0	0	20	27	14	24	5	0	0	90
1932	0	0	0	0	0	15	23	17	7	0	0	0	62
1933	0	0	0	0	1	12	19	26	21	0	0	0	79
1934	0	0	0	0	1	19	31	31	12	0	0	0	94
1935	0	0	0	0	0	2	25	31	6	0	0	0	64
1936	0	0	0	0	0	19	17	23	19	0	0	0	78
1937	0	0	0	0	0	15	24	28	7	0	0	0	74
1938	0	0	0	0	0	10	22	24	20	4	0	0	80
1939	0	0	0	0	0	12	28	30	29	6	0	0	105
1940	0	0	0	0	0	2	16	15	11	0	0	0	44
mean	0.0	0.0	0.0	0.0	0.2	12.6	23.2	23.9	15.6	1.5	0.0	0.0	77.0
s.d.	0.0	0.0	0.0	0.0	0.4	6.5	4.8	6.5	8.1	2.5	0.0	0.0	17.5
max	0	0	0	0	1	20	31	31	29	6	0	0	105
min	0	0	0	0	0	2	16	14	6	0	0	0	44
1941	0	0	0	0	0	2	21	25	7	0	0	0	55
1942	0	0	0	0	0	11	20	18	5	0	0	0	54
1943	0	0	0	0	6	25	24	30	9	0	0	0	94
1944	0	0	0	0	0	14	26	28	7	1	0	0	76
1945	0	0	0	0	2	21	23	24	19	0	0	0	89
1946	0	0	2	0	0	10	25	25	8	0	0	0	70
1947	0	0	0	0	4	22	28	29	20	18	0	0	121
1948	0	0	0	1	2	25	30	30	19	2	0	0	109
1949	0	0	0	0	4	23	23	19	13	0	0	0	82
1950	0	0	0	0	1	15	19	27	8	0	0	0	70
mean	0.0	0.0	0.2	0.1	1.9	16.8	23.9	25.5	11.5	2.1	0.0	0.0	82.0
s.d.	0.0	0.0	0.6	0.3	2.1	7.7	3.5	4.2	5.8	5.6	0.0	0.0	21.8
max	0	0	2	1	6	25	30	30	20	18	0	0	121
min	0	0	0	0	0	2	19	18	5	0	0	0	54
1951	0	0	0	0	5	21	30	31	12	3	0	0	102
1952	0	0	0	0	3	24	27	31	18	5	0	0	108
1953	0	0	0	0	8	28	21	19	20	7	0	0	103
1954	0	0	0	0	1	24	28	31	29	14	0	0	127
1955	0	0	2	3	11	21	29	27	30	7	0	0	130
1956	0	0	0	0	18	23	31	29	28	16	0	0	145
1957	0	0	0	0	11	17	29	29	15	2	0	0	103
1958	0	0	0	0	11	25	29	28	14	1	0	0	108
1959	0	0	0	1	11	21	29	30	21	8	0	0	121
1960	0	0	0	2	9	25	29	27	21	8	0	0	121
mean	0.0	0.0	0.2	0.6	8.8	22.9	28.2	28.2	20.8	7.1	0.0	0.0	116.8
s.d.	0.0	0.0	0.6	1.1	4.9	3.0	2.7	3.6	6.4	4.9	0.0	0.0	14.4
max	0	0	2	3	18	28	31	31	30	16	0	0	145
min	0	0	0	0	1	17	21	19	12	1	0	0	102

Table 31. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	0	0	5	18	23	29	19	1	0	0	95
1962	0	0	0	0	6	23	30	31	16	10	0	0	116
1963	0	0	0	3	18	29	30	30	17	13	0	0	140
1964	0	0	0	0	8	21	29	28	15	0	0	0	101
1965	0	0	0	1	2	25	30	29	19	1	0	0	107
1966	0	0	0	0	3	20	30	24	16	3	0	0	96
1967	0	0	2	0	6	21	22	25	15	3	0	0	94
1968	0	0	0	0	5	14	24	28	10	1	0	0	82
1969	0	0	0	0	9	21	31	27	21	8	0	0	117
1970	0	0	0	0	2	19	26	27	21	1	0	0	96
mean	0.0	0.0	0.2	0.4	6.4	21.1	27.5	27.8	16.9	4.1	0.0	0.0	104.4
s.d.	0.0	0.0	0.6	1.0	4.7	4.0	3.4	2.1	3.3	4.6	0.0	0.0	16.4
max	0	0	2	3	18	29	31	31	21	13	0	0	140
min	0	0	0	0	2	14	22	24	10	0	0	0	82
1971	0	0	0	0	3	27	24	24	17	4	0	0	99
1972	0	0	0	3	8	21	22	31	22	4	0	0	111
1973	0	0	0	0	10	11	28	25	8	2	0	0	84
1974	0	0	0	0	2	9	27	20	4	0	0	0	62
1975	0	0	0	0	1	12	21	23	10	2	0	0	69
1976	0	0	0	0	0	7	17	28	10	0	0	0	62
1977	0	0	0	0	6	23	31	25	19	2	0	0	106
1978	0	0	0	0	9	22	29	26	13	4	0	0	103
1979	0	0	0	0	5	13	18	25	6	3	0	0	70
1980	0	0	0	0	3	24	30	30	24	1	0	0	112
mean	0.0	0.0	0.0	0.3	4.7	16.9	24.7	25.7	13.3	2.2	0.0	0.0	87.8
s.d.	0.0	0.0	0.0	0.9	3.5	7.2	5.0	3.3	6.9	1.5	0.0	0.0	20.6
max	0	0	0	3	10	27	31	31	24	4	0	0	112
min	0	0	0	0	0	7	17	20	4	0	0	0	62
1981	0	0	0	0	0	19	24	28	7	1	0	0	79
1982	0	0	0	0	2	19	26	30	20	2	0	0	99
1983	0	0	0	0	1	5	22	26	11	0	0	0	65
1984	0	0	0	0	5	16	26	29	13	0	0	0	89
1985	0	0	0	0	3	22	26	31	18	2	0	0	102
1986	0	1	0	0	1	16	28	25	12	3	0	0	86
1987	0	0	0	7	4	15	27	29	10	0	0	0	92
1988	0	0	0	0	4	25	22	26	16	0	0	0	93
1989	0	0	0	0	11	5	14	21	11	5	0	0	67
1990	0	0	0	1	3	27	26	28	19	8	0	0	112
mean	0.0	0.1	0.0	0.8	3.4	16.9	24.1	27.3	13.7	2.1	0.0	0.0	88.4
s.d.	0.0	0.3	0.0	2.2	3.1	7.4	4.1	2.9	4.3	2.6	0.0	0.0	14.9
max	0	1	0	7	11	27	28	31	20	8	0	0	112
min	0	0	0	0	0	5	14	21	7	0	0	0	65

Table 31. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1991	0	0	0	0	3	21	30	24	12	3	0	0	93
1992	0	0	0	0	0	13	28	16	13	0	0	0	70

Table 31. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	0.0	0.0	0.2	0.2	3.2	16.1	23.4	24.9	16.8	3.5	0.1	0.0	88.3
s.d.	0.0	0.2	0.6	0.6	4.3	7.4	6.5	4.9	5.9	3.3	0.5	0.0	18.0
max	0	1	3	3	19	27	30	31	30	12	3	0	129
min	0	0	0	0	0	3	6	13	7	0	0	0	58
1911-40													
mean	0.0	0.0	0.2	0.2	2.8	15.5	24.2	25.0	16.8	3.0	0.1	0.0	87.7
s.d.	0.0	0.2	0.6	0.6	4.4	7.8	5.9	5.4	6.5	3.2	0.5	0.0	19.3
max	0	1	3	3	19	27	31	31	29	12	3	0	129
min	0	0	0	0	0	2	6	13	6	0	0	0	44
1921-50													
mean	0.0	0.0	0.1	0.1	2.0	14.7	23.8	25.6	15.1	2.4	0.1	0.0	83.9
s.d.	0.0	0.0	0.4	0.3	3.1	7.6	4.7	4.8	6.9	4.2	0.5	0.0	20.8
max	0	0	2	1	13	25	31	31	29	18	3	0	129
min	0	0	0	0	0	2	14	14	5	0	0	0	44
1931-60													
mean	0.0	0.0	0.1	0.2	3.6	17.4	25.1	25.9	16.0	3.6	0.0	0.0	91.9
s.d.	0.0	0.0	0.5	0.7	4.8	7.3	4.3	5.1	7.6	5.1	0.0	0.0	25.1
max	0	0	2	3	18	28	31	30	30	18	0	0	145
min	0	0	0	0	0	2	16	14	5	0	0	0	44
1941-70													
mean	0.0	0.0	0.2	0.4	5.7	20.3	26.5	27.2	16.4	4.4	0.0	0.0	101.1
s.d.	0.0	0.0	0.6	0.9	4.9	5.7	3.7	3.5	6.4	5.3	0.0	0.0	22.6
max	0	0	2	3	18	29	31	31	30	18	0	0	145
min	0	0	0	0	0	2	19	18	5	0	0	0	54
1951-80													
mean	0.0	0.0	0.1	0.4	6.6	20.3	26.8	27.2	17.0	4.5	0.0	0.0	103.0
s.d.	0.0	0.0	0.5	0.1	4.6	5.5	4.0	3.2	6.4	4.3	0.0	0.0	20.6
max	0	0	2	3	18	29	31	31	30	16	0	0	145
min	0	0	0	0	0	7	17	19	4	0	0	0	62
1961-90													
mean	0.0	0.0	0.1	0.5	4.8	18.3	25.4	26.9	14.6	2.8	0.0	0.0	93.5
s.d.	0.0	0.2	0.4	1.5	3.9	6.5	4.3	2.9	5.2	3.2	0.0	0.0	18.6
max	0	1	2	7	18	29	31	31	24	13	0	0	140
min	0	0	0	0	0	5	14	20	4	0	0	0	62

Table 32. Mean Minimum Monthly and Annual Temperature (in °C) for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	4.7	3.5	6.9	9.7	15.5	20.5	22.6	21.9	17.4	11.2	7.1	1.3	11.9
1902	0.7	3.2	8.9	14.6	19.3	20.2	21.8	22.8	17.2	12.4	11.7	2.9	13.0
1903	2.3	4.7	10.2	11.6	15.1	16.2	20.4	21.4	15.0	10.1	5.1	0.5	11.0
1904	-0.2	7.1	10.8	11.5	15.8	19.6	20.2	22.3	19.8	12.4	5.5	3.7	12.4
1905	0.6	-0.1	11.7	13.2	19.1	21.6	20.7	22.0	19.2	13.1	10.2	0.0	12.6
1906	2.3	2.6	6.7	13.3	16.2	20.1	21.0	20.5	19.9	9.5	7.8	6.8	12.2
1907	2.3	4.7	14.4	10.7	14.8	20.2	21.8	21.8	18.7	14.2	5.6	4.9	12.9
1908	3.5	4.3	13.6	15.1	17.5	21.2	21.1	21.5	18.4	9.2	7.2	6.0	13.2
1909	5.9	5.3	8.4	11.8	15.7	20.3	23.1	22.2	17.4	11.2	11.2	0.4	12.7
1910	3.6	2.9	9.3	10.6	15.7	19.3	21.4	22.5	18.8	12.1	7.8	3.6	12.3
mean	2.6	3.8	10.1	12.2	16.5	19.9	21.4	21.9	18.2	11.5	7.9	3.0	12.4
s.d.	1.9	1.9	2.6	1.8	1.6	1.5	0.9	0.7	1.5	1.6	2.4	2.4	0.6
max	5.9	7.1	14.4	15.1	19.3	21.6	23.1	22.8	19.9	14.2	11.7	6.8	13.2
min	-0.2	-0.1	6.7	9.7	14.8	16.2	20.2	20.5	15.0	9.2	5.1	0.0	11.0
1911	7.6	9.4	9.7	13.5	15.0	21.1	22.0	22.2	21.1	13.5	5.1	3.4	13.6
1912	1.2	0.7	6.6	12.7	17.1	19.3	22.4	21.6	18.3	12.8	4.4	3.2	11.7
1913	3.8	2.3	6.3	10.5	15.7	19.0	21.7	20.9	17.9	11.7	11.5	4.6	12.2
1914	4.7	2.6	6.4	12.0	17.1	21.4	22.5	22.3	18.3	12.6	7.0	2.2	12.4
1915	1.0	4.8	3.1	10.6	17.2	21.5	21.4	20.7	19.0	12.0	8.1	3.4	11.9
1916	6.3	3.7	8.4	11.4	16.8	20.5	22.4	21.7	17.2	10.9	5.5	4.1	12.4
1917	5.4	4.4	7.8	11.2	12.8	19.6	23.5	21.3	17.6	8.2	3.6	1.7	11.4
1918	-2.8	6.5	11.4	12.1	17.5	22.1	20.4	20.8	15.3	14.9	7.3	7.2	12.7
1919	2.3	4.3	8.8	11.5	15.3	19.2	21.6	21.8	19.3	18.2	8.8	-0.7	12.5
1920	3.5	6.4	8.3	11.0	17.7	18.6	21.0	20.4	18.9	11.4	4.6	3.2	12.1
mean	3.3	4.5	7.7	11.6	16.2	20.2	21.9	21.4	18.3	12.6	6.6	3.2	12.3
s.d.	3.0	2.5	2.3	0.9	1.5	1.2	0.9	0.6	1.5	2.6	2.4	2.0	0.6
max	7.6	9.4	11.4	13.5	17.7	22.1	23.5	22.3	21.1	18.2	11.5	7.2	13.6
min	-2.8	0.7	3.1	10.5	12.8	18.6	20.4	20.4	15.3	8.2	3.6	-0.7	11.4

Table 32. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1921	6.1	4.9	13.0	10.4	14.9	20.0	21.4	20.6	20.3	9.0	8.8	5.6	12.9
1922	2.6	7.6	7.5	12.6	16.9	19.9	20.4	20.0	17.6	9.2	7.3	6.5	12.3
1923	6.5	4.9	5.9	11.5	15.5	19.3	20.3	20.5	17.9	11.4	4.7	7.1	12.1
1924	-0.7	3.3	5.1	11.2	13.3	20.0	19.4	20.5	16.8	11.7	7.6	3.6	11.0
1925	0.6	5.3	7.7	13.7	13.8	21.3	22.9	21.6	21.1	14.2	7.5	1.8	12.6
1926	2.7	6.2	5.9	10.7	15.5	19.5	21.1	22.0	20.9	16.0	6.0	5.4	12.7
1927	5.6	8.6	8.5	15.3	19.1	20.5	21.2	21.6	19.1	13.4	12.7	3.2	14.1
1928	3.5	5.0	8.5	9.9	15.5	20.1	21.7	21.8	17.2	14.6	6.8	2.8	12.3
1929	4.2	2.0	10.2	14.7	16.8	20.1	21.5	20.8	18.5	13.1	5.3	3.6	12.6
1930	0.6	8.5	6.4	13.4	17.7	18.9	21.5	21.2	19.0	12.3	7.6	2.2	12.4
mean	3.2	5.6	7.9	12.3	15.9	20.0	21.2	21.1	18.8	12.5	7.4	4.2	12.5
s.d.	2.5	2.1	2.4	1.9	1.8	0.7	0.9	0.7	1.5	2.3	2.2	1.8	0.8
max	6.5	8.6	13.0	15.3	19.1	21.3	22.9	22.0	21.1	16.0	12.7	7.1	14.1
min	-0.7	2.0	5.1	9.9	13.3	18.9	19.4	20.0	16.8	9.0	4.7	1.8	11.0
1931	3.2	6.2	4.7	10.4	13.4	19.6	22.3	19.8	19.6	14.9	10.9	6.8	12.6
1932	6.1	9.5	5.8	12.5	16.4	20.5	22.7	21.7	18.5	10.4	3.6	3.2	12.6
1933	6.6	3.9	9.2	10.9	18.4	18.2	22.1	21.3	20.6	14.1	7.8	7.8	13.4
1934	5.9	6.0	7.7	14.0	16.4	21.3	22.2	22.9	18.0	14.9	9.7	4.4	13.6
1935	5.9	5.7	12.6	14.0	16.9	21.1	22.5	22.1	18.6	14.5	7.9	3.0	13.7
1936	1.4	2.3	10.3	10.7	17.4	21.0	21.9	22.0	20.2	11.5	5.6	5.7	12.5
1937	6.8	6.1	6.7	12.0	16.3	21.3	22.0	22.5	18.6	12.6	5.9	6.4	13.1
1938	5.5	9.3	12.9	13.1	16.9	20.6	22.1	21.8	17.7	13.4	6.4	4.5	13.7
1939	5.3	5.6	9.3	12.2	16.3	21.5	22.6	21.8	19.8	13.7	6.5	5.8	13.4
1940	-2.5	4.4	9.1	13.0	15.7	19.7	21.8	20.7	16.9	12.6	8.5	7.4	12.3
mean	4.4	5.9	8.8	12.3	16.4	20.5	22.2	21.7	18.8	13.3	7.3	5.5	13.1
s.d.	2.9	2.2	2.7	1.3	1.3	1.0	0.3	0.9	1.2	1.5	2.1	1.7	0.5
max	6.8	9.5	12.9	14.0	18.4	21.5	22.7	22.9	20.6	14.9	10.9	7.8	13.7
min	-2.5	2.3	4.7	10.4	13.4	18.2	21.8	19.8	16.9	10.4	3.6	3.0	12.3

Table 32. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	5.7	4.0	7.0	13.9	17.7	20.9	22.3	22.8	21.4	18.5	6.0	6.5	13.9
1942	1.8	4.7	7.9	14.1	17.2	21.4	22.0	22.8	18.4	13.0	9.9	4.9	13.2
1943	3.9	6.3	7.4	13.4	18.0	21.6	22.0	21.7	17.7	11.1	4.7	4.2	12.7
1944	3.8	9.4	9.4	13.2	16.6	21.2	21.9	22.1	18.9	11.4	9.0	2.6	13.3
1945	2.9	7.2	12.5	13.3	15.8	21.4	22.3	21.9	19.7	11.7	10.2	3.4	13.5
1946	4.2	5.6	10.4	14.6	17.2	20.1	22.1	21.7	18.9	13.9	10.6	7.1	13.9
1947	5.0	0.7	5.6	14.3	16.0	21.0	20.4	22.3	19.4	15.9	6.6	5.5	12.7
1948	0.1	5.4	9.1	14.3	17.5	20.8	22.0	21.1	17.0	10.8	5.8	4.6	12.4
1949	2.7	5.6	7.1	10.8	17.4	20.2	21.4	19.0	16.9	13.7	5.3	4.7	12.1
1950	7.9	6.3	6.1	10.8	17.2	19.7	20.6	19.6	17.4	13.2	4.3	2.1	12.1
mean	3.8	5.5	8.3	13.3	17.0	20.8	21.7	21.5	18.6	13.3	7.2	4.6	13.0
s.d.	2.2	2.3	2.1	1.4	0.7	0.6	0.7	1.3	1.4	2.4	2.4	1.6	0.7
max	7.9	9.4	12.5	14.6	18.0	21.6	22.3	22.8	21.4	18.5	10.6	7.1	13.9
min	0.1	0.7	5.6	10.8	15.8	19.7	20.4	19.0	16.9	10.8	4.3	2.1	12.1
1951	2.2	3.5	7.8	11.2	16.1	20.9	21.7	22.2	18.3	13.7	5.5	3.9	12.3
1952	7.7	5.9	6.3	10.3	15.8	20.9	21.5	21.7	16.6	7.4	6.6	2.5	11.9
1953	4.2	3.9	11.6	11.0	17.8	21.9	21.8	21.7	17.6	13.0	5.3	1.2	12.6
1954	3.3	5.4	6.0	14.1	14.3	19.6	22.5	21.9	17.3	13.6	3.5	1.7	11.9
1955	2.2	2.7	8.4	13.6	17.7	17.9	21.7	21.3	19.3	9.6	4.9	2.7	11.8
1956	0.7	4.8	5.9	10.1	17.5	19.6	21.9	21.1	15.6	11.2	3.0	4.1	11.3
1957	2.9	8.0	5.2	12.1	16.9	21.2	22.1	21.1	17.0	10.0	6.8	2.4	12.1
1958	-0.8	0.2	2.6	10.2	15.9	20.2	21.8	20.9	19.4	11.7	6.4	0.1	10.7
1959	-0.9	4.2	3.2	10.3	18.3	20.1	21.2	21.6	18.9	12.2	1.8	3.2	11.2
1960	1.9	-0.7	3.1	11.7	14.7	20.0	22.2	22.8	17.9	14.2	7.8	1.7	11.5
mean	2.3	3.8	6.0	11.4	16.5	20.2	21.9	21.6	17.8	11.7	5.2	2.4	11.7
s.d.	2.5	2.6	2.8	1.4	1.4	1.1	0.4	0.6	1.2	2.2	1.9	1.2	0.6
max	7.7	8.0	11.6	14.1	18.3	21.9	22.5	22.8	19.4	14.2	7.8	4.1	12.6
min	-0.9	-0.7	2.6	10.1	14.3	17.9	21.2	20.9	15.6	7.4	1.8	0.1	10.7

Table 32. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	-1.1	4.2	8.5	8.6	15.4	19.4	21.3	18.9	18.1	10.4	5.8	2.1	11.0
1962	-2.3	6.2	4.0	10.5	17.0	20.0	22.0	21.4	18.6	13.7	5.5	1.9	11.5
1963	-2.6	1.0	7.2	15.0	17.3	20.1	22.2	20.6	18.8	12.7	8.9	-1.3	11.6
1964	0.7	1.1	7.1	13.9	17.9	21.0	21.8	22.8	19.3	9.5	8.2	3.1	12.2
1965	3.4	2.5	4.2	14.8	18.5	20.4	22.1	20.8	19.4	11.0	11.2	3.7	12.7
1966	1.3	1.9	7.2	12.6	17.0	19.2	23.1	21.3	17.9	9.9	8.1	2.0	11.8
1967	1.6	1.3	9.2	16.3	14.9	20.6	20.9	20.3	16.3	8.8	5.9	3.1	11.6
1968	2.7	0.2	5.9	12.9	16.1	19.9	21.3	21.7	16.3	11.8	5.1	1.8	11.3
1969	4.1	4.0	4.6	13.0	16.1	19.9	23.6	22.0	18.0	13.2	4.8	2.9	12.2
1970	0.0	2.7	6.5	14.0	15.8	20.1	21.8	22.6	20.9	11.6	3.9	7.2	12.3
mean	0.8	2.5	6.4	13.2	16.6	20.1	22.0	21.2	18.4	11.3	6.7	2.7	11.8
s.d.	2.3	1.9	1.8	2.3	1.1	0.5	0.8	1.2	1.4	1.6	2.3	2.1	0.5
max	4.1	6.2	9.2	16.3	18.5	21.0	23.6	22.8	20.9	13.7	11.2	7.2	12.7
min	-2.6	0.2	4.0	8.6	14.9	19.2	20.9	18.9	16.3	8.8	3.9	-1.3	11.0
1971	4.2	3.5	6.1	10.9	15.7	21.2	22.4	20.7	19.8	14.9	6.3	7.9	12.8
1972	4.2	3.9	8.8	13.0	15.5	20.3	20.9	21.5	20.7	12.4	5.7	1.0	12.3
1973	0.0	3.3	9.7	10.6	14.6	19.9	21.8	19.7	19.2	14.2	11.5	2.2	12.2
1974	4.1	4.7	12.1	12.3	18.5	18.7	20.9	20.6	16.4	12.7	7.1	3.5	12.6
1975	4.8	3.5	8.8	12.6	17.8	19.4	21.0	21.1	16.1	12.1	6.4	4.1	12.3
1976	1.1	7.5	9.7	12.5	14.0	18.5	21.1	19.5	17.3	7.9	3.3	1.4	11.2
1977	-2.3	2.9	8.4	12.2	17.2	20.9	22.3	22.1	20.1	12.2	8.5	3.1	12.3
1978	-2.0	-0.6	6.0	13.2	17.0	19.8	21.8	21.6	20.4	12.0	9.9	3.4	11.9
1979	-1.2	3.3	7.7	13.2	16.6	19.8	22.1	20.9	17.1	12.6	4.4	3.1	11.6
1980	4.7	2.6	6.6	9.9	17.0	21.4	22.5	21.9	20.7	10.2	5.8	4.1	12.3
mean	1.8	3.5	8.4	12.0	16.4	20.0	21.7	21.0	18.8	12.1	6.9	3.4	12.2
s.d.	2.9	2.0	1.9	1.2	1.4	1.0	0.6	0.9	1.8	1.9	2.5	1.9	0.5
max	4.8	7.5	12.1	13.2	18.5	21.4	22.5	22.1	20.7	14.9	11.5	7.9	12.8
min	-2.3	-0.6	6.0	9.9	14.0	18.5	20.9	19.5	16.1	7.9	3.3	1.0	11.2

Table 32. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	1.6	4.1	7.2	15.7	15.6	21.5	22.6	21.2	16.9	12.8	7.4	3.4	12.5
1982	1.5	3.3	10.9	11.7	17.4	20.2	21.9	22.2	17.9	11.9	8.1	5.5	12.7
1983	2.9	4.4	6.4	10.1	14.9	19.1	21.6	21.7	17.5	12.7	7.8	-1.4	11.5
1984	-0.5	3.5	7.9	11.3	16.3	20.1	21.6	21.5	17.9	15.1	7.1	9.9	12.6
1985	-0.6	3.3	11.2	13.5	16.5	20.4	21.6	21.8	18.6	15.6	11.6	0.4	12.8
1986	3.8	6.7	7.8	14.1	16.7	21.1	22.5	20.6	21.2	13.1	9.7	3.8	13.4
1987	2.0	6.4	6.7	10.1	17.6	20.1	21.8	22.8	17.4	10.9	8.6	4.7	12.4
1988	0.6	3.2	7.3	11.6	15.1	19.4	21.9	22.1	18.9	12.4	8.2	4.3	12.1
1989	6.3	3.4	8.6	13.4	17.9	18.9	21.1	21.2	16.4	10.4	7.1	-3.6	11.8
1990	4.6	5.8	8.6	10.9	17.2	21.1	21.0	21.3	19.5	10.3	7.7	1.8	12.5
mean	2.2	4.4	8.3	12.2	16.5	20.2	21.8	21.6	18.2	12.5	8.3	2.9	12.4
s.d.	2.2	1.4	1.6	1.9	1.0	0.9	0.5	0.6	1.4	1.8	1.4	3.8	0.6
max	6.3	6.7	11.2	15.7	17.9	21.5	22.6	22.8	21.2	15.6	11.6	9.9	13.4
min	-0.6	3.2	6.4	10.1	14.9	18.9	21.0	20.6	16.4	10.3	7.1	-3.6	11.5
1991	1.7	4.0	8.2	14.1	18.9	21.9	23.1	22.3	18.1	12.6	3.7	5.8	12.9
1992	1.9	5.2	7.7	11.4	15.6	20.1	22.5	19.5	18.5	11.2	4.5	4.5	11.9

Table 32. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	3.0	4.7	8.5	12.1	16.2	20.0	21.5	21.4	18.4	12.2	7.3	3.5	12.4
s.d.	2.4	2.2	2.6	1.6	1.6	1.1	0.9	0.7	1.5	2.2	2.3	2.1	0.7
max	7.6	9.4	14.4	15.3	19.3	22.1	23.5	22.8	21.1	18.2	12.7	7.2	14.1
min	-2.8	-0.1	3.1	9.7	12.8	16.2	19.4	20.0	15.0	8.2	3.6	-0.7	11.0
1911-40													
mean	3.6	5.3	8.1	12.1	16.2	20.2	21.7	21.4	18.7	12.8	7.1	4.3	12.6
s.d.	2.8	2.3	2.4	1.4	1.5	1.0	0.9	0.8	1.4	2.1	2.2	2.0	0.7
max	7.6	9.5	13.0	15.3	19.1	22.1	23.5	22.9	21.1	18.2	12.7	7.8	14.1
min	-2.8	0.7	3.1	9.9	12.8	18.2	19.4	19.8	15.3	8.2	3.6	-0.7	11.0
1921-50													
mean	3.8	5.7	8.3	12.6	16.5	20.4	21.7	21.4	18.7	13.0	7.3	4.7	12.9
s.d.	2.5	2.1	2.4	1.6	1.4	0.9	0.8	1.0	1.3	2.1	2.2	1.7	0.7
max	7.9	9.5	13.0	15.3	19.1	21.6	22.9	22.9	21.4	18.5	12.7	7.8	14.1
min	-2.5	0.7	4.7	9.9	13.3	18.2	19.4	19.0	16.8	9.0	3.6	1.8	11.0
1931-60													
mean	3.5	5.1	7.7	12.3	16.6	20.5	21.9	21.6	18.4	12.8	6.6	4.1	12.6
s.d.	2.6	2.5	2.7	1.5	1.1	0.9	0.5	0.9	1.3	2.1	2.3	2.0	0.9
max	7.9	9.5	12.9	14.6	18.4	21.9	22.7	22.9	21.4	18.5	10.9	7.8	13.9
min	-2.5	-0.7	2.6	10.1	13.4	17.9	20.4	19.0	15.6	7.4	1.8	0.1	10.7
1941-70													
mean	2.3	3.9	6.9	12.6	16.7	20.4	21.9	21.4	18.2	12.1	6.4	3.2	12.2
s.d.	2.6	2.5	2.4	1.9	1.1	0.8	0.6	1.0	1.3	2.2	2.3	1.9	0.8
max	7.9	9.4	12.5	16.3	18.5	21.9	23.6	22.8	21.4	18.5	11.2	7.2	13.9
min	-2.6	-0.7	2.6	8.6	14.3	17.9	20.4	18.9	15.6	7.4	1.8	-1.3	10.7

Table 32. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951-80													
mean	1.6	3.2	6.9	12.2	16.5	20.1	21.8	21.3	18.3	11.7	6.3	2.8	11.9
s.d.	2.6	2.2	2.4	1.8	1.3	0.9	0.6	0.9	1.5	1.9	2.3	1.8	0.5
max	7.7	8.0	12.1	16.3	18.5	21.9	23.6	22.8	20.9	14.9	11.5	7.9	12.8
min	-2.6	-0.7	2.6	8.6	14.0	17.9	20.9	18.9	15.6	7.4	1.8	-1.3	10.7
1961-90													
mean	1.6	3.5	7.7	12.5	16.5	20.1	21.8	21.3	18.5	12.0	7.3	3.0	12.1
s.d.	2.5	1.9	1.9	1.8	1.2	0.8	0.7	0.9	1.5	1.8	2.1	2.7	0.6
max	6.3	7.5	12.1	16.3	18.5	21.5	23.6	22.8	21.2	15.6	11.6	9.9	13.4
min	-2.6	-0.6	4.0	8.6	14.0	18.5	20.9	18.9	16.1	7.9	3.3	-3.6	11.0

Table 33. Minimum Daily Temperature (°C) by Month and Year for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	-4.4	-5.6	-2.8	1.1	8.3	13.3	19.4	18.9	8.3	3.3	-2.2	-9.4	-9.4
1902	-5.6	-3.9	0.6	7.2	13.3	12.8	18.9	20.6	7.2	5.6	-0.6	-3.9	-5.6
1903	-5.0	-10.6	1.1	1.7	4.4	8.9	16.7	19.4	7.2	1.7	-8.3	-5.6	-10.6
1904	-9.4	-5.0	-0.6	1.1	7.8	15.6	18.9	16.1	16.1	2.8	-5.0	-6.1	-9.4
1905	-8.3	-13.3	5.6	5.0	13.3	18.9	15.0	17.8	12.8	2.2	-1.7	-5.0	-13.3
1906	-7.2	-6.7	-2.8	3.9	7.2	16.1	16.7	13.3	16.1	1.1	-2.8	-2.8	-7.2
1907	-7.5	-2.8	1.7	3.3	7.2	11.7	13.9	19.4	11.1	2.8	-6.1	-2.8	-6.1
1908	-5.6	-5.6	3.3	2.8	4.4	16.1	17.2	18.3	6.1	0.0	-4.4	-3.9	-5.6
1909	-7.8	-6.7	-0.6	1.7	3.9	16.1	20.6	20.0	2.8	2.8	-1.1	-7.2	-7.8
1910	-8.9	-10.6	2.2	1.1	10.0	12.8	17.2	20.0	10.6	-3.9	-2.2	-6.4	-10.6
1911	-12.2	-5.6	2.2	7.8	8.3	15.6	17.8	13.3	15.0	1.7	-8.9	-5.6	-12.2
1912	-11.7	-9.4	-1.1	2.8	7.8	12.2	21.1	18.3	10.0	5.6	-6.1	-3.9	-11.7
1913	-8.9	-3.9	-2.8	2.8	11.7	12.2	19.4	14.4	4.4	0.6	-0.6	-5.0	-8.9
1914	-3.3	-7.8	-2.2	1.1	11.1	16.7	20.0	19.4	10.0	-2.2	-3.9	-6.7	-7.8
1915	-5.0	-2.8	-6.1	-2.2	8.9	16.1	15.6	15.0	13.3	5.6	-3.9	-5.6	-6.1
1916	-9.4	-6.1	-2.2	0.6	9.4	13.9	21.1	15.0	4.4	1.1	-6.7	-8.9	-9.4
1917	-4.4	-9.4	-4.4	3.3	5.0	10.6	17.8	13.3	9.4	-3.3	-2.8	-11.7	-11.7
1918	-16.7	-4.4	0.0	2.8	10.6	19.4	17.2	18.3	6.1	1.7	-1.7	-7.2	-16.7
1919	-8.9	-2.8	-2.2	2.8	7.8	10.0	18.9	18.3	11.7	10.0	-2.8	-11.7	-11.7
1920	-7.9	-2.8	-5.0	-2.2	12.8	14.4	18.3	16.1	7.8	0.6	-4.4	-6.1	-6.1
1921	-3.3	-2.8	1.1	1.1	7.2	17.2	19.4	17.2	17.8	2.2	-0.6	-6.1	-6.1
1922	-3.3	-4.4	-5.0	5.0	11.7	16.7	13.9	15.6	12.8	1.7	-1.7	-3.3	-5.0
1923	-2.8	-5.6	-7.8	2.8	7.8	15.6	16.1	13.3	11.7	-0.6	-2.8	-3.9	-7.8
1924	-11.1	-8.9	-3.9	-0.6	6.1	13.9	11.7	17.2	8.9	1.7	-3.9	-9.4	-11.1
1925	-6.7	-4.4	-0.6	7.8	3.3	18.3	20.6	17.2	16.7	1.1	-2.2	-7.8	-7.8

Table 33. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1926	-3.9	-1.1	-1.1	2.2	7.2	12.2	16.7	18.9	12.2	3.9	-2.8	-5.6	-5.6
1927	-6.7	-1.7	-1.1	4.4	11.7	16.7	17.8	13.9	10.0	4.4	-1.1	-7.2	-7.2
1928	-12.2	-2.2	1.1	-0.6	7.2	13.3	20.0	20.0	8.9	2.8	-2.8	-6.1	-12.2
1929	-7.8	-7.8	-2.8	6.7	4.4	15.6	18.3	15.6	12.8	-0.6	-6.1	-17.2	-17.2
1930	-20.0	-2.2	-3.9	7.8	11.1	9.4	18.9	16.1	11.1	1.1	-3.9	-4.4	-20.0
1931	-4.4	-0.6	-3.3	0.0	6.1	12.8	19.4	13.9	7.8	1.1	1.1	-2.2	-4.4
1932	-3.9	-2.8	-7.8	2.8	10.6	16.1	20.0	17.8	12.2	1.7	-5.6	-7.2	-7.8
1933	-6.1	-13.9	-1.7	0.0	11.7	10.6	19.4	18.9	13.9	4.4	-2.8	-2.8	-13.9
1934	-6.1	-3.3	-2.8	6.1	9.4	18.3	16.1	19.4	10.0	8.9	1.1	-5.0	-6.1
1935	-10.0	-3.9	2.8	3.9	10.6	17.8	18.3	17.8	8.3	8.3	0.0	-5.0	-10.0
1936	-7.8	-9.4	2.2	-1.7	13.3	15.0	18.3	17.2	12.2	5.0	-1.7	-3.3	-9.4
1937	-1.7	-3.9	-3.3	2.2	10.6	16.1	18.9	20.6	10.6	0.0	-3.9	-6.1	-6.1
1938	-4.4	-4.4	1.1	0.6	8.3	16.1	20.0	18.9	7.2	0.0	-7.8	-3.9	-7.8
1939	-5.0	-5.6	0.0	1.1	8.9	18.3	19.4	20.0	13.3	1.1	-1.7	-5.0	-5.6
1940	-14.4	-2.8	-1.7	-1.1	10.0	15.6	18.9	14.4	7.8	4.4	-5.0	-2.8	-14.4
1941	-5.6	-4.4	-0.6	7.2	11.7	15.6	18.9	20.6	14.4	6.1	-2.8	-2.2	-5.6
1942	-5.6	-2.8	-2.2	0.6	9.4	18.9	17.8	21.1	5.0	1.7	-1.1	-3.3	-5.6
1943	-12.2	-4.4	-9.4	2.8	12.8	20.0	16.1	15.6	12.2	0.0	-3.9	-7.8	-12.2
1944	-7.8	-4.4	-0.6	2.2	6.1	18.3	19.4	18.9	14.4	2.8	-2.8	-4.4	-7.8
1945	-2.8	-1.7	2.2	2.8	6.1	15.6	17.8	17.8	11.1	5.0	-3.3	-9.4	-9.4
1946	-6.1	-3.9	0.6	5.0	10.6	11.7	18.9	16.1	15.0	2.2	3.3	-6.1	-6.1
1947	-8.9	-7.8	-2.8	2.2	8.9	13.3	13.9	20.6	9.4	9.4	-1.1	-2.8	-8.9
1948	-9.4	-3.9	-7.8	5.0	10.0	15.6	20.0	18.3	10.0	0.6	-1.7	-2.2	-9.4
1949	-12.2	-10.0	0.0	2.2	11.1	17.8	19.4	12.8	6.1	4.4	-3.3	-3.9	-12.2
1950	-3.3	-0.6	-1.7	2.2	13.3	13.9	16.1	16.7	12.8	7.8	-6.1	-11.1	-11.1

Table 33. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951	-6.7	-17.8	-2.2	2.2	11.1	17.2	20.0	19.4	12.8	7.2	-6.1	-7.2	-17.8
1952	-1.1	-2.8	-1.1	3.3	7.8	17.2	18.3	15.6	10.6	0.0	-2.8	-6.1	-6.1
1953	-2.8	-1.7	2.2	2.8	7.8	18.3	16.7	20.0	11.1	5.6	-0.6	-7.2	-7.2
1954	-8.3	-4.4	-2.2	2.2	4.4	12.2	20.0	19.4	9.4	0.6	-1.1	-6.7	-8.3
1955	-7.2	-7.8	-4.4	6.7	11.7	10.6	18.3	16.7	12.8	-0.6	-4.4	-10.0	-10.0
1956	-6.1	-2.8	-5.6	2.8	11.1	12.8	18.9	12.8	10.0	3.3	-6.1	-6.1	-6.1
1957	-10.0	-1.7	-4.4	2.2	6.7	17.2	18.3	16.7	12.2	-2.8	-1.7	-10.6	-10.6
1958	-7.2	-10.0	-1.1	3.9	8.9	14.4	17.2	15.0	10.6	5.6	-3.9	-6.7	-10.0
1959	-10.0	-1.7	-3.3	0.6	12.2	16.1	19.4	17.8	13.9	4.4	-6.7	-2.8	-10.0
1960	-8.3	-7.8	-6.1	3.3	3.9	15.6	18.9	20.0	11.7	3.3	-1.1	-6.1	-8.3
1961	-7.8	-1.7	-0.6	1.7	7.2	15.6	18.3	15.0	8.3	2.2	-3.3	-7.8	-7.8
1962	-15.0	-1.7	-3.9	-2.8	7.2	16.7	20.0	15.6	12.2	3.9	-1.1	-8.9	-15.0
1963	-12.8	-7.2	-2.2	4.4	8.3	17.8	19.4	13.3	6.1	5.0	-2.2	-11.1	-12.8
1964	-12.2	-5.6	-1.7	3.9	9.4	12.2	18.3	20.0	13.9	3.3	-2.8	-5.6	-12.2
1965	-8.3	-6.7	-5.0	5.0	8.9	16.1	18.9	15.0	11.7	0.6	-0.6	-2.2	-8.3
1966	-10.6	-5.6	-3.3	2.2	12.2	12.8	19.4	13.9	11.1	1.7	-4.4	-7.8	-10.6
1967	-6.7	-6.7	-3.9	10.0	7.8	14.4	12.2	12.2	3.3	2.8	-1.7	-5.0	-6.7
1968	-6.7	-5.0	-5.6	3.9	7.8	13.9	14.4	16.1	10.6	3.3	-3.3	-5.0	-6.7
1969	-8.3	-3.3	-3.9	7.2	8.3	10.6	20.6	18.3	11.1	4.4	-4.4	-3.3	-8.3
1970	-10.0	-5.0	-1.1	0.6	6.7	12.2	15.6	16.1	11.1	2.2	-5.6	-4.4	-10.0
1971	-5.0	-6.7	-5.6	-1.1	5.0	16.7	17.8	16.7	12.8	5.6	-0.6	1.7	-6.7
1972	-7.8	-7.2	-1.1	3.3	11.1	11.7	14.4	17.2	10.6	6.1	0.0	-8.3	-8.3
1973	-9.4	-7.8	1.7	-0.6	6.1	15.0	18.9	15.6	12.8	3.3	1.7	-7.2	-9.4
1974	-6.1	-5.0	0.0	3.9	10.6	12.2	16.7	17.2	8.9	3.9	-2.2	-5.6	-6.1
1975	-9.4	-7.2	-2.8	0.0	13.3	11.1	16.1	17.8	7.2	3.3	-5.6	-7.8	-9.4

Table 33. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1976	-10.6	-3.9	-0.6	5.0	6.1	13.9	18.3	15.6	8.9	-0.6	-9.4	-8.3	-10.6
1977	-12.2	-4.4	1.1	5.6	11.1	13.9	20.6	20.0	15.6	3.3	-2.2	-6.1	-12.2
1978	-7.8	-8.3	-3.3	5.0	7.2	16.7	17.8	18.9	13.9	3.4	1.1	-9.4	-9.4
1979	-12.2	-8.3	-2.5	3.3	8.7	12.2	17.2	18.3	10.0	5.0	-6.1	-7.8	-12.2
1980	-2.2	-7.2	-10.6	1.7	9.4	14.4	19.4	17.8	17.2	0.6	-2.8	-4.4	-10.6
1981	-5.0	-11.1	-1.1	7.8	6.7	18.3	19.4	16.7	7.8	2.2	-1.7	-6.7	-11.1
1982	-15.0	-6.1	-3.3	1.7	7.2	14.4	20.0	20.6	8.3	1.7	-1.1	-5.6	-15.0
1983	-5.0	-1.1	-2.2	2.2	6.7	12.8	16.7	20.6	5.6	4.4	-3.9	-14.4	-14.4
1984	-9.4	-7.2	-3.3	1.7	6.1	10.0	18.3	18.3	9.4	3.3	-2.8	-6.1	-9.4
1985	-12.2	-7.8	3.9	4.4	10.0	14.4	18.3	17.2	7.2	5.6	3.3	-7.8	-12.2
1986	-3.3	-4.4	-3.9	5.6	10.0	17.8	20.6	12.8	18.3	5.6	-1.7	-0.6	-4.4
1987	-5.6	-2.8	-3.9	-1.7	13.3	16.7	18.3	20.6	11.1	4.4	-2.2	-4.4	-5.6
1988	-7.2	-8.3	-2.8	1.7	9.4	13.9	17.8	17.2	11.7	5.6	0.0	-5.6	-8.3
1989	-3.3	-8.3	-5.6	-1.1	11.7	12.8	17.2	13.9	7.2	-2.8	-2.2	-16.1	-16.1
1990	-5.6	-1.1	-1.1	0.6	10.6	17.8	15.6	16.7	8.3	3.3	-2.8	-11.1	-11.1
1991	-5.6	-4.4	1.1	1.1	8.9	19.4	20.6	18.9	8.3	5.0	-6.7	-2.8	-6.7
1992	-7.2	-1.1	-1.1	2.2	4.4	14.4	20.0	13.9	10.0	5.6	-5.0	-3.3	-7.2

Table 34. Frost-free Days at Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	22	23	26	30	31	30	31	31	30	31	28	16	329
1902	16	21	31	30	31	30	31	31	30	31	29	19	330
1903	18	24	31	30	31	30	31	31	30	31	21	15	323
1904	14	23	28	30	31	30	31	31	30	31	27	18	324
1905	17	14	31	30	31	30	31	31	30	31	29	14	319
1906	15	18	28	30	31	30	31	31	30	31	27	26	328
1907	16	21	31	30	31	30	31	31	30	31	25	27	334
1908	22	21	31	30	31	30	31	31	30	29	25	26	337
1909	24	20	29	30	31	30	31	31	30	31	28	13	328
1910	19	19	31	30	31	30	31	31	30	29	28	20	329
mean	18.3	20.4	29.7	30.0	31.0	30.0	31.0	31.0	30.0	30.6	26.7	19.4	328.1
s.d.	3.4	2.9	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.5	5.3	5.2
max	24	24	31	30	31	30	31	31	30	31	29	27	337
min	14	14	26	30	31	30	31	31	30	29	21	13	319
1911	26	24	31	30	31	30	31	31	30	31	21	21	337
1912	16	15	27	30	31	30	31	31	30	31	26	23	321
1913	20	19	23	30	31	30	31	31	30	31	29	25	330
1914	21	18	26	30	31	30	31	31	30	30	27	20	325
1915	18	26	21	29	31	30	31	31	30	31	25	22	325
1916	25	21	30	30	31	30	31	31	30	31	22	19	331
1917	23	19	27	30	31	30	31	31	30	26	24	17	319
1918	5	23	30	30	31	30	31	31	30	31	27	21	320
1919	18	22	29	30	31	30	31	31	30	31	27	14	324
1920	18	24	26	29	31	30	31	31	30	31	23	21	325
mean	19.0	21.1	27.0	29.8	31.0	30.0	31.0	31.0	30.0	30.4	25.1	20.3	325.7
s.d.	5.9	3.3	3.2	0.4	0.0	0.0	0.0	0.0	0.0	1.6	2.6	3.1	5.6
max	26	26	31	30	31	31	30	31	30	31	29	25	337
min	5	15	21	29	31	30	31	31	30	26	21	14	319
1921	24	23	31	30	31	30	31	31	30	31	28	26	346
1922	21	25	27	30	31	30	31	31	30	31	29	24	340
1923	25	21	27	30	31	30	31	31	30	29	27	24	336
1924	12	21	25	29	31	30	31	31	30	31	27	17	315
1925	14	23	29	30	31	30	31	31	30	31	29	19	328
1926	20	26	30	30	31	30	31	31	30	31	24	22	336
1927	25	27	29	30	31	30	31	31	30	31	29	18	342
1928	21	22	31	29	31	30	31	31	30	31	27	19	333
1929	20	18	30	30	31	30	31	31	30	30	23	17	321
1930	19	25	26	30	31	30	31	31	30	31	28	16	328
mean	20.1	23.1	28.5	29.8	31.0	30.0	31.0	31.0	30.0	30.7	27.1	20.2	332.5
s.d.	4.3	2.7	2.1	0.4	0.0	0.0	0.0	0.0	0.0	0.7	2.1	3.5	9.6
max	25	27	31	30	31	30	31	31	30	31	29	26	346
min	12	18	25	29	31	30	31	31	30	29	23	16	315

Table 34. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1931	23	27	22	29	31	30	31	31	30	31	30	30	345
1932	25	27	23	30	31	30	31	31	30	31	19	18	326
1933	26	21	29	29	31	30	31	31	30	31	28	29	346
1934	25	25	29	30	31	30	31	31	30	31	30	22	345
1935	25	24	31	30	31	30	31	31	30	31	29	20	343
1936	19	17	31	29	31	30	31	31	30	31	24	24	328
1937	28	23	27	30	31	30	31	31	30	30	23	25	339
1938	26	25	31	30	31	30	31	31	30	30	20	24	339
1939	28	24	30	30	31	30	31	31	30	31	27	24	347
1940	8	22	29	29	31	30	31	31	30	31	26	29	327
mean	23.3	23.5	28.2	29.6	31.0	30.0	31.0	31.0	30.0	30.8	25.6	24.5	338.5
s.d.	6.0	3.0	3.3	0.5	0.0	0.0	0.0	0.0	0.0	0.4	4.0	4.0	8.4
max	28	27	31	30	31	30	31	31	30	31	30	30	347
min	8	17	22	29	31	30	31	31	30	30	19	18	326
1941	27	21	29	30	31	30	31	31	30	31	27	29	347
1942	17	21	28	30	31	30	31	31	30	31	26	24	330
1943	23	21	27	30	31	30	31	31	30	30	24	20	328
1944	20	26	30	30	31	30	31	31	30	31	27	21	338
1945	21	25	31	30	31	30	31	31	30	31	27	21	339
1946	23	22	31	30	31	30	31	31	30	31	30	26	346
1947	23	18	28	30	31	30	31	31	30	31	27	26	336
1948	10	22	27	30	31	30	31	31	30	31	26	21	320
1949	20	22	30	30	31	30	31	31	30	31	24	23	333
1950	26	27	28	30	31	30	31	31	30	31	22	20	337
mean	21.0	22.5	28.9	30.0	31.0	30.0	31.0	31.0	30.0	30.9	26.0	23.1	335.4
s.d.	4.9	2.7	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.2	3.1	8.1
max	27	27	31	30	31	30	31	31	30	31	30	29	347
min	10	18	27	30	31	30	31	31	30	30	22	20	320
1951	19	17	29	30	31	30	31	31	30	31	23	21	323
1952	22	26	30	30	31	30	31	31	30	30	23	24	338
1953	25	25	31	30	31	30	31	31	30	31	29	18	342
1954	21	25	20	30	31	30	31	31	30	31	24	15	319
1955	19	17	21	30	31	30	31	31	30	30	18	22	310
1956	15	22	26	30	31	30	31	31	30	31	15	17	309
1957	21	26	28	30	31	30	31	31	30	28	26	15	327
1958	10	11	25	30	31	30	31	31	30	31	28	14	202
1959	12	17	24	30	31	30	31	31	30	31	13	21	301
1960	16	9	22	30	31	30	31	31	30	31	27	19	307
mean	18.0	19.5	25.6	30.0	31.0	30.0	31.0	31.0	30.0	30.5	22.6	18.6	317.8
s.d.	4.7	6.3	3.9	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.5	3.4	14.5
max	25	26	31	30	31	30	31	31	30	31	29	24	342
min	10	9	20	30	31	30	31	31	30	28	13	14	301

Table 34. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	12	19	29	30	31	30	31	31	30	31	26	16	316
1962	8	25	22	29	31	30	31	31	30	31	27	22	317
1963	11	18	29	30	31	30	31	31	30	31	26	11	309
1964	16	17	30	30	31	30	31	31	30	31	25	18	320
1965	18	15	22	30	31	30	31	31	30	31	29	21	319
1966	20	16	25	30	31	30	31	31	30	31	26	21	322
1967	10	16	28	30	31	30	31	31	30	31	28	20	316
1968	20	13	23	30	31	30	31	31	30	31	24	18	312
1969	19	24	26	30	31	30	31	31	30	31	25	23	331
1970	13	18	28	30	31	30	31	31	30	31	24	22	319
mean	14.7	18.1	26.2	29.9	31.0	30.0	31.0	31.0	30.0	31.0	26.0	19.2	318.1
s.d.	4.4	3.8	3.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.6	3.6	5.9
max	20	25	30	30	31	30	31	31	30	31	29	23	331
min	8	13	22	29	31	30	31	31	30	31	24	11	309
1971	21	17	27	28	31	30	31	31	30	31	29	31	337
1972	22	20	30	30	31	30	31	31	30	31	29	14	329
1973	14	18	31	28	31	30	31	31	30	31	30	18	323
1974	22	22	30	30	31	30	31	31	30	31	28	23	339
1975	23	19	30	29	31	30	31	31	30	31	21	24	330
1976	17	27	30	30	31	30	31	31	30	30	23	21	331
1977	11	19	31	30	31	30	31	31	30	31	28	25	328
1978	5	11	28	30	31	30	31	31	30	31	30	20	308
1979	12	18	28	30	31	30	31	31	30	31	26	22	320
1980	26	18	28	30	31	30	31	31	30	31	26	21	333
mean	17.3	18.9	29.3	29.5	31.0	30.0	31.0	31.0	30.0	30.9	27	21.9	327.8
s.d.	6.6	4.0	1.4	0.8	0.0	0.0	0.0	0.0	0.0	0.3	3.0	4.5	29.0
max	26	27	31	30	31	30	31	31	30	31	30	31	339
min	5	11	27	28	31	30	31	31	30	30	21	14	308
1981	22	20	30	30	31	30	31	31	30	31	29	22	337
1982	19	19	29	30	31	30	31	31	30	31	27	23	331
1983	23	27	28	30	31	30	31	31	30	31	26	13	331
1984	14	24	29	30	31	30	31	31	30	31	27	28	336
1985	16	17	31	30	31	30	31	31	30	31	30	16	324
1986	23	24	29	30	31	30	31	31	30	31	29	27	346
1987	17	25	29	28	31	30	31	31	30	31	28	24	335
1988	13	23	28	30	31	30	31	31	30	31	28	26	332
1989	28	18	26	29	31	30	31	31	30	29	24	7	314
1990	24	26	26	30	31	30	31	31	30	31	25	18	333
mean	19.9	22.3	28.5	29.7	31.0	30.0	31.0	31.0	30.0	30.8	27.3	20.4	331.9
s.d.	4.9	3.5	1.6	0.7	0.0	0.0	0.0	0.0	0.0	0.6	1.9	6.8	8.4
max	28	27	31	30	31	30	31	31	30	31	30	28	346
min	13	17	26	28	31	30	31	31	30	29	24	7	314

Table 34. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1991	20	19	31	30	31	30	31	31	30	31	20	22	326
1992	19	25	29	30	31	30	31	31	30	31	21	22	330

Table 34. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	19.1	21.5	28.4	29.9	31.0	30.0	31.0	31.0	30.0	30.6	26.3	20.0	328.8
s.d.	4.6	3.1	2.6	0.3	0.0	0.0	0.0	0.0	0.0	1.1	2.5	3.9	7.4
max	26	27	31	30	31	30	31	31	30	31	29	27	346
min	5	14	21	29	31	30	31	31	30	26	21	13	315
1911-40													
mean	20.8	22.6	27.9	29.7	31.0	30.0	31.0	31.0	30.0	30.6	25.9	21.7	332.2
s.d.	5.6	3.1	2.9	0.4	0.0	0.0	0.0	0.0	0.0	1.0	3.0	4.0	9.4
max	28	27	31	30	31	30	31	31	30	31	30	30	347
min	5	15	21	29	31	30	31	31	30	26	19	14	315
1921-50													
mean	21.5	23.0	28.5	29.8	31.0	30.0	31.0	31.0	30.0	30.8	26.2	22.6	335.5
s.d.	5.1	2.7	2.3	0.4	0.0	0.0	0.0	0.0	0.0	0.5	2.9	3.9	8.8
max	28	27	31	30	31	30	31	31	30	31	30	30	347
min	8	17	22	29	31	30	31	31	30	29	19	16	315
1931-60													
mean	20.8	21.8	27.6	29.9	31.0	30.0	31.0	31.0	30.0	30.7	24.7	22.1	330.6
s.d.	5.5	4.5	3.3	0.3	0.0	0.0	0.0	0.0	0.0	0.6	4.3	4.2	13.9
max	28	27	31	30	31	30	31	31	30	31	30	30	347
min	8	9	20	29	31	30	31	31	30	28	13	14	301
1941-70													
mean	17.9	20.0	26.9	30.0	31.0	30.0	31.0	31.0	30.0	30.8	24.9	20.3	323.8
s.d.	5.2	4.7	3.2	0.2	0.0	0.0	0.0	0.0	0.0	0.6	3.8	3.8	12.9
max	27	27	31	30	31	30	31	31	30	31	30	29	347
min	8	9	20	29	31	30	31	31	30	28	13	11	301
1951-80													
mean	16.7	18.8	27.0	29.8	31.0	30.0	31.0	31.0	30.0	30.8	25.2	19.9	321.2
s.d.	5.4	4.7	3.3	0.6	0.0	0.0	0.0	0.0	0.0	0.6	4.1	4.0	11.1
max	26	27	31	30	31	30	31	31	30	31	30	31	342
min	5	9	20	28	31	30	31	31	30	28	13	11	301
1961-90													
mean	17.3	19.8	28.0	29.7	31.0	30.0	31.0	31.0	30.0	30.9	26.8	20.5	325.9
s.d.	5.6	4.1	2.5	0.7	0.0	0.0	0.0	0.0	0.0	0.4	2.3	5.1	9.6
max	28	27	31	30	31	30	31	31	30	31	30	31	346
min	5	11	22	28	31	30	31	31	30	29	21	7	308

Table 35. Growing Seasons for Nacogdoches, Texas, 1901-92

Year	Last Frost*	First Frost*	Duration (days)
1901	20-Mar	15-Nov	239
1902	15-Feb	27-Nov	284
1903	23-Feb	18-Nov	267
1904	14-Mar	12-Nov	242
1905	21-Feb	29-Nov	280
1906	20-Mar	12-Nov	236
1907	15-Feb	11-Nov	268
1908	21-Feb	24-Oct	245
1909	16-Mar	18-Nov	246
1910	25-Feb	29-Oct	245
1911	24-Feb	12-Nov	260
1912	24-Mar	3-Nov	223
1913	28-Mar	10-Nov	226
1914	23-Mar	28-Oct	218
1915	3-Apr	15-Nov	225
1916	4-Mar	14-Nov	254
1917	18-Mar	20-Oct	215
1918	17-Mar	19-Nov	246
1919	6-Mar	14-Nov	252
1920	5-Apr	13-Nov	221
1921	21-Feb	11-Nov	262
1922	4-Mar	26-Nov	266
1923	20-Mar	22-Oct	215
1924	1-Apr	25-Nov	237
1925	3-Mar	23-Nov	264
1926	14-Mar	5-Nov	235
1927	4-Mar	17-Nov	257
1928	11-Apr	4-Nov	206
1929	2-Mar	25-Oct	236
1930	29-Mar	25-Nov	240
1931	1-Apr	4-Dec	246
1932	14-Mar	9-Nov	239
1933	15-Apr	25-Nov	223
1934	19-Mar	1-Dec	256
1935	28-Feb	13-Nov	257
1936	3-Apr	4-Nov	214
1937	31-Mar	23-Oct	205
1938	20-Feb	24-Oct	245
1939	2-Mar	4-Nov	246
1940	13-Apr	13-Nov	213

Table 35. Continued

Year	Last Frost	First Frost	Duration (days)
1941	11-Mar	24-Nov	257
1942	28-Mar	12-Nov	228
1943	8-Mar	28-Oct	233
1944	30-Mar	27-Nov	241
1945	23-Feb	22-Nov	271
1946	15-Feb	3-Dec	290
1947	16-Mar	8-Nov	236
1948	13-Mar	10-Nov	241
1949	2-Mar	1-Nov	243
1950	15-Mar	5-Nov	234
1951	14-Mar	3-Nov	233
1952	24-Mar	8-Oct	197
1953	23-Feb	10-Nov	259
1954	16-Mar	6-Nov	234
1955	30-Mar	31-Oct	214
1956	17-Mar	9-Nov	236
1957	10-Mar	27-Oct	230
1958	21-Mar	29-Nov	252
1959	18-Mar	6-Nov	232
1960	19-Mar	11-Nov	236
1961	10-Mar	9-Nov	243
1962	2-Apr	4-Nov	215
1963	6-Mar	2-Nov	240
1964	9-Mar	21-Nov	256
1965	22-Mar	30-Nov	252
1966	25-Mar	2-Nov	221
1967	9-Mar	3-Nov	238
1968	24-Mar	12-Nov	232
1969	26-Mar	15-Nov	233
1970	22-Mar	4-Nov	226
1971	7-Apr	25-Nov	231
1972	3-Mar	30-Nov	271
1973	11-Apr	6-Dec	238
1974	26-Mar	15-Nov	233
1975	3-Apr	14-Nov	224
1976	17-Mar	21-Oct	217
1977	27-Feb	10-Nov	255
1978	10-Mar	1-Oct	204
1979	31-May	14-Nov	166
1980	4-Mar	19-Nov	259

Table 35. Continued

Year	Last Frost	First Frost	Duration (days)
1981	19-Mar	21-Nov	246
1982	8-Mar	4-Nov	240
1983	22-Mar	25-Nov	247
1984	7-Mar	22-Nov	259
1985	13-Feb	2-Dec	291
1986	22-Mar	14-Nov	236
1987	4-Apr	11-Nov	220
1988	19-Mar	28-Nov	253
1989	11-Apr	20-Oct	191
1990	21-Mar	6-Nov	229
1991	27-Feb	3-Nov	248
1992	12-Mar	5-Nov	237
mean	12-Mar	14-Nov	239
s.d.			21.95
max	13-Feb	6-Dec	291
min	15-Apr	1-Oct	166

*Last frost before growing season.

*First frost after growing season.

Table 36. Heating Degree Units, Base 18.3 °C, for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	231.4	263.6	143.3	78.9	6.9	0.0	0.0	0.0	7.5	25.6	150.0	328.3	1235.6
1902	347.5	280.8	120.6	16.9	0.0	0.0	0.0	0.0	9.2	28.6	79.2	283.9	1166.7
1903	320.0	258.9	121.4	55.0	23.9	9.2	0.0	0.0	3.3	81.1	196.1	307.8	1376.7
1904	358.3	177.5	97.5	67.2	5.6	0.0	0.0	0.0	0.0	35.0	146.1	271.4	1158.6
1905	381.7	372.5	55.6	36.4	0.0	0.0	0.0	0.0	0.0	63.6	104.4	398.9	1413.1
1906	294.7	262.2	190.8	26.9	16.1	0.0	0.0	0.0	0.0	86.1	128.3	197.8	1203.1
1907	295.6	180.3	48.3	87.8	15.8	0.0	0.0	0.0	0.0	35.8	202.2	247.5	1113.3
1908	276.1	238.3	68.3	29.2	13.3	0.0	0.0	0.0	10.6	80.8	127.5	214.2	1058.3
1909	238.3	189.7	116.9	55.0	17.5	0.0	0.0	0.0	9.2	28.9	58.3	375.8	1089.7
1910	260.3	268.6	59.7	57.2	3.3	0.0	0.0	0.0	0.0	55.8	136.9	288.3	1130.3
mean	300.4	249.2	102.2	51.1	9.3	0.9	0.0	0.0	4.1	52.1	132.9	291.4	1194.5
s.d.	51.0	58.3	45.4	23.1	8.4	2.9	0.0	0.0	4.6	24.3	45.5	64.5	117.9
max	381.7	372.5	190.8	87.8	23.9	9.2	0.0	0.0	10.6	86.1	202.2	398.9	1413.1
min	231.4	177.5	48.3	16.9	0.0	0.0	0.0	0.0	0.0	25.6	58.3	197.8	1058.3
1911	183.9	133.6	98.9	50.3	10.3	0.0	0.0	0.0	0.0	51.1	229.7	304.4	1062.2
1912	354.4	322.5	214.4	48.6	3.3	0.0	0.0	0.0	0.6	24.2	195.8	333.6	1497.5
1913	285.8	268.1	198.3	61.7	2.2	0.8	0.0	0.0	6.4	103.3	56.7	294.7	1278.1
1914	221.9	279.7	193.3	46.1	4.2	0.0	0.0	0.0	2.8	70.3	168.6	396.9	1383.9
1915	372.8	222.5	319.7	50.3	1.7	0.0	0.0	0.0	0.0	26.1	136.1	261.1	1390.3
1916	222.8	238.1	113.1	68.9	10.3	0.0	0.0	0.0	6.7	41.4	172.8	259.4	1133.3
1917	254.2	214.4	159.4	74.7	45.3	0.0	0.0	0.0	0.0	94.2	177.8	351.4	1371.4
1918	440.6	173.3	56.7	56.1	4.4	0.0	0.0	0.0	9.4	20.3	185.8	198.3	1145.0
1919	301.4	211.1	89.7	34.7	3.3	0.0	0.0	0.0	0.0	5.3	94.4	288.3	1028.3
1920	290.6	172.5	123.9	43.3	0.3	0.0	0.0	0.0	2.5	41.7	223.9	306.9	1205.6
mean	292.8	223.6	156.7	53.5	8.5	0.1	0.0	0.0	2.8	47.8	164.2	299.5	1249.6
s.d.	78.5	56.4	77.3	12.1	13.3	0.3	0.0	0.0	3.5	32.4	54.6	54.7	158.3
max	440.6	322.5	319.7	74.7	45.3	0.8	0.0	0.0	9.4	103.3	229.7	396.9	1497.5
min	183.9	133.6	56.7	34.7	0.3	0.0	0.0	0.0	0.0	5.3	56.7	198.3	1028.3

Table 36. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1921	212.5	199.7	61.1	89.7	14.4	0.0	0.0	0.0	0.0	34.4	77.8	173.6	863.3
1922	325.3	159.7	131.7	18.3	0.0	0.0	0.0	0.0	0.0	28.6	122.5	185.6	971.7
1923	153.6	231.9	215.3	57.2	12.8	0.0	0.0	0.0	0.0	63.3	188.3	205.3	1127.8
1924	367.8	270.8	211.1	50.6	16.9	0.0	0.0	0.0	8.6	43.3	158.6	343.9	1471.7
1925	364.2	192.8	138.6	34.7	20.3	0.0	0.0	0.0	0.0	96.9	195.6	358.6	1401.7
1926	345.0	171.4	222.2	97.8	11.7	0.0	0.0	0.0	1.4	16.9	202.5	250.3	1319.2
1927	243.6	144.4	166.1	33.1	2.5	0.0	0.0	0.0	0.0	21.4	57.2	341.9	1010.3
1928	298.6	248.9	143.6	121.7	9.7	0.0	0.0	0.0	0.0	40.3	190.6	304.7	1358.1
1929	273.3	352.8	117.5	20.3	13.3	0.0	0.0	0.0	0.0	38.9	260.3	291.4	1367.8
1930	409.7	150.3	202.5	0.8	0.8	0.0	0.0	0.0	1.1	60.0	173.9	342.2	1341.4
mean	299.4	212.3	161.0	52.4	10.2	0.0	0.0	0.0	1.1	44.4	162.7	279.7	1223.3
s.d.	79.2	65.2	52.2	39.2	7.0	0.0	0.0	0.0	2.7	23.7	61.2	71.0	211.6
max	409.7	352.8	222.2	121.7	20.3	0.0	0.0	0.0	8.6	96.9	260.3	358.6	1471.7
min	153.6	144.4	61.1	0.8	0.0	0.0	0.0	0.0	0.0	16.9	57.2	173.6	863.3
1931	294.2	189.4	242.8	80.6	24.2	0.0	0.0	0.0	0.0	24.4	91.9	230.8	1178.3
1932	233.1	115.3	209.7	34.4	0.0	0.0	0.0	0.0	0.0	70.6	265.3	348.1	1276.4
1933	224.2	286.1	145.8	79.2	7.2	0.0	0.0	0.0	0.0	18.1	137.2	150.6	1048.3
1934	269.2	195.6	160.8	14.7	1.4	0.0	0.0	0.0	0.0	1.1	109.7	294.4	1046.9
1935	251.9	227.5	70.6	57.2	2.8	0.0	0.0	0.0	3.1	10.8	168.9	321.7	1114.4
1936	312.2	298.3	76.1	67.5	0.0	0.0	0.0	0.0	1.7	55.0	208.9	235.8	1255.6
1937	235.0	210.3	202.2	78.9	0.0	0.0	0.0	0.0	0.0	56.9	225.0	283.6	1291.9
1938	289.2	133.3	53.3	69.2	7.8	0.0	0.0	0.0	0.8	19.4	194.2	263.9	1031.1
1939	234.4	205.8	106.1	60.8	1.9	0.0	0.0	0.0	0.0	35.8	190.6	208.9	1044.4
1940	491.1	259.4	120.8	60.8	3.3	0.0	0.0	0.0	11.7	18.6	157.8	191.1	1314.7
mean	283.4	212.1	138.8	60.3	4.9	0.0	0.0	0.0	1.7	31.1	174.9	252.9	1160.2
s.d.	79.0	59.4	64.7	21.1	7.3	0.0	0.0	0.0	3.6	22.7	53.0	61.1	116.3
max	491.1	298.3	242.8	80.6	24.2	0.0	0.0	0.0	11.7	70.6	265.3	348.1	1314.7
min	224.2	115.3	53.3	14.7	0.0	0.0	0.0	0.0	0.0	1.1	91.9	150.6	1031.1

Table 36. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	235.6	276.7	211.9	23.9	0.3	0.0	0.0	0.0	0.0	21.4	190.8	227.8	1188.3
1942	333.3	259.2	158.1	31.9	8.1	0.0	0.0	0.0	15.8	21.4	117.2	252.5	1197.5
1943	295.3	164.7	172.2	26.1	0.0	0.0	0.0	0.0	6.4	53.6	206.1	303.3	1227.8
1944	304.2	143.1	124.7	44.7	12.2	0.0	0.0	0.0	0.0	26.4	152.8	335.8	1143.9
1945	322.2	150.8	39.7	30.8	15.6	0.0	0.0	0.0	0.0	39.4	93.3	286.9	978.9
1946	295.0	186.1	75.0	14.2	0.0	0.0	0.0	0.0	0.0	23.6	102.2	178.1	874.2
1947	288.9	301.4	206.7	21.4	0.3	0.0	0.0	0.0	0.0	0.0	164.7	224.4	1207.8
1948	387.5	221.1	130.3	14.7	1.7	0.0	0.0	0.0	0.0	36.9	178.3	233.1	1203.6
1949	320.3	190.6	144.2	78.9	0.0	0.0	0.0	0.0	3.6	43.6	146.9	240.3	1168.3
1950	186.7	175.3	178.9	73.1	0.0	0.0	0.0	0.0	1.9	12.5	201.1	301.7	1131.1
mean	296.9	206.9	144.2	36.0	3.8	0.0	0.0	0.0	2.8	27.9	155.4	258.4	1132.1
s.d.	54.5	55.2	54.7	22.9	5.9	0.0	0.0	0.0	5.1	15.8	40.5	47.4	114.9
max	387.5	301.4	211.9	78.9	15.6	0.0	0.0	0.0	15.8	53.6	206.1	335.8	1227.8
min	186.7	143.1	39.7	14.2	0.0	0.0	0.0	0.0	0.0	0.0	93.3	178.1	874.2
1951	287.5	246.9	143.1	70.3	1.9	0.0	0.0	0.0	0.0	19.4	200.8	244.4	1214.4
1952	169.4	185.6	168.6	65.0	8.1	0.0	0.0	0.0	0.0	91.1	180.6	306.4	1174.7
1953	231.9	230.8	54.7	54.2	9.7	0.0	0.0	0.0	0.0	28.6	184.2	335.0	1129.2
1954	267.5	137.2	181.7	26.9	25.8	0.0	0.0	0.0	0.0	49.7	173.9	267.8	1130.6
1955	315.0	241.1	138.3	23.1	0.0	0.6	0.0	0.0	0.0	52.8	190.6	267.2	1228.6
1956	294.2	204.4	153.6	58.3	1.9	0.0	0.0	0.0	0.0	10.0	194.4	213.9	1130.8
1957	280.3	126.7	165.3	52.2	8.6	0.0	0.0	0.0	0.0	61.4	174.7	232.5	1101.7
1958	348.1	320.0	221.9	46.1	3.9	0.0	0.0	0.0	0.8	30.8	140.8	324.4	1436.9
1959	372.5	213.3	173.1	76.4	0.0	0.0	0.0	0.0	0.0	35.3	256.7	251.7	1378.9
1960	329.7	331.4	263.6	31.1	10.3	0.0	0.0	0.0	0.6	24.7	124.4	343.6	1459.4
mean	289.6	223.7	166.4	50.4	7.0	0.1	0.0	0.0	0.1	40.4	182.1	278.7	1238.5
s.d.	58.6	67.2	54.6	18.4	7.7	0.2	0.0	0.0	0.3	23.8	35.4	45.6	136.0
max	372.5	331.4	263.6	76.4	25.8	0.6	0.0	0.0	0.8	91.1	256.7	343.6	1459.4
min	169.4	126.7	54.7	23.1	0.0	0.0	0.0	0.0	0.0	10.0	124.4	213.9	1101.7

Table 36. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	386.9	185.0	91.9	96.4	2.8	1.4	0.0	0.0	0.3	53.6	189.2	276.4	1283.9
1962	391.4	116.1	200.8	48.1	0.8	0.0	0.0	0.0	0.0	25.8	159.4	301.1	1243.6
1963	441.1	258.9	97.8	19.7	3.3	0.0	0.0	0.0	1.9	6.7	115.8	407.2	1352.5
1964	323.3	310.3	128.6	13.9	0.8	0.0	0.0	0.0	3.1	50.0	115.8	259.2	1205.0
1965	242.5	282.2	254.7	18.3	0.0	0.0	0.0	0.0	0.6	54.7	47.5	226.7	1127.2
1966	363.6	268.6	145.3	39.4	4.2	0.0	0.0	0.0	0.0	53.6	106.7	307.2	1288.6
1967	315.0	275.0	93.9	5.3	8.3	0.0	0.0	0.0	12.5	44.2	136.7	264.2	1155.0
1968	338.9	331.9	195.0	38.6	0.6	0.0	0.0	0.0	1.4	33.9	195.3	291.7	1427.2
1969	274.4	233.6	251.1	19.7	5.3	1.4	0.0	0.0	0.0	38.6	176.4	261.7	1262.2
1970	392.5	244.7	180.6	36.7	10.3	0.0	0.0	0.0	0.0	70.6	208.6	161.9	1305.8
mean	347.1	250.6	164.0	33.6	3.6	0.3	0.0	0.0	2.0	43.2	145.1	275.7	1265.1
s.d.	60.2	62.3	61.9	25.9	3.5	0.6	0.0	0.0	3.8	17.9	50.0	62.5	89.3
max	441.1	331.9	254.7	96.4	10.3	1.4	0.0	0.0	12.5	70.6	208.6	407.2	1427.2
min	242.5	116.1	91.9	5.3	0.0	0.0	0.0	0.0	0.0	6.7	47.5	161.9	1127.2
1971	241.9	218.9	163.9	49.7	15.3	0.0	0.0	0.0	3.6	4.7	150.3	166.1	1014.4
1972	264.2	230.0	85.6	32.8	1.4	0.0	0.0	0.0	0.0	63.3	227.2	343.6	1248.1
1973	385.8	255.3	84.7	86.4	6.1	0.0	0.0	0.0	0.0	25.0	61.1	275.8	1180.3
1974	294.4	202.5	80.0	43.9	1.9	0.0	0.0	0.0	16.4	24.2	176.9	282.2	1122.5
1975	246.1	234.7	150.0	57.2	1.4	0.0	0.0	0.0	8.3	36.4	160.8	275.6	1170.6
1976	311.4	128.6	123.3	26.9	19.2	0.0	0.0	0.0	1.4	118.6	264.2	321.1	1314.7
1977	458.6	231.4	122.2	28.1	0.0	0.0	0.0	0.0	0.0	38.1	136.1	277.5	1291.9
1978	493.1	389.2	182.2	31.1	16.1	0.0	0.0	0.0	0.0	42.8	106.7	276.7	1537.8
1979	465.8	301.1	140.0	34.7	5.6	0.0	0.0	0.0	1.1	23.9	214.4	270.3	1456.9
1980	276.1	283.3	172.8	70.6	2.5	0.0	0.0	0.0	0.0	68.6	196.9	251.4	1322.2
mean	343.7	247.5	130.5	46.1	6.9	0.0	0.0	0.0	3.1	44.6	169.5	274.0	1265.9
s.d.	98.0	68.3	37.8	20.0	7.2	0.0	0.0	0.0	5.4	32.2	60.0	46.3	155.3
max	493.1	389.2	182.2	86.4	19.2	0.0	0.0	0.0	16.4	118.6	264.2	343.6	1537.8
min	241.9	128.6	80.0	26.9	0.0	0.0	0.0	0.0	0.0	4.7	61.1	166.1	1014.4

Table 36. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	329.7	234.4	147.8	10.8	10.0	0.0	0.0	0.0	6.4	71.4	121.1	285.0	1216.7
1982	321.7	281.7	123.9	70.0	3.1	0.0	0.0	0.0	4.2	65.6	159.2	240.8	1270.0
1983	334.7	249.2	170.8	94.2	6.9	3.6	0.0	0.0	8.1	34.7	147.5	441.1	1490.8
1984	394.4	219.2	144.7	53.3	8.9	0.0	0.0	0.0	9.2	25.6	169.7	131.1	1156.1
1985	417.8	281.4	83.6	26.4	0.3	0.0	0.0	0.0	2.5	29.2	95.0	355.0	1291.1
1986	257.2	170.8	102.5	25.3	3.3	0.0	0.0	0.3	0.0	45.3	145.6	309.7	1060.0
1987	325.6	202.2	159.7	66.9	0.0	0.0	0.0	0.0	0.0	40.0	125.0	246.9	1166.4
1988	383.1	260.8	149.7	33.9	2.8	0.0	0.0	0.0	0.0	22.2	122.2	252.2	1226.9
1989	230.0	285.6	146.9	47.2	0.0	0.0	0.0	0.0	15.6	54.2	145.6	437.5	1362.5
1990	228.1	154.4	130.6	54.2	1.1	0.0	0.0	0.0	1.9	74.7	114.2	296.7	1055.8
mean	322.2	234.0	136.0	48.2	3.6	0.4	0.0	0.0	4.8	46.3	134.5	299.6	1229.6
s.d.	66.6	46.8	26.5	25.0	3.7	1.1	0.0	0.1	5.1	19.3	22.7	93.9	133.3
max	417.8	285.6	170.8	94.2	10.0	3.6	0.0	0.03	15.6	74.7	169.7	441.1	1490.8
min	228.1	154.4	83.6	10.8	0.0	0.0	0.0	0.0	0.0	22.2	95.0	131.1	1055.8
1991	367.8	208.6	121.7	21.9	6.4	0.0	0.0	0.0	6.7	21.4	242.8	232.8	1230.0
1992	328.3	195.3	116.1	59.2	22.5	0.0	0.0	0.0	0.8	15.0	227.8	276.4	1241.4

Table 36. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	297.5	228.4	140.0	52.3	9.7	0.3	0.0	0.0	2.6	48.1	153.3	290.2	1222.5
s.d.	68.4	60.1	63.9	26.3	9.6	1.7	0.0	0.0	3.7	26.3	54.2	62.1	162.8
max	440.6	372.5	319.7	121.7	45.3	9.2	0.0	0.0	10.6	103.3	260.3	398.9	1497.5
min	153.6	133.6	48.3	0.8	0.0	0.0	0.0	0.0	0.0	5.3	56.7	173.6	863.3
1911-40													
mean	291.9	216.0	152.2	55.4	7.9	0.0	0.0	0.0	1.9	41.1	167.3	277.4	1211.0
s.d.	76.4	58.6	64.0	25.9	9.6	0.2	0.0	0.0	3.3	26.7	54.7	63.5	165.3
max	49.1	352.8	319.7	121.7	45.3	0.8	0.0	0.0	11.7	103.3	265.3	396.9	1497.5
min	153.6	115.3	53.3	0.8	0.0	0.0	0.0	0.0	0.0	1.1	56.7	150.6	863.3
1921-50													
mean	293.2	210.4	148.0	49.6	6.3	0.0	0.0	0.0	1.9	34.5	164.3	263.7	1171.9
s.d.	69.7	58.1	56.3	29.7	7.1	0.0	0.0	0.0	3.8	21.5	51.1	59.7	153.9
max	491.1	352.8	242.8	121.7	24.2	0.0	0.0	0.0	15.8	96.9	265.3	358.6	1471.7
min	153.6	115.3	39.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	57.2	150.6	863.3
1931-60													
mean	290.0	214.2	149.8	48.9	5.2	0.0	0.0	0.0	1.5	33.1	170.8	263.3	1177.0
s.d.	62.9	59.1	57.4	22.6	6.9	0.1	0.0	0.0	3.7	21.0	43.6	51.3	127.0
max	491.1	331.4	263.6	80.6	25.8	0.6	0.0	0.0	15.8	91.1	265.3	348.1	1459.4
min	169.4	115.3	39.7	14.2	0.0	0.0	0.0	0.0	0.0	0.0	91.9	150.6	874.2
1941-70													
mean	311.2	227.1	158.2	40.0	4.8	0.1	0.0	0.0	1.6	37.1	160.9	270.9	1211.9
s.d.	61.5	62.3	56.1	23.1	6.0	0.4	0.0	0.0	3.7	20.0	43.9	51.4	125.4
max	441.1	331.9	263.6	96.4	25.8	1.4	0.0	0.0	15.8	91.1	256.7	407.2	1459.4
min	169.4	116.1	39.7	5.3	0.0	0.0	0.0	0.0	0.0	0.0	47.5	161.9	874.2

Table 36. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951-80													
mean	326.8	240.6	153.6	43.4	5.9	0.1	0.0	0.0	1.7	42.7	165.6	276.1	1256.5
s.d.	76.7	64.8	53.2	22.1	6.4	0.4	0.0	0.0	3.9	24.5	50.2	50.3	126.0
max	493.1	389.2	263.6	96.4	25.8	1.4	0.0	0.0	16.4	118.6	264.2	407.2	1537.8
min	169.4	116.1	54.7	5.3	0.0	0.0	0.0	0.0	0.0	4.7	47.5	161.9	1014.4
1961-90													
mean	337.6	244.0	143.5	42.7	4.7	0.2	0.0	0.0	3.3	44.7	149.7	283.1	1253.6
s.d.	74.9	58.2	45.5	23.8	5.1	0.7	0.0	0.1	4.8	23.2	47.7	68.9	125.6
max	493.1	289.2	254.7	96.4	19.2	3.6	0.0	0.3	16.4	118.6	264.2	441.1	1537.8
min	228.1	116.1	80.0	5.3	0.0	0.0	0.0	0.0	0.0	4.7	47.5	131.1	1014.4

Table 37. Cooling Degree Units, Base 18.3 °C, for Nacogdoches, Texas, 1901-92

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901	1.4	1.7	12.2	24.7	113.6	254.2	303.9	310.0	163.3	35.6	6.4	0.3	1227.2
1902	0.0	0.0	16.7	77.8	380.0	248.3	256.1	315.0	161.1	51.4	25.6	0.0	1531.9
1903	4.2	3.6	11.7	44.2	88.9	123.6	236.9	264.4	133.3	45.3	17.2	0.0	973.3
1904	1.1	21.4	58.3	35.3	117.8	221.1	241.9	279.4	218.1	92.8	1.4	4.4	1293.1
1905	0.0	0.0	25.0	38.9	175.8	250.0	231.9	280.3	206.1	80.6	26.7	0.0	1315.3
1906	6.9	0.6	6.7	53.6	135.3	228.6	248.6	243.3	209.7	10.6	10.6	6.1	1160.6
1907	3.3	4.4	101.7	20.3	78.3	225.6	289.7	312.8	223.3	73.9	1.1	5.8	1340.3
1908	0.0	0.0	82.2	80.6	145.3	241.7	260.3	257.2	182.2	36.1	10.6	8.1	1304.2
1909	18.1	14.7	17.2	45.0	113.6	226.4	321.1	324.4	220.3	72.2	43.1	1.9	1418.1
1910	3.3	0.6	27.2	30.6	96.7	195.8	265.3	305.3	239.4	103.1	19.7	5.0	1291.9
mean	3.8	4.7	35.9	45.1	131.4	221.5	265.6	289.2	195.7	60.1	16.2	3.2	1285.6
s.d.	5.5	7.4	33.1	20.5	39.6	38.5	29.9	28.0	34.0	29.1	13.1	3.1	148.7
max	18.1	21.4	101.7	80.6	190.0	254.2	321.1	324.4	239.4	103.0	43.1	8.1	1531.9
min	0.0	0.0	6.7	20.3	78.3	123.6	231.9	243.3	133.3	10.6	1.1	0.0	973.3
1911	21.1	31.9	41.9	46.9	112.8	281.7	251.9	277.5	281.1	86.7	17.2	0.0	1450.8
1912	0.3	0.0	9.2	46.1	123.6	169.7	300.0	269.2	200.3	69.7	3.1	0.0	1191.1
1913	1.7	0.0	15.0	32.8	101.7	193.6	295.6	293.3	135.8	73.1	29.2	1.4	1173.1
1914	4.4	0.0	15.3	40.0	123.1	276.9	338.1	263.1	188.9	76.4	5.3	0.0	1331.4
1915	0.0	0.0	2.5	21.9	137.2	268.9	270.8	227.2	191.1	53.9	33.1	0.6	1207.2
1916	9.2	1.9	28.3	32.5	125.0	238.6	301.1	292.8	195.3	67.8	11.4	10.8	1314.7
1917	11.4	14.4	29.7	40.3	62.8	236.9	332.2	321.7	186.4	52.8	0.0	3.9	1292.5
1918	3.1	20.8	46.1	40.8	160.3	302.2	316.4	289.2	139.4	85.0	14.2	12.2	1429.7
1919	0.0	0.0	15.3	63.9	104.2	203.6	296.7	308.6	223.6	157.8	20.6	1.9	1396.1
1920	4.4	3.1	17.8	57.8	187.2	227.2	301.1	256.1	246.1	60.0	11.1	0.0	1371.9
mean	5.6	7.2	22.1	42.3	123.8	239.9	300.4	279.9	198.8	78.3	14.5	3.1	1315.9
s.d.	6.7	11.3	14.1	12.3	33.8	42.7	25.7	27.4	44.0	30.2	10.8	4.6	99.6
max	21.1	31.9	46.1	63.9	187.2	302.2	338.1	321.7	281.1	157.8	33.1	12.2	1450.8
min	0.0	0.0	2.5	21.9	62.8	169.7	251.9	227.2	135.8	52.8	0.0	0.0	1173.1

Table 37. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1921	0.6	0.0	39.2	13.9	114.2	236.7	289.4	310.8	268.1	53.9	46.1	9.7	1382.5
1922	0.3	24.7	13.1	59.7	158.9	248.3	288.9	291.1	243.1	63.9	10.6	26.4	1428.9
1923	9.2	7.8	3.9	42.5	105.0	237.5	290.6	315.3	192.2	73.1	0.0	9.4	1286.4
1924	0.0	0.0	5.8	43.6	75.3	253.1	305.8	364.2	177.8	78.3	27.2	14.2	1345.3
1925	0.0	1.1	11.1	58.6	83.3	271.4	321.4	290.0	242.8	88.3	6.7	2.5	1377.2
1926	0.0	5.0	1.4	11.7	84.7	192.2	240.3	283.9	249.4	122.2	3.9	0.0	1194.7
1927	0.6	8.1	18.3	83.3	167.2	199.4	261.4	299.7	210.3	85.8	53.6	8.9	1396.7
1928	6.4	0.0	18.9	22.8	116.1	194.7	271.4	295.6	153.6	121.4	10.3	0.8	1211.9
1929	2.8	0.0	38.9	72.8	98.3	207.5	256.4	284.7	200.6	78.6	5.0	4.7	1250.3
1930	0.0	8.3	2.5	58.1	113.1	199.7	304.4	293.3	192.8	39.4	9.7	0.0	1221.4
mean	2.0	5.5	15.3	46.7	111.6	224.1	283.0	302.9	213.1	80.5	17.3	7.7	1309.5
s.d.	3.2	7.7	13.9	24.4	30.6	28.6	25.2	23.9	36.4	26.3	18.7	8.2	86.6
max	9.2	24.7	39.2	83.3	167.2	271.4	321.4	364.2	268.1	122.2	53.6	26.4	1428.9
min	0.0	0.0	1.4	11.7	75.3	192.2	240.3	283.9	153.6	39.4	0.0	0.0	1194.7
1931	0.0	0.0	0.0	18.1	50.8	224.7	310.6	228.9	245.0	127.2	33.1	10.0	1248.3
1932	9.2	17.8	8.3	47.8	105.0	222.2	307.2	269.4	159.2	31.1	0.0	0.0	1177.2
1933	2.5	3.6	12.2	24.4	142.8	189.2	258.9	266.7	238.3	64.7	11.4	10.6	1225.3
1934	0.0	0.0	13.3	61.9	116.4	266.9	322.8	335.8	178.6	111.4	24.4	0.0	1431.7
1935	9.7	0.0	58.3	53.6	102.2	216.9	297.5	316.1	172.2	98.3	21.7	0.0	1346.7
1936	0.8	6.7	25.3	39.2	122.5	262.8	267.5	308.3	225.3	34.2	13.1	1.4	1306.9
1937	5.3	9.7	4.4	46.1	126.1	250.0	286.4	308.9	179.4	56.9	5.6	0.3	1279.2
1938	4.4	16.7	44.4	51.7	124.2	229.7	278.6	277.8	196.9	108.3	31.7	2.2	1366.7
1939	0.8	2.5	17.5	49.2	119.2	244.2	327.5	314.2	260.6	106.7	1.4	5.8	1449.4
1940	0.0	1.1	18.9	51.1	87.5	174.7	262.8	229.2	142.2	64.7	6.7	0.0	1038.9
mean	3.3	5.8	20.3	44.3	109.7	228.1	292.0	285.5	199.8	80.4	14.9	3.0	1287.0
s.d.	3.7	6.8	18.2	13.5	25.6	29.8	24.9	37.1	40.1	34.2	12.1	4.2	123.2
max	9.7	17.8	58.3	61.9	142.8	266.9	327.5	335.8	260.6	127.2	33.1	10.6	1449.4
min	0.0	0.0	0.0	18.1	50.8	174.7	258.9	228.9	142.2	31.1	0.0	0.0	1038.9

Table 37. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	1.7	0.0	5.3	45.3	129.2	215.0	271.7	293.3	225.3	148.3	2.8	0.0	1337.8
1942	0.0	0.6	18.3	48.6	117.2	230.6	270.6	291.4	169.2	60.8	41.4	6.7	1255.3
1943	9.7	2.2	8.9	64.4	170.6	273.9	300.8	308.6	156.7	46.7	9.2	3.6	1355.3
1944	0.0	12.5	11.1	47.8	113.6	250.3	302.8	313.3	189.2	65.3	22.8	1.4	1330.0
1945	0.0	8.9	47.2	65.8	131.4	257.2	282.8	294.4	235.0	47.2	48.3	0.0	1418.3
1946	0.6	4.2	28.6	93.9	130.0	211.9	289.7	286.1	185.8	87.5	28.3	9.7	1356.4
1947	7.8	0.0	2.5	70.6	120.3	246.7	279.4	341.4	256.9	172.8	5.6	5.3	1509.2
1948	0.3	7.5	46.7	91.9	153.9	264.7	311.1	323.9	185.6	60.0	10.8	15.0	1471.4
1949	3.9	5.8	4.4	31.9	170.8	240.3	281.7	235.0	173.1	70.6	13.1	3.3	1233.9
1950	22.8	8.3	16.4	30.6	152.5	208.9	246.1	260.0	158.9	77.2	15.8	3.1	1200.6
mean	4.7	5.0	18.9	59.1	138.9	239.9	283.7	294.7	193.6	83.6	19.8	4.8	1346.8
s.d.	7.3	4.3	16.7	22.3	21.4	22.8	18.9	30.6	34.1	42.8	15.3	4.7	100.0
max	22.8	12.5	47.2	93.9	170.8	273.9	311.1	341.4	256.9	172.8	48.3	15.0	1509.2
min	0.0	0.0	2.5	30.6	113.6	208.9	246.1	235.0	156.7	46.7	2.8	0.0	1200.6
1951	0.8	13.1	26.9	51.1	134.2	248.3	319.7	356.7	203.9	89.2	12.8	10.3	1466.9
1952	26.7	3.3	4.7	16.9	116.9	264.7	288.3	317.8	187.8	38.9	24.7	2.8	1293.6
1953	2.8	0.0	33.1	31.9	162.5	301.9	270.3	274.4	200.8	106.4	3.1	0.0	1387.2
1954	0.8	6.7	17.8	82.8	83.1	237.8	348.3	350.6	252.2	143.1	0.0	5.0	1528.1
1955	1.4	1.9	58.1	87.5	182.8	210.8	312.8	286.9	253.9	80.8	31.7	3.9	1512.5
1956	4.2	12.8	18.3	40.3	187.2	239.4	344.7	341.4	210.6	99.4	6.9	16.4	1521.7
1957	0.0	20.0	0.0	58.6	161.7	245.0	331.1	307.8	171.9	37.2	15.3	2.8	1351.4
1958	0.0	0.8	0.0	29.7	152.8	253.9	307.2	304.7	195.6	51.9	16.9	0.0	1313.6
1959	0.0	6.7	0.3	41.9	193.6	248.9	299.4	303.3	220.3	83.9	11.1	0.0	1409.4
1960	7.2	0.6	4.7	59.2	132.8	251.9	321.1	314.4	209.7	118.6	10.6	1.4	1432.2
mean	4.4	6.6	16.4	50.0	150.7	250.3	314.3	315.8	210.7	84.9	13.3	4.2	1421.7
s.d.	8.2	6.7	18.9	22.7	34.6	23.0	24.3	26.7	26.0	34.5	9.5	5.3	85.7
max	26.7	20.0	58.1	87.5	193.6	301.9	348.3	356.7	253.9	143.1	31.7	16.4	1528.1
min	0.0	0.0	0.0	16.9	83.1	210.8	270.3	274.4	171.9	37.2	0.0	0.0	1293.6

Table 37. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0.0	1.4	33.3	43.3	136.4	202.5	270.6	262.5	205.6	64.2	11.1	0.0	1230.8
1962	0.0	4.2	0.6	34.7	174.2	245.8	322.2	333.6	214.2	116.4	2.2	0.0	1448.1
1963	0.0	0.0	20.0	118.3	188.6	268.9	322.2	318.9	216.9	124.7	28.6	0.0	1607.2
1964	1.1	0.0	7.2	83.1	180.3	259.4	331.7	341.4	208.9	38.9	25.8	6.4	1484.2
1965	8.6	1.4	0.8	114.4	170.6	248.9	324.2	308.3	225.6	59.7	25.0	0.0	1487.5
1966	0.0	0.3	10.3	66.1	139.7	219.7	345.0	274.7	184.2	45.3	22.8	9.2	1317.2
1967	9.4	0.0	52.8	127.5	120.0	259.7	266.4	283.9	168.1	41.9	5.3	6.9	1341.9
1968	0.6	2.2	12.2	58.1	133.3	217.2	270.8	301.1	148.9	69.4	9.4	0.6	1223.9
1969	5.3	0.0	1.1	46.7	133.9	245.6	366.1	323.9	212.5	101.9	14.4	0.0	1451.4
1970	0.8	0.0	5.0	90.3	137.8	239.7	301.4	335.6	252.5	60.6	6.1	18.6	1448.3
mean	2.6	0.9	14.3	78.2	151.5	240.7	312.1	308.4	203.7	72.3	15.1	4.2	1404.1
s.d.	3.8	1.4	16.9	33.6	24.2	21.3	33.9	27.3	29.6	31.1	9.7	6.2	122.3
max	9.4	4.2	52.8	127.5	188.6	268.9	366.1	341.4	252.5	124.7	28.6	18.6	1607.2
min	0.0	0.0	0.6	34.7	120.0	202.5	266.4	262.5	148.9	38.9	2.2	0.0	1223.9
1971	5.3	3.1	13.6	46.1	129.4	277.5	321.7	268.6	220.0	104.2	18.9	6.1	1414.4
1972	10.6	9.2	19.2	76.4	130.6	253.3	260.0	293.9	259.4	78.3	9.4	0.0	1400.3
1973	0.0	1.4	14.7	34.7	119.7	205.0	287.8	245.0	194.4	94.7	48.6	0.8	1246.9
1974	4.7	8.3	58.1	49.4	170.6	191.7	282.2	258.6	106.7	53.1	16.1	0.0	1199.4
1975	11.4	1.4	20.0	48.1	146.9	207.5	261.7	268.6	139.2	67.8	10.3	5.8	1188.6
1976	0.0	8.3	26.9	41.7	65.8	178.1	251.4	252.5	163.6	17.2	1.7	0.0	1007.2
1977	0.0	2.8	12.2	32.5	154.4	255.6	320.0	291.9	220.0	64.2	12.8	0.0	1366.4
1978	2.8	0.0	5.6	61.1	163.9	240.8	333.6	303.9	205.8	70.0	28.9	2.8	1419.2
1979	0.0	3.3	16.7	34.7	140.0	209.7	275.0	261.1	140.8	84.4	6.9	0.0	1172.8
1980	0.0	3.3	4.7	21.7	130.0	273.6	350.3	322.2	266.9	50.6	14.2	1.1	1438.6
mean	3.5	4.1	19.2	44.6	135.1	229.3	294.4	276.6	191.7	68.4	16.8	1.7	1285.4
s.d.	4.5	3.3	15.2	15.6	29.3	35.2	34.5	25.0	53.2	24.8	13.4	2.4	143.8
max	11.4	9.2	58.1	76.4	170.6	277.5	350.3	322.2	266.9	104.2	48.6	6.1	1438.6
min	0.0	0.0	4.7	21.7	65.8	178.1	251.4	245.0	106.7	17.2	1.7	0.0	1007.2

Table 37. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	0.0	2.8	3.1	106.1	100.8	251.9	301.9	291.7	156.4	80.6	6.1	0.0	1301.4
1982	6.1	3.3	47.5	35.3	140.8	233.3	288.6	320.0	202.8	61.9	14.2	10.3	1364.2
1983	0.0	0.0	3.9	20.0	95.6	182.2	274.2	284.7	179.4	73.1	18.6	0.0	1131.7
1984	0.0	0.3	15.8	56.4	149.2	230.8	303.1	309.2	182.2	89.4	17.5	22.2	1376.1
1985	0.0	4.7	35.3	70.8	136.1	249.4	284.7	318.6	217.8	94.7	40.8	0.0	1453.1
1986	0.0	15.6	9.4	65.6	118.6	238.3	307.8	266.7	232.8	62.2	17.8	0.0	1334.7
1987	0.0	0.0	8.3	60.8	161.1	223.1	284.7	337.2	163.3	34.7	15.6	0.0	1288.9
1988	0.0	0.8	15.3	46.9	118.1	242.8	292.2	305.8	210.8	41.9	16.9	1.1	1292.8
1989	4.2	4.4	28.9	76.4	172.5	170.0	250.6	268.3	164.4	68.6	31.9	0.0	1240.3
1990	1.1	4.4	25.0	45.0	144.2	278.6	290.6	314.4	240.0	80.8	25.6	1.1	1450.8
mean	1.1	3.6	19.2	58.3	133.7	230.1	287.8	301.7	195.0	68.8	20.5	3.5	1323.4
s.d.	2.2	4.6	14.6	23.9	25.1	32.3	16.5	23.2	30.0	19.4	9.9	7.3	96.6
max	6.1	15.6	47.5	106.1	172.5	278.6	307.8	337.2	240.0	94.7	40.8	22.2	1453.1
min	0.0	0.0	3.1	20.0	95.6	170.0	250.6	266.7	156.4	34.7	6.1	0.0	1131.7
1991	0.0	0.6	22.8	60.3	169.2	266.7	327.5	299.4	177.5	90.6	8.6	3.9	1426.9
1992	0.0	1.1	4.4	48.1	109.4	212.2	298.3	228.6	181.1	45.3	4.4	0.0	1133.1

Table 37. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1901-30													
mean	3.8	5.8	24.4	44.7	126.6	228.5	283.0	290.6	202.5	73.0	16.0	4.6	1303.7
s.d.	5.4	8.7	23.2	19.1	56.7	36.7	29.8	27.3	37.8	29.1	14.1	5.9	111.6
max	21.1	31.9	101.7	83.3	380.0	302.2	338.1	364.2	281.1	157.8	53.6	26.4	1531.9
min	0.0	0.0	1.4	11.7	62.8	123.6	231.9	227.2	133.3	10.6	0.0	0.0	973.3
1911-40													
mean	3.6	6.2	19.2	44.4	115.0	230.7	291.8	289.4	203.9	79.7	15.6	4.6	1304.1
s.d.	4.9	8.5	15.3	17.1	29.8	33.8	25.4	30.6	39.4	29.4	13.9	6.1	101.4
max	21.1	31.9	58.3	83.3	187.2	302.2	338.1	364.2	281.1	157.8	53.6	26.4	1450.8
min	0.0	0.0	0.0	11.7	50.8	169.7	240.3	227.2	135.8	31.1	0.0	0.0	1038.9
1921-50													
mean	3.3	5.4	18.2	50.0	120.1	230.7	286.2	294.4	202.1	81.5	17.3	5.2	1314.5
s.d.	5.0	6.2	15.9	21.0	28.7	27.2	22.7	30.8	36.6	33.9	15.2	6.1	103.8
max	22.8	24.7	58.3	93.9	170.8	273.9	327.5	364.2	268.1	172.8	53.6	26.4	1509.2
min	0.0	0.0	0.0	11.7	50.8	174.7	240.3	228.9	142.2	31.1	0.0	0.0	1038.9
1931-60													
mean	4.1	5.8	18.5	51.1	133.1	239.5	296.6	298.7	201.3	83.0	16.0	4.0	1351.8
s.d.	6.5	5.9	17.4	20.2	32.0	26.2	25.7	33.3	33.5	36.1	12.4	4.6	115.0
max	26.7	20.0	58.3	93.9	193.6	301.9	348.3	356.7	260.6	172.8	48.3	16.4	1528.1
min	0.0	0.0	0.0	16.9	50.8	174.7	246.1	228.9	142.2	31.1	0.0	0.0	1038.9
1941-70													
mean	3.9	4.2	16.6	62.4	147.1	243.7	303.3	306.3	202.6	80.3	16.1	4.4	1390.8
s.d.	6.5	5.1	17.0	28.4	27.0	22.1	29.2	28.7	29.9	35.6	11.7	5.2	105.3
max	26.7	20.0	58.1	127.5	193.6	301.9	366.1	356.7	256.9	172.8	48.3	18.6	1607.2
min	0.0	0.0	0.0	16.9	83.1	202.5	246.1	235.0	148.9	37.2	0.0	0.0	1200.6

Table 37. Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951-80													
mean	3.5	3.9	16.6	57.6	145.8	240.1	306.9	300.3	202.0	75.2	15.1	3.4	1370.4
s.d.	5.6	4.8	16.6	28.5	29.6	27.7	31.5	30.7	37.7	30.2	10.7	4.9	130.9
max	26.7	20.0	58.1	127.5	193.6	301.9	366.1	356.7	266.9	143.1	48.6	18.6	1607.2
min	0.0	0.0	0.0	16.9	65.8	178.1	251.4	245.0	106.7	17.2	0.0	0.0	1007.2
1961-90													
mean	2.4	2.9	17.6	60.4	140.1	233.4	298.1	295.6	196.8	69.9	17.5	3.1	1337.6
s.d.	3.6	3.5	15.2	28.3	26.7	29.6	30.3	28.0	38.2	24.7	11.0	5.6	128.4
max	11.4	15.6	58.1	127.5	188.6	278.6	366.1	341.4	266.9	124.7	48.6	22.2	1607.2
min	0.0	0.0	0.6	20.0	65.8	170.0	250.6	245.0	106.7	17.2	1.7	0.0	1007.2

APPENDIX III
(Streamflow Data)

Table 38 . Monthly and Annual Total Streamflow in cms for LaNana Creek, Nacogdoches, Texas, 1964-91

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1964										0.0	0.0	0.8	0.8
1965	11.0	22.0	49.2	17.3	68.1	14.0	0.9	0.0	2.9	0.0	0.4	17.6	203.4
1966	53.2	43.3	17.5	80.7	83.1	6.1	1.5	7.7	2.0	0.8	0.5	2.3	298.8
1967	2.4	7.9	7.0	8.0	6.4	18.1	1.3	0.0	0.0	0.0	0.0	0.4	51.5
1968	57.0	20.1	34.4	151.5	84.1	32.6	58.5	5.3	15.6	2.5	17.8	85.1	564.7
1969	27.6	93.6	127.5	118.1	93.4	4.2	0.5	0.1	0.1	0.6	0.9	2.8	469.5
1970	4.4	16.3	37.2	16.1	7.1	0.9	0.0	0.7	0.7	2.8	1.6	1.3	89.0
1971	1.3	3.7	2.1	0.5	4.6	0.2	1.2	0.5	0.7	0.9	2.9	18.9	37.6
1972	34.6	19.1	9.3	8.9	3.7	3.6	17.2	1.0	0.4	16.8	49.7	69.9	234.2
1973	132.5	33.7	86.4	110.6	21.1	61.7	5.5	3.6	17.3	29.5	77.1	58.4	637.5
1974	130.5	46.8	15.3	7.3	6.8	1.9	2.9	1.7	21.0	11.6	72.6	36.1	354.5
1975	66.7	194.8	38.6	29.8	39.7	49.3	7.1	2.8	1.5	2.6	4.7	4.1	441.7
1976	6.5	18.8	20.6	17.4	24.9	28.1	19.5	0.5	1.5	1.7	2.5	36.8	178.8
1977	29.8	47.1	46.8	19.0	5.6	3.4	0.3	3.1	0.9	1.1	2.1	3.6	162.8
1978	28.8	31.8	28.8	19.6	12.3	2.5	0.2	0.3	2.1	0.1	13.9	16.0	156.4
1979	137.2	103.4	108.0	69.3	205.5	250.1	15.6	4.1	11.0	7.0	53.7	40.0	1005.1
1980	56.1	47.0	30.1	52.6	65.2	5.9	0.7	0.9	5.0	0.7	2.4	1.5	268.2
1981	2.1	5.6	6.6	1.7	10.3	18.6	14.0	0.9	33.4	29.7	21.0	5.8	149.7
1982	21.9	28.9	18.0	149.3	29.7	10.8	7.5	1.1	1.2	7.9	59.6	146.1	482.0
1983	34.9	88.6	49.3	17.4	92.6	44.9	4.4	5.2	1.5	0.6	4.4	71.3	415.0
1984	27.1	65.5	63.8	13.5	6.6	5.4	9.6	0.8	1.9	49.9	30.4	29.1	303.6
1985	33.9	55.9	54.1	53.4	33.5	2.7	1.8	1.7	2.5	46.3	109.2	48.1	443.1
*1986	10.3	14.6	4.9	8.1	34.7	157.2	16.9	2.2	2.7				251.7
*1987													
*1988										1.5	3.3	6.3	11.1
1989	55.5	39.3	86.9	21.3	70.4	52.0	63.2	2.2	4.9	1.1	0.4	1.1	398.5
1990	22.9	76.3	40.0	16.7	136.9	42.2	1.6	0.4	0.5	2.3	4.4	7.9	352.1
1991	106.3	86.2	24.2	127.3	79.9	9.9	2.2	10.6	2.9				449.6

*October 1986-September 1988 data are missing.

Table 39 . Monthly and Annual Total Streamflow in cm for LaNana Creek, Nacogdoches, Texas, 1964-91

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1964										0.00	0.01	0.08	0.09
1965	1.17	2.34	5.24	1.84	7.27	1.50	0.09	0.00	0.31	0.00	0.05	1.88	21.70
1966	5.67	4.62	1.87	8.61	8.87	0.65	0.16	0.83	0.21	0.08	0.06	0.25	31.88
1967	0.26	0.85	0.75	0.85	0.68	1.93	0.14	0.00	0.00	0.00	0.00	0.04	5.49
1968	6.09	2.15	3.66	16.16	8.97	3.48	6.24	0.57	1.67	0.27	1.90	9.07	60.23
1969	2.95	9.99	13.60	12.60	9.97	0.44	0.05	0.01	0.02	0.07	0.10	0.30	50.09
1970	0.47	1.73	3.97	1.72	0.76	0.09	0.00	0.07	0.08	0.29	0.17	0.14	9.49
1971	0.14	0.39	0.23	0.06	0.49	0.02	0.13	0.05	0.08	0.10	0.31	2.02	4.01
1972	3.69	2.03	0.99	0.95	0.39	0.38	1.84	0.10	0.04	1.80	5.30	7.46	24.98
1973	14.13	3.60	9.22	11.80	2.25	6.58	0.59	0.39	1.84	3.15	8.23	6.23	68.01
1974	13.92	4.99	1.64	0.77	0.73	0.20	0.31	0.19	2.24	1.24	7.74	3.85	37.81
1975	7.12	20.78	4.12	3.18	4.24	5.26	0.75	0.30	0.16	0.28	0.50	0.43	47.11
1976	0.69	2.01	2.20	1.86	2.66	2.99	2.08	0.06	0.16	0.18	0.26	3.92	19.07
1977	3.18	5.02	4.99	2.03	0.60	0.37	0.04	0.33	0.09	0.11	0.22	0.38	17.36
1978	3.07	3.39	3.07	2.09	1.32	0.27	0.03	0.03	0.23	0.02	1.48	1.70	16.68
1979	14.64	11.03	11.52	7.39	21.92	26.68	1.66	0.44	1.18	0.75	5.73	4.27	107.20
1980	5.99	5.02	3.21	5.61	6.96	0.63	0.08	0.10	0.53	0.07	0.26	0.16	28.61
1981	0.22	0.60	0.71	0.18	1.10	1.98	1.49	0.10	3.56	3.17	2.24	0.62	15.97
1982	2.33	3.08	1.92	15.93	3.17	1.15	0.80	0.11	0.12	0.84	6.36	15.59	51.41
1983	3.72	9.45	5.26	1.86	9.87	4.79	0.47	0.55	0.16	0.06	0.47	7.60	44.27
1984	2.90	6.98	6.80	1.44	0.70	0.58	1.03	0.09	0.20	5.32	3.24	3.11	32.38
1985	3.61	5.96	5.77	5.70	3.57	0.29	0.19	0.19	0.27	4.94	11.65	5.13	47.27
*1986	1.10	1.56	0.52	0.87	3.70	16.77	1.80	0.24	0.29				26.85
*1977													
*1988										0.16	0.35	0.67	1.18
1989	5.92	4.19	9.27	2.27	7.51	5.55	6.74	0.23	0.53	0.12	0.04	0.12	42.50
1990	2.45	8.14	4.27	1.78	14.61	4.51	0.17	0.04	0.05	0.24	0.47	0.84	37.56
1991	11.34	9.20	2.58	13.58	8.53	1.06	0.24	1.13	0.31				47.96

*October 1986-September 1988 data are missing.

Table 40 . Monthly and Annual Maximum Daily Streamflow in cms for LaNana Creek, Nacogdoches, Texas, 1964-91

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1964										0.0	0.0	0.2	0.2
1965	7.8	3.1	26.4	2.3	12.3	1.4	0.2	0.0	2.3	0.0	0.1	6.3	26.4
1966	11.2	9.9	1.4	35.7	19.8	0.5	0.5	4.9	0.6	0.2	0.0	0.3	35.7
1967	0.2	3.4	0.7	1.2	2.8	8.0	0.5	0.0	0.0	0.0	0.0	0.1	8.0
1968	31.1	5.7	3.4	42.5	16.5	9.2	20.5	0.5	4.5	0.3	5.4	18.8	42.5
1969	2.5	23.2	28.9	19.3	37.6	0.5	0.1	0.0	0.1	0.3	0.3	0.9	37.6
1970	0.8	4.2	5.8	2.2	2.8	0.5	0.0	0.4	0.2	0.8	0.3	0.3	5.8
1971	0.1	0.7	0.2	0.0	2.2	0.1	0.5	0.3	0.3	0.2	2.3	3.2	3.2
1972	5.4	1.4	1.0	2.7	0.5	1.2	8.1	0.2	0.1	8.1	13.2	11.4	13.2
1973	30.0	4.5	31.7	25.2	5.7	14.1	0.9	0.5	4.1	5.0	20.5	21.8	31.7
1974	40.8	22.0	0.8	1.4	1.3	0.7	1.3	0.6	6.6	3.5	14.2	6.1	40.8
1975	17.2	96.8	3.4	2.9	6.8	23.1	0.5	0.4	0.2	1.0	1.2	0.6	96.8
1976	1.3	4.0	1.8	7.8	3.3	6.8	5.1	0.1	0.5	0.5	0.6	8.8	8.8
1977	7.6	14.7	11.7	1.5	1.1	1.2	0.1	2.4	0.2	0.5	1.0	1.6	14.7
1978	6.3	6.3	6.4	5.2	2.3	1.0	0.2	0.1	1.7	0.0	10.4	8.6	10.4
1979	39.3	18.1	18.9	11.5	75.3	162.2	8.5	0.5	7.6	2.8	28.3	7.0	162.2
1980	21.5	13.6	4.8	21.6	34.0	2.1	0.3	0.7	2.8	0.3	0.5	0.2	34.0
1981	0.4	2.6	1.9	0.2	1.6	10.3	3.4	0.5	28.3	7.7	4.2	0.3	28.3
1982	8.5	4.2	2.7	40.5	8.0	4.7	2.8	0.1	0.3	2.8	27.6	25.9	40.5
1983	4.4	17.7	8.7	1.1	32.8	23.3	0.5	1.1	0.5	0.1	1.1	27.7	32.8
1984	2.8	27.1	18.8	1.4	1.7	2.1	6.7	0.1	0.5	13.0	5.6	2.5	27.1
1985	5.1	13.6	5.3	12.5	7.0	0.3	0.4	0.8	0.6	18.1	46.8	9.7	46.8
*1986	0.5	1.4	0.3	2.0	7.1	89.6	7.8	0.4	0.5				89.6
*1987													
*1988										0.7	0.8	1.0	1.0
1989	19.8	5.2	39.6	2.1	36.2	12.3	27.9	0.2	2.3	0.2	0.1	0.4	39.6
1990	6.2	11.9	11.0	4.2	32.8	30.0	0.4	0.1	0.2	1.5	2.2	3.3	32.8
1991	21.6	18.6	5.2	35.7	32.5	1.6	0.2	4.4	0.7				35.7

*October 1986-September 1988 data are missing.

APPENDIX IV
(Municipal Water Data)

Table 41. Monthly and Annual Total Municipal Water Production Data for Nacogdoches, Texas (in thousands of cubic meters) 1981-1991

Date	Lake	Wells	Total
1981			
Jan	282.085	383.655	665.74
Feb	270.480	353.920	624.40
Mar	325.396	400.574	725.97
Apr	343.069	435.309	778.38
May	353.250	387.561	740.81
Jun	358.504	417.258	775.76
Jul	427.788	426.028	853.82
Aug	466.164	506.198	972.36
Sep	384.162	429.847	814.01
Oct	391.865	391.320	783.18
Nov	306.786	372.444	679.23
Dec	291.146	392.966	684.11
Total	4200.695	4897.080	9097.77
1992			
Jan	338.163	433.258	771.42
Feb	324.931	334.151	659.08
Mar	340.919	371.112	712.03
Apr	330.949	369.242	700.19
May	321.770	395.328	717.10
Jun	361.036	481.853	842.89
Jul	360.529	472.796	833.32
Aug	452.186	573.560	1025.75
Sep	443.670	405.714	849.38
Oct	351.225	447.724	798.95
Nov	306.267	402.894	709.16
Dec	334.745	333.504	668.25
Total	4266.390	5021.136	9287.52
1983			
Jan	304.011	377.773	681.78
Feb	282.312	358.614	640.93
Mar	301.093	383.988	685.08
Apr	293.455	394.242	687.70
May	324.484	405.854	730.34
Jun	314.639	392.198	706.84
Jul	312.679	488.303	800.98
Aug	372.739	550.066	922.81
Sep	349.219	483.136	832.36
Oct	311.271	458.700	769.97
Nov	270.968	396.539	667.51
Dec	287.660	466.955	754.62
Total	3724.530	5156.368	8880.92

Table 41. Continued

Date	Lake	Wells	Total
1984			
Jan	276.017	488.318	764.34
Feb	211.835	478.159	689.99
Mar	238.754	455.018	693.77
Apr	283.137	459.953	743.09
May	337.891	393.761	731.65
Jun	359.632	469.703	829.34
Jul	451.289	535.082	986.37
Aug	406.131	581.493	987.62
Sep	394.904	564.677	959.58
Oct	347.262	417.156	764.42
Nov	296.536	407.470	704.01
Dec	262.244	463.704	725.95
Total	3865.632	5714.494	9580.13
1985			
Jan	232.176	543.855	776.03
Feb	254.344	392.822	647.17
Mar	249.859	374.272	624.13
Apr	280.949	433.519	714.47
May	347.115	381.044	728.16
Jun	384.677	559.431	944.11
Jul	425.608	534.665	960.27
Aug	424.465	545.945	970.41
Sep	394.601	534.745	929.35
Oct	275.321	476.547	751.87
Nov	193.425	509.919	703.34
Dec	224.943	482.629	707.57
Total	3687.483	5769.393	9456.88
1986			
Jan	216.657	490.562	707.22
Feb	199.227	463.534	662.76
Mar	238.137	546.940	785.08
Apr	266.350	524.117	790.47
May	263.595	493.288	756.88
Jun	286.278	453.984	740.26
Jul	411.002	589.336	1000.34
Aug	408.629	568.995	977.62
Sep	429.030	345.820	774.85
Oct	278.655	536.861	815.52
Nov	213.958	493.598	707.56
Dec	183.247	520.827	704.07
Total	3394.765	6027.862	9422.63

Table 41. Continued

Date	Lake	Wells	Total
1987			
Jan	190.136	513.821	703.96
Feb	168.383	482.527	650.91
Mar	188.364	535.313	723.68
Apr	359.390	528.730	888.12
May	481.921	340.976	822.90
Jun	402.497	440.544	843.04
Jul	398.890	465.036	863.93
Aug	673.609	507.852	1181.46
Sep	312.126	527.648	839.77
Oct	339.002	588.866	927.89
Nov	267.316	455.052	722.37
Dec	221.044	451.263	672.31
Total	4002.700	5837.630	9840.33
1988			
Jan	275.328	458.375	733.70
Feb	198.519	490.241	688.76
Mar	229.246	503.522	732.77
Apr	300.113	524.317	824.43
May	503.799	628.821	1132.62
Jun	808.749	593.401	1402.15
Jul	797.079	463.466	1260.55
Aug	691.512	511.562	1203.07
Sep	440.082	604.476	1044.56
Oct	342.535	671.202	1013.74
Nov	178.822	588.439	767.26
Dec	168.451	549.022	717.47
Total	4934.235	6586.844	11521.08
1989			
Jan	199.341	533.594	732.93
Feb	171.767	504.707	676.47
Mar	185.037	592.046	777.08
Apr	218.856	641.531	860.39
May	236.510	644.809	881.32
Jun	224.276	599.230	823.51
Jul	284.397	615.021	899.42
Aug	383.277	570.937	954.21
Sep	403.356	575.551	978.91
Oct	291.453	568.416	859.87
Nov	242.694	511.039	753.73
Dec	271.918	539.245	811.16
Total	3112.882	6896.126	10009.00

Table 41. Continued

Date	Lake	Wells	Total
1990			
Jan	234.659	497.228	731.89
Feb	199.526	459.518	659.04
Mar	217.074	501.978	719.05
Apr	286.339	449.866	736.20
May	306.846	459.011	765.86
Jun	435.127	551.997	987.12
Jul	452.372	613.522	1085.92
Aug	620.025	624.650	1244.67
Sep	457.576	562.125	1019.70
Oct	435.975	534.162	970.14
Nov	417.058	346.369	763.43
Dec	249.299	462.103	711.40
Total	4311.880	6062.560	10374.44
1991			
Jan	347.103	343.879	690.98
Feb	194.549	420.396	614.95
Mar	371.736	344.189	715.93
Apr	279.159	466.119	745.28
May	294.761	460.404	755.16
Jun	301.805	456.532	758.34
Jul	379.794	597.920	977.71
Aug	386.683	547.576	934.26
Sep	280.355	569.998	850.35
Oct	381.929	577.667	959.60
Nov	222.815	499.707	722.52
Dec	258.235	428.500	686.74
Total	3698.924	5712.887	9411.82

APPENDIX V
(Kf Values for Log-Pearson type III Distribution)

Table 42. Kf Values for Positive Skew Coefficients (g) for Different Return Periods (Percent Probabilities Are in Parentheses) *

(g)	Return Periods, in Years										
	1.0101	1.0526	1.1111	1.25	2	5	10	25	50	100	200
	(99)	(95)	(90)	(80)	(50)	(20)	(10)	(4)	(2)	(1)	(0.5)
3.0	-0.667	-0.665	-0.660	-0.636	-0.396	0.420	1.180	2.278	3.152	4.051	4.970
2.9	-0.690	-0.688	-0.681	-0.651	-9.390	0.440	1.195	2.277	3.134	4.013	4.909
2.8	-0.714	-0.711	-0.702	-0.666	-0.384	0.460	1.210	2.275	3.114	3.973	4.847
2.7	-0.740	-0.736	-0.724	-0.681	-0.376	0.479	1.224	2.272	3.093	3.932	4.783
2.6	-0.769	-0.762	-0.747	-0.696	-0.368	0.499	1.238	2.267	3.071	3.889	4.718
2.5	-0.799	-0.790	-0.771	-0.711	-0.360	0.518	1.250	2.262	3.048	3.845	4.652
2.4	-0.832	-0.819	-0.795	-0.725	-0.351	0.537	1.262	2.256	3.023	3.800	4.584
2.3	-0.867	-0.850	-0.819	-0.739	-0.341	0.555	1.274	2.248	2.997	3.753	4.515
2.2	-0.905	-0.882	-0.844	-0.752	-0.330	0.574	1.284	2.240	2.970	3.705	4.444
2.1	-0.946	-0.914	-0.869	-0.765	-0.319	0.592	1.294	2.230	2.942	3.656	4.372
2.0	-0.990	-0.949	-0.895	-0.777	-0.307	0.609	1.302	2.219	2.912	3.605	4.298
1.9	-1.037	-0.984	-0.920	-0.788	-0.294	0.627	1.310	2.207	2.881	3.553	4.223
1.8	-1.087	-1.020	-0.945	-0.799	-0.282	0.643	1.318	2.193	2.848	3.499	4.147
1.7	-1.140	-1.056	-0.970	-0.808	-0.268	0.660	1.324	2.179	2.815	3.444	4.069
1.6	-1.197	-1.093	-0.994	-0.817	-0.254	0.675	1.329	2.163	2.780	3.388	3.990
1.5	-1.256	-1.131	-1.018	-0.825	-0.240	0.690	1.333	2.146	2.743	3.330	3.910
1.4	-1.318	-1.168	-1.041	-0.832	-0.255	0.705	1.337	2.128	2.706	3.271	3.828
1.3	-1.383	-1.206	-1.064	-0.838	-0.210	0.719	1.339	2.108	2.666	3.211	3.745
1.2	-1.449	-1.243	-1.086	-0.844	-0.195	0.732	1.340	2.087	2.626	3.149	3.661
1.1	-1.518	-1.280	-1.107	-0.848	-0.180	0.745	1.341	2.066	2.585	3.087	3.575

Table 42. Continued

(g)	Return Periods, in Years										
	1.0101 (99)	1.0526 (95)	1.1111 (90)	1.25 (80)	2 (50)	5 (20)	10 (10)	25 (4)	50 (2)	100 (1)	200 (0.5)
1.0	-1.588	-1.317	-1.128	-0.852	-0.164	0.758	1.340	2.043	2.542	3.022	3.489
0.9	-1.660	-1.353	-1.147	-0.854	-0.148	0.769	1.339	2.018	2.498	2.957	3.401
0.8	-1.733	-1.388	-1.166	-0.856	-0.132	0.780	1.336	1.993	2.453	2.891	3.312
0.7	-1.806	-1.423	-1.183	-0.857	-0.116	0.790	1.333	1.967	2.407	2.824	3.223
0.6	-1.880	-1.458	-1.200	-0.857	-0.099	0.800	1.328	1.939	2.359	2.755	3.132
0.5	-1.955	-1.491	-1.216	-0.856	-0.083	0.808	1.323	1.910	2.311	2.686	3.041
0.4	-2.029	-1.524	-1.231	-0.855	-0.066	0.816	1.317	1.880	2.261	2.615	2.949
0.3	-2.104	-1.555	-1.245	-0.853	-0.050	0.824	1.309	1.849	2.211	2.544	2.856
0.2	-2.178	-1.586	-1.258	-0.850	-0.033	0.830	1.301	1.818	2.159	2.472	2.763
0.1	-2.252	-1.616	-1.270	-0.846	-0.017	0.836	1.292	1.785	2.107	2.400	2.670
0	-2.326	-1.645	-1.282	-0.842	0.	0.842	1.282	1.751	2.054	1.326	2.576

*From Chang (1982)

Table 43. Kf Values for Negative Skew Coefficients (g) for Different Return Periods (Percent Probabilities Are in Parentheses) *

(g)	Return Periods, in Years										
	1.0101 (99)	1.0526 (95)	1.1111 (90)	1.25 (80)	2 (50)	5 (20)	10 (10)	25 (4)	50 (2)	100 (1)	200 (0.5)
0	-2.326	-1.645	-1.282	-0.842	0	0.842	1.282	1.751	2.054	2.326	2.576
- .1	-2.400	-1.673	-1.292	-0.836	0.017	0.846	1.270	1.716	2.000	2.252	2.482
- .2	-2.472	-1.700	-1.301	-0.830	0.033	0.850	1.258	1.680	1.945	2.178	2.388
- .3	-2.544	-1.726	-1.309	-0.824	0.050	0.853	1.245	1.643	1.890	2.104	2.294
- .4	-2.615	-1.750	-1.317	-0.816	0.066	0.855	1.231	1.606	1.834	2.092	2.201
- .5	-2.686	-1.774	-1.323	-0.808	0.083	0.856	1.216	1.567	1.777	1.955	2.108
- .6	-2.755	-1.797	-1.328	-0.800	0.099	0.857	1.200	1.528	1.720	1.880	2.016
- .7	-2.824	-1.819	-1.333	-0.790	0.116	0.857	1.183	1.488	1.663	1.806	1.926
- .8	-2.891	-1.839	-1.336	-0.780	0.132	0.856	1.166	1.448	1.606	1.733	1.837
- .9	-2.957	-1.858	-1.339	-0.769	0.148	0.354	1.147	1.407	1.549	1.660	1.749
-1.0	-3.022	-1.877	-1.340	-0.758	0.164	0.852	1.128	1.366	1.492	1.588	1.664
-1.1	-3.087	-1.894	-1.341	-0.745	0.180	0.848	1.107	1.324	1.435	1.518	1.581
-1.2	-3.149	-1.910	-1.340	-0.732	0.195	0.844	1.086	1.282	1.379	1.449	1.501
-1.3	-3.211	-1.925	-1.339	-0.719	0.210	0.838	1.064	1.240	1.324	1.383	1.424
-1.4	-3.271	-1.938	-1.337	-0.705	0.225	0.832	1.041	1.198	1.270	1.318	1.351
-1.5	-3.330	-1.951	-1.333	-0.690	0.240	0.825	1.018	1.157	1.217	1.256	1.282
-1.6	-3.388	-1.962	-1.329	-0.675	0.254	0.817	0.994	1.116	1.166	1.197	1.216
-1.7	-3.444	-1.972	-1.324	-0.660	0.268	0.808	0.970	1.075	1.116	1.140	1.155
-1.8	-3.499	-1.981	-1.318	-0.643	0.282	0.799	0.945	1.035	1.069	1.087	1.097
-1.9	-3.553	-1.989	-1.310	-0.627	0.294	0.788	0.920	0.996	1.023	1.037	1.044

Table 43. Continued

(g)	Return Periods, in Years										
	1.0101	1.0526	1.1111	1.25	2	5	10	25	50	100	200
	(99)	(95)	(90)	(80)	(50)	(20)	(10)	(4)	(2)	(1)	(0.5)
-2.0	-3.605	-1.996	-1.302	-0.609	0.307	0.777	0.895	0.959	0.980	0.990	0.995
-2.1	-3.656	-2.001	-1.294	-0.592	0.319	0.765	0.869	0.923	0.939	0.946	0.949
-2.2	-3.705	-2.006	-1.284	-0.574	0.330	0.752	0.844	0.888	0.900	0.905	0.907
-2.3	-3.753	-2.009	-1.274	-0.555	0.341	0.739	0.819	0.855	0.864	0.867	0.869
-2.4	-3.800	-2.011	-1.262	-0.537	0.351	0.725	0.795	0.823	0.830	0.832	0.833
-2.5	-3.845	-2.012	-1.250	-0.518	0.360	0.711	0.771	0.793	0.798	0.799	0.800
-2.6	-3.889	-2.013	-1.238	-0.499	0.368	0.696	0.747	0.764	0.768	0.769	0.769
-2.7	-3.932	-2.012	-1.224	-0.479	0.376	0.681	0.724	0.738	0.740	0.740	0.741
-2.8	-3.973	-2.010	-1.210	-0.460	0.384	0.666	0.702	0.712	0.714	0.714	0.714
-2.9	-4.013	-2.007	-1.195	-0.440	0.390	0.651	0.681	0.683	0.689	0.690	0.690
-3.00	-4.051	-2.003	-1.180	-0.420	0.396	0.636	0.660	0.666	0.666	0.667	0.668

*From Chang (1982)

APPENDIX VI
(Tables for Determining Gumbel's Distribution)

Table 44. Gumbel's Reduced Variates (y) for Return Periods (T) from 2 to 109, 200, 500 and 1000 Years

Decades	Years									
	0	1	2	3	4	5	6	7	8	9
0	.	.	0.3665	0.9027	1.2459	1.4999	1.7020	1.8698	2.0134	2.1389
10	2.2504	2.3506	2.4417	2.5252	2.6022	2.6738	2.7405	2.8031	2.8619	2.9175
20	2.9702	2.0202	3.0679	3.1134	3.1568	3.1985	3.2386	3.2770	3.3141	3.3498
30	3.3843	3.4176	3.4499	3.4812	3.5115	3.5409	3.5695	3.5972	3.6243	3.6506
40	3.6762	3.7013	3.7256	3.7495	3.7727	3.7954	3.8177	3.8394	3.8607	3.8815
50	3.9019	3.9219	3.9416	3.9608	3.9797	3.9982	4.0164	4.0342	4.0518	4.0690
60	4.0860	4.1026	4.1190	4.1351	4.1510	4.1666	4.1820	4.1972	4.2121	4.2268
70	4.2413	4.2556	4.2697	4.2836	4.2973	4.3108	4.3241	4.3373	4.3503	4.3631
80	4.3757	4.3882	4.4006	4.4128	4.4248	4.4367	4.4485	4.4601	4.716	4.4830
90	4.4942	4.5053	4.5163	4.5272	4.5380	4.5486	4.5591	4.5695	4.5798	4.5900
100	4.6002	4.6101	4.6201	4.6299	4.6396	4.6492	4.6587	4.6681	4.6775	4.6867
200	5.2958									
500	6.2136									
1000	6.9073									

From Chang (1982)

Table 45. Gumbels Expected Mean ($\bar{y}_n$) for Sample Sizes (N) from 10 to 109

Decades	Sample size, N									
	0	1	2	3	4	5	6	7	8	9
10	0.495206	0.499614	0.503498	0.506951	0.510045	0.512836	0.515369	0.517680	0.419798	0.51749
20	0.523551	0.525223	0.526779	0.528230	0.529587	0.530860	0.532059	0.533186	0.534252	0.535261
30	0.536217	0.537123	0.537984	0.538804	0.539587	0.540334	0.541049	0.541731	0.542384	0.543012
40	0.543613	0.544191	0.544749	0.545284	0.545799	0.546296	0.546776	0.547238	0.547684	0.548118
50	0.548535	0.548940	0.549333	0.549711	0.550081	0.550437	0.550786	0.551122	0.551450	0.551768
60	0.552077	0.552378	0.552670	0.552956	0.553235	0.553505	0.553769	0.554027	0.554279	0.554524
70	0.554754	0.554997	0.555226	0.555449	0.555667	0.555881	0.556089	0.556292	0.556493	0.556688
80	0.556879	0.556967	0.557250	0.557430	0.557607	0.557779	0.557948	0.558115	0.558278	0.558438
90	0.558595	0.558749	0.558899	0.559049	0.559195	0.559337	0.559478	0.559616	0.559751	0.559885
100	0.560016	0.560145	0.560273	0.560397	0.560520	0.560641	0.560760	0.560876	0.560991	0.561105

Note: These values apply to periods of consecutive records, i.e., 10 to 109 years.
From Chang (1982)

Table 46. Gumbel's Expected Standard Deviation (σ_n) for Sample Sizes (N) from 10 to 109

Decades	Sample size, N									
	0	1	2	3	4	5	6	7	8	9
10	0.949625	0.967579	0.983269	0.997127	1.009474	1.020568	1.030600	1.039725	1.048073	1.055740
20	1.062819	1.609374	1.075466	1.081148	1.086462	1.091443	1.096125	1.100537	1.104701	1.108639
30	1.112371	1.115915	1.119284	1.122492	1.125550	1.128471	1.131263	1.133935	1.136497	1.138953
40	1.141315	1.143581	1.145762	1.147864	1.149888	1.151841	1.153727	1.155549	1.157309	1.159012
50	1.160659	1.162256	1.163802	1.165304	1.166759	1.168173	1.169544	1.170878	1.172175	1.173436
60	1.174664	1.175859	1.177023	1.178157	1.179262	1.180340	1.181392	1.182418	1.183481	1.184397
70	1.185352	1.186286	1.187198	1.188090	1.188963	1.189816	1.190652	1.191470	1.192271	1.193055
80	1.193823	1.194576	1.195313	1.196037	1.196746	1.197442	1.198126	1.198794	1.199451	1.200096
90	1.200730	1.201352	1.201963	1.202562	1.203153	1.203733	1.204304	1.204863	1.205414	1.205956
100	1.206488	1.207012	1.207528	1.208035	1.208534	1.209035	1.209510	1.209987	1.210456	1.210917

Note: These values apply to periods of consecutive records, i.e., 10 to 109 years.
From Chang (1982)

APPENDIX VII
(Selected Conversion Factors, Metric to Non-metric)

Table 47. Conversion Factors for a Few Selected Metric and Non-metric Units

To convert Column 1 into Column 2, multiply by:	Column 1, Metric Unit	Column 2, Non-metric	To convert Column 2 into Column 1 multiply by:
	Length		
0.621	kilometer, k, (10^3 m)	mile, mi	1.609
3.28	meters, m	foot, ft	0.304
3.94×10^{-2}	millimeter, mm	inch, in	25.4
	Area		
2.47	hectare, ha	acre	0.405
0.386	square km, km2 (10^3m)^2	square mile, mi^2	2.59
	Volume		
264.2	cubic meter, m^3	gallon	3.785×10^{-3}
	Discharge		
35.34	cubic meters per second (cms)	cubic feet per second (cfs)	28.3×10^{-3}
	Temperature		
(9/5 °C) + 32	Celsius, °C	Fahrenheit, °F	5/9(°F-32)
1.8	Degree unit, °C	Degree unit, °F	0.556
	Energy		
4.19×10^4	Joule per square meter, J m2	calorie per square cm langley	2.387×10^{-5}
	Velocity		
0.621	km per hour (km/hr)	mile per hour (mph)	1.609

VITA

After completing his work at John Marshall High School, San Antonio in 1987, Larry David Clendenen entered the, then, School of Forestry, at Stephen F. Austin State University in Nacogdoches, Texas. He received the degree of Bachelor of Science in Forestry in May, 1992. In June of 1992 he officially entered the Graduate School at Stephen F. Austin State University where he work as a Graduate Teaching Assistant during the Fall and Spring semesters teaching dendrology laboratories and assisting with the forest pathology lab. He worked summers as Research Assistant in forest hydrology. He also worked part time as a technical writer for an environmental consulting firm during 1992. He received the degree of Master of Science in Forestry in August of 1994.

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