# Climate of the Fort Cobb Reservoir Watershed, Southwestern Oklahoma, 1940–2007

Chapter 2 of

## Assessment of Conservation Practices in the Fort Cobb Reservoir Watershed, Southwestern Oklahoma

Compiled by the U.S. Geological Survey and the Agricultural Research Service

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**U.S. Department of the Interior**
**U.S. Geological Survey**

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KEN SALAZAR, Secretary

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## Conversion Factors

SI to Inch/Pound

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| centimeter (cm) | 0.3937 | inch (in.) |
| millimeter | 0.039 | inch |
| kilometer (km) | 0.6214 | mile (mi) |
| | Area | |
| hectare | 2.47 | acre |
| square kilometer ($km^2$) | 0.3861 | square mile |

Elevation refers to distance above sea level referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F = (1.8 × °C) +32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C = (°F - 32) / 1.8

# Climate of the Fort Cobb Reservoir Watershed, Southwestern Oklahoma, 1940–2007

By Jurgen D. Garbrecht[1] and Daniel N. Moriasi[1]

## Abstract

Climate data are essential for assessing the hydrologic system of a watershed and interpreting the effectiveness of soil and water conservation efforts. A review of the 1940-2005 annual precipitation record revealed several persistent multiyear time periods of drought and above-normal precipitation. The longest period of above-normal precipitation was in the 1980s and 1990s. Mean monthly precipitation was bimodal, with the first peak in May and a smaller second peak in September. Since 1980, there had been a substantial increase in precipitation in March, whereas precipitation during summer months remained essentially unchanged. Spatial variability of monthly and daily precipitation was large. More intense precipitation events were recorded during summer months than during winter months. Annual air temperature did not reveal a relevant trend or pronounced multiyear variation, nor was there any evidence of a notable correlation between annual temperature and precipitation variations. Spatial variability of monthly air temperature was within the instrument error range and of little practical significance for most hydrologic applications.

## Introduction

The Fort Cobb Reservoir watershed covers 813 square kilometers in western Oklahoma (fig. 1). Precipitation and air temperature are two critical weather variables that affect water resources, agricultural production, and soil and water conservation in this and other watersheds. Precipitation is directly linked to runoff, soil erosion, transport of agricultural chemicals, vegetation growth, and water quantity and quality. Air temperature primarily influences evapotranspiration, timing of growing season, and biomass production. Precipitation and air temperature are also key components in hydrologic and environmental investigations, controlling variables in numeric watershed model applications, and important considerations in interpretation of water-quantity and -quality observations. In this chapter, characteristics of the 1940 through 2005 monthly and annual precipitation and air temperature for the Fort Cobb Reservoir watershed are reviewed, and spatial variability characteristics of monthly and daily precipitation and air temperature for 2005 through 2007 are presented.

## Monthly and Annual Precipitation and Air Temperature

### Data Sources and Preparation

#### Precipitation

Observed daily precipitation data collected at four National Weather Service (NWS) Cooperative Stations (Coop Stations) were used to compute watershed-average monthly and annual precipitation for the Fort Cobb Reservoir watershed from 1940 through 2005. The four NWS Coop Stations were Carnegie, Lookeba, Fort Cobb, and Weatherford (table 1 and fig. 1). Daily precipitation data were obtained from the Oklahoma Climatological Survey in Norman, Oklahoma (Oklahoma Climatological Survey, 2008). Missing daily precipitation values at each of the four NWS stations were filled by substituting with adjusted daily precipitation

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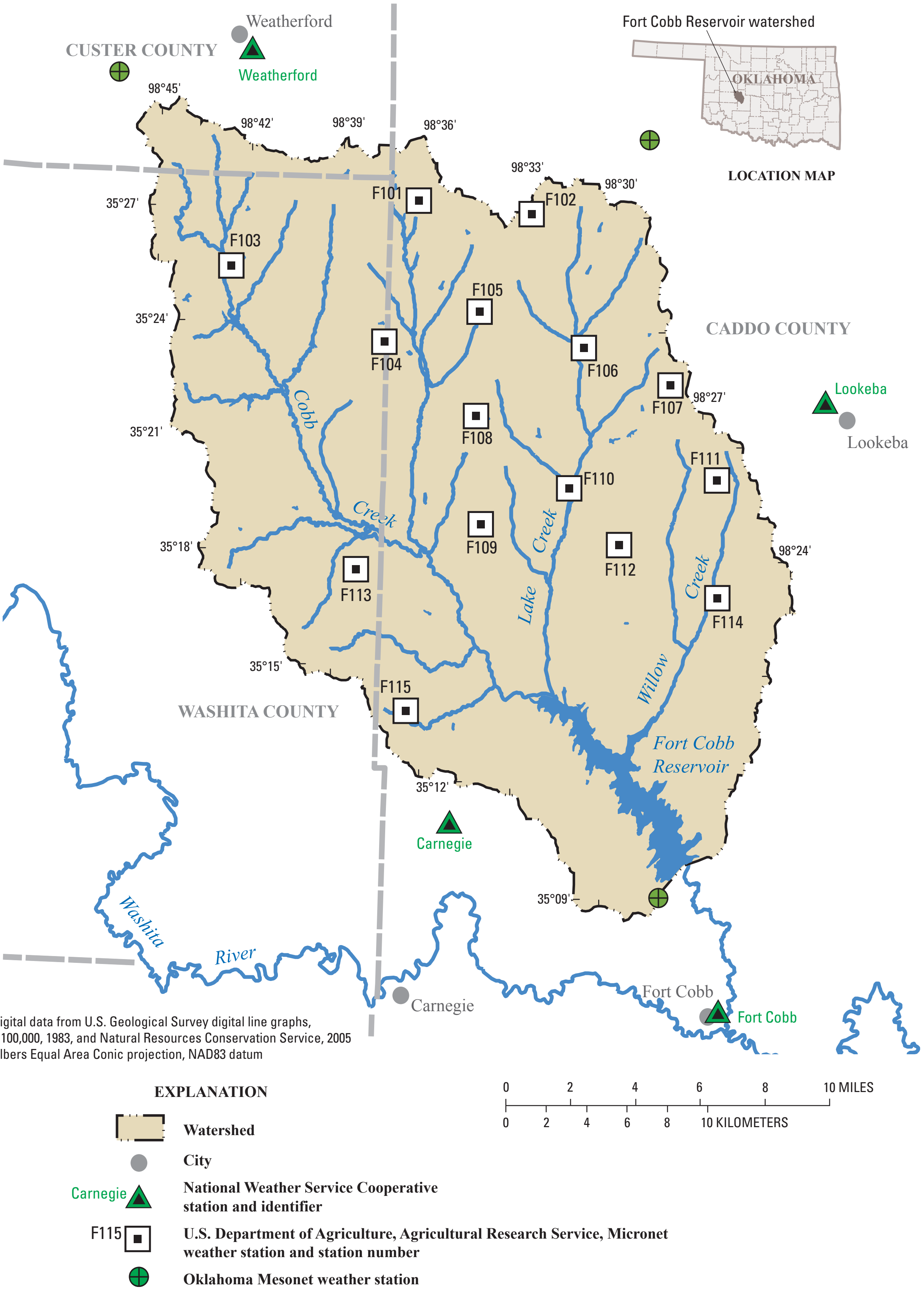
[1] Agricultural Research Service, Grazinglands Research Laboratory, El Reno, Oklahoma.



Digital data from U.S. Geological Survey digital line graphs, 1:100,000, 1983, and Natural Resources Conservation Service, 2005
Albers Equal Area Conic projection, NAD83 datum

**Figure 1.** Location of the Fort Cobb Reservoir watershed and selected Mesonet, Micronet, and National Weather Service Cooperative Stations, southwestern Oklahoma.

**Table 1.** National Weather Service Cooperative Stations data used to compute watershed-average monthly and annual precipitation and air temperature for the Fort Cobb Reservoir watershed, southwestern Oklahoma.

[ID, identification number; latitude and longitude are in decimal degrees; elevation is meters above sea level; NA, not available; max, maximum; min, minimum]

| Station ID | Station name | Latitude | Longitude | Elevation (meter) | Available data type | Precipitation record length | Air temperature record length |
|---|---|---|---|---|---|---|---|
| 341504 | Carnegie | 35.18 | - 98.58 | 396 | Precipitation; Temperature max and min | 1914 - 2005 | 1914 - 2005 |
| 343281 | Fort Cobb | 35.10 | - 98.43 | 451 | Precipitation | 1938 - 1975 | NA |
| 345329 | Lookeba | 35.37 | - 98.38 | 439 | Precipitation | 1940 - present | NA |
| 349422 | Weatherford | 35.52 | - 98.70 | 500 | Precipitation; Temperature max and min | 1905 - present | 1905 - present |

values at nearby NWS Coop Stations, U.S. Department of Agriculture, Agricultural Research Service (ARS) Micronet stations, or Oklahoma Mesonet stations (Brock and others, 1995). The adjustment accounts for spatial precipitation gradients, station altitude and exposure, and/or any other causes. The adjustment factor was defined as the ratio between monthly precipitation normals of the station with missing daily precipitation values and corresponding monthly normals of the station from which data are used for substitution. Normals are defined as the arithmetic mean of a climatologic variable computed over three consecutive decades (Guttman, 1989). Monthly normals for each station were available through the National Oceanic and Atmospheric Administration (1994 and 2002) and Owenby and Ezell (1992).

The NWS station at Fort Cobb was discontinued in 1975. Precipitation data collected from 1976 through 1993 at that station were substituted with adjusted precipitation from the NWS station at Carnegie, 14.5 kilometers away, and missing values of precipitation since 1994 were substituted with precipitation data collected at the Oklahoma Mesonet Station at Fort Cobb, 8 kilometers away. After missing precipitation values were substituted, daily precipitation at each of the four NWS Coop Stations was summed into monthly values that were averaged over the four stations to approximate monthly precipitation in the watershed. Arithmetic averaging of monthly precipitation was presumed sufficient because the four NWS Coop Stations were located at about the four corners of the watershed (fig.1). Annual precipitation was calculated as the sum of monthly precipitation.

Volunteer observers operate the NWS Coop Stations and routinely make one daily weather observation, commonly at a predetermined time, either morning, noon, afternoon, or evening (Owenby and Ezell, 1992). Observation time may lead to ambiguities when assigning observed precipitation values to a midnight-to-midnight day. An example of such ambiguity would be a 7 AM precipitation observation. Such an observation includes precipitation from 7 AM to midnight of the previous day and precipitation between midnight and 7 AM of the current day. Thus, a portion of the current day precipitation is assigned to the previous day. Measurement timing may be an issue when correlating daily precipitation with daily runoff, which is traditionally measured on a midnight-to-midnight basis. Also, observations may not be made at exactly the same time each day, nor is the observation time necessarily the same for observers at different stations. For example, an observer may not make a 7 AM observation during a thunderstorm but may wait until the storm passes, thus assigning the total storm precipitation to a single day, whereas if the observation would have been made at precisely 7 AM during the storm, the total storm precipitation would have been split between 2 days. Effects of such observational ambiguities are presumed to be minimal on the computed monthly and annual precipitation because precipitation is cumulative, and the exact day on which the precipitation occurred is not a relevant factor when performing such a summation.

A 5-year sine-weighted centered moving average (SWCMA) was used to show short-term persistent variations in annual precipitation (Chow, 1964). The term "centered" means the weighted average is computed at the center of the 5-year moving average window. The term "sine-weighted" means weights are proportional to sine values of six equally spaced angles from 0 through 180 degrees. These steps lead to five nonzero weights, each corresponding, in sequence, to a position in the 5-year moving average window. Practical implementation of the 5-year SWCMA required the time series be extended at both ends by two positions. The two extended positions at the beginning of the time series are assigned the weighted average annual precipitation of the first three precipitation values. The two extended positions at the end of the time series are calculated similarly. The SWCMA method is a simple time series filter, requires minimal computations, and is easily understood and accepted by agricultural producers and water resource managers who need to identify short-term persistent variations in annual precipitation.

A long-term trend also was calculated for annual precipitation. A long-term trend is a slow, systematic change over many decades that indicates the non-stationary nature of climate. A trend is not necessarily a straight line, but a gently curved line that displays low-frequency variations over time. Therefore, the long-term trend can be viewed as representing the time-dependent non-stationary mean annual precipitation. In this investigation, long-term trend was defined by a 31-year SWCMA applied twice in succession. Terms "centered" and "sine-weighted" are the same as explained for the 5-year SWCMA. Practical implementation of the 31-year SWCMA required the time series be extended at both ends by 15 positions, which again were assigned a weighted average annual precipitation calculated similarly as for the 5-year SWCMA. The 31-year SWCMA was applied twice successively, where the first application removed persistent variations of about 10 years or less, and the second application smoothed remaining irregularities in the trend line in areas of pronounced curvature that may have existed at the 10- to 15-year time scale. The end result was a smooth trend line that follows persistent and systematic changes lasting about 20 years or longer. This methodology to identify a trend line was considered suitable for time series of 60 years or longer.

## Air Temperature

Air temperature is referred to as temperature in this chapter. Observed daily minimum and maximum temperatures at two NWS Coop Stations (Carnegie and Weatherford, Oklahoma) were used to compute the 1940 through 2005 monthly and annual temperature for the Fort Cobb Reservoir watershed (table 1 and fig.1). Temperature was not recorded at either the Lookeba or Fort Cobb NWS stations; therefore, these stations were not used for estimating watershed-average temperature. Daily temperature data at the two NWS Coop Stations were obtained from the Oklahoma Climatological Survey in Norman, Oklahoma (Oklahoma Climatological Survey, 2008). Missing daily temperature values at the two NWS Coop Stations were substituted by using adjusted temperature values from nearby NWS Coop Stations, ARS Micronet stations, or Oklahoma Mesonet stations. Adjustment factors were necessary to account for spatial temperature gradients, station altitude and exposure, and/or any other causes. A separate adjustment factor was used for minimum and maximum temperature, and the adjustment factor value was computed in the same way as for precipitation. After all missing values were substituted, average daily temperature at each of the two NWS Coop Stations was computed as the average of daily minimum and maximum temperature. Monthly mean minimum, mean maximum, mean average daily temperature, and annual mean average daily temperature were computed for each NWS Coop Station as an arithmetic average of daily values. Finally, monthly temperature for the Fort Cobb Reservoir watershed was estimated as the average of the monthly temperature values at the two NWS Coop Stations. Annual average temperature for the watershed was computed as the mean of the monthly temperatures.

Because the NWS Coop network is operated by volunteers, time of observation may vary between observers, and occasionally circumstances lead to a temperature reading at a time different from the usual time. Also, attribution of observed minimum and maximum temperature to a particular day may be ambiguous, similar to the ambiguities described for precipitation observations. As a result, comparison of daily temperature values between stations may exhibit a day-offset, which can become apparent when a strong cold front moves across the region. Effects of such shortcomings in temperature observations are lessened when considering mean monthly and annual temperature values, as done in this climate review.

A 5-year and 31-year SWCMA were used to display persistent short-term variations and long-term trends in annual temperature. Computations of the SWCMA were similar to the computations for annual precipitation.

## Annual and Monthly Precipitation Characteristics

### Annual Precipitation

The 1940 through 2005 time series of annual precipitation for the Fort Cobb Reservoir watershed is shown in figure 2, and corresponding statistics are listed in table 2. Year-to-year variations in annual precipitation exceeding 254 millimeters (mm) were not unusual. Several extreme low annual precipitation values (less than 508 mm) were recorded in the 1950s, and several high values (above 965 mm) were recorded in the 1980s and 1990s. Long-term trend in annual precipitation (fig. 2) indicated that lower average annual precipitation prevailed before 1980 as compared to after 1980. The 1940 through 1979 mean annual precipitation was 719 mm, whereas the 1980 through 2005 mean annual precipitation was 811 mm. The 5-year SWCMA in figure 3 shows that the 5-year mean annual precipitation has been gradually declining from 1995 through 2005. Whether decline will continue or reverse in the coming years remains to be seen.

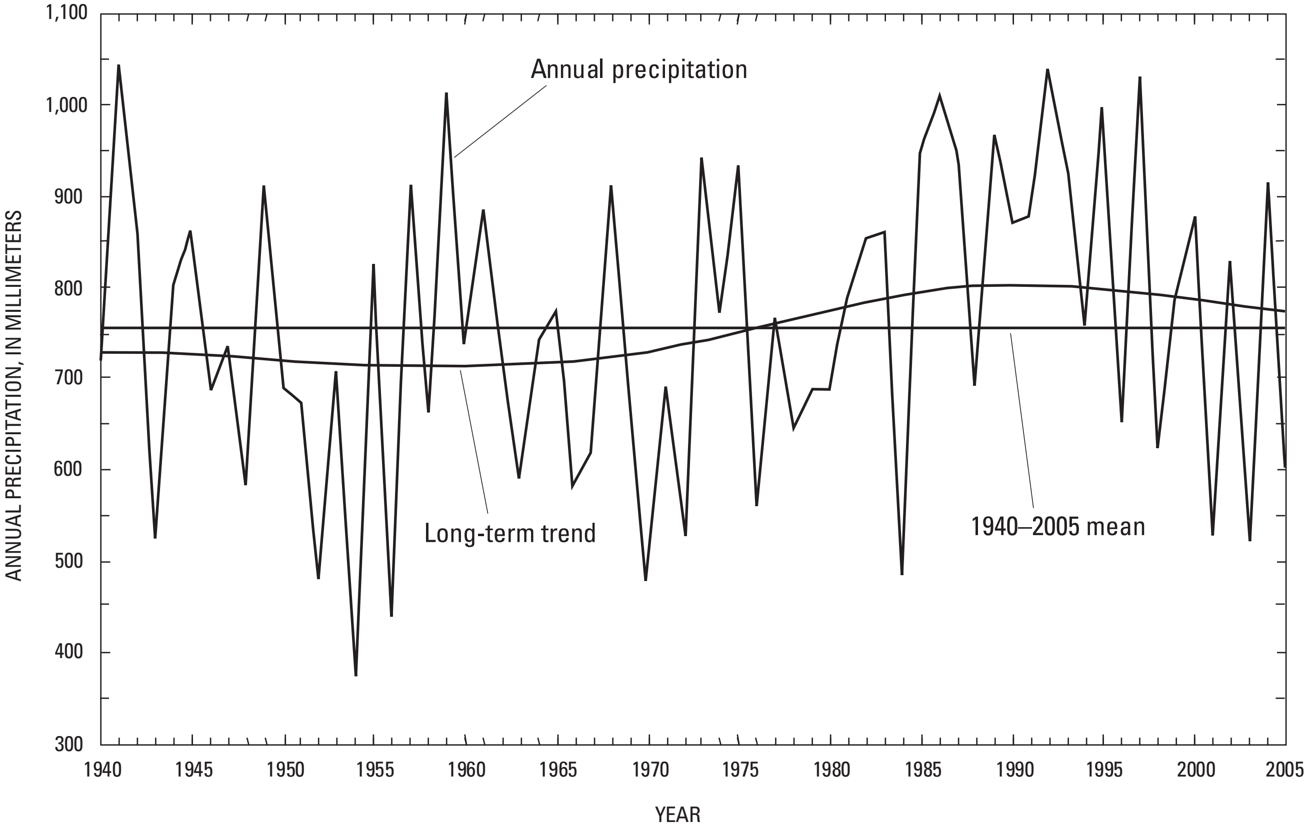


**Figure 2.** Time series of annual precipitation (1940–2005) and long-term trend in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

**Table 2.** Basic statistics of annual precipitation and temperature for the Fort Cobb Reservoir watershed, southwestern Oklahoma, 1940-2005.

| Statistic | Annual precipitation (millimeters) | Annual maximum air temperature (Celsius) | Annual minimum air temperature (Celsius) | Annual average air temperature (Celsius) |
|---|---|---|---|---|
| Mean | 754.9 | 20.5 | 7.7 | 14.1 |
| Median | 750.3 | 20.4 | 7.6 | 14.0 |
| Minimum | 371.6 | 18.9 | 6.6 | 13.0 |
| Maximum | 1,043.7 | 23.3 | 9.0 | 15.9 |
| Range | 672.1 | 4.4 | 2.4 | 2.9 |
| Average year to year difference | 216.1 | 0.83 | 0.55 | 0.56 |

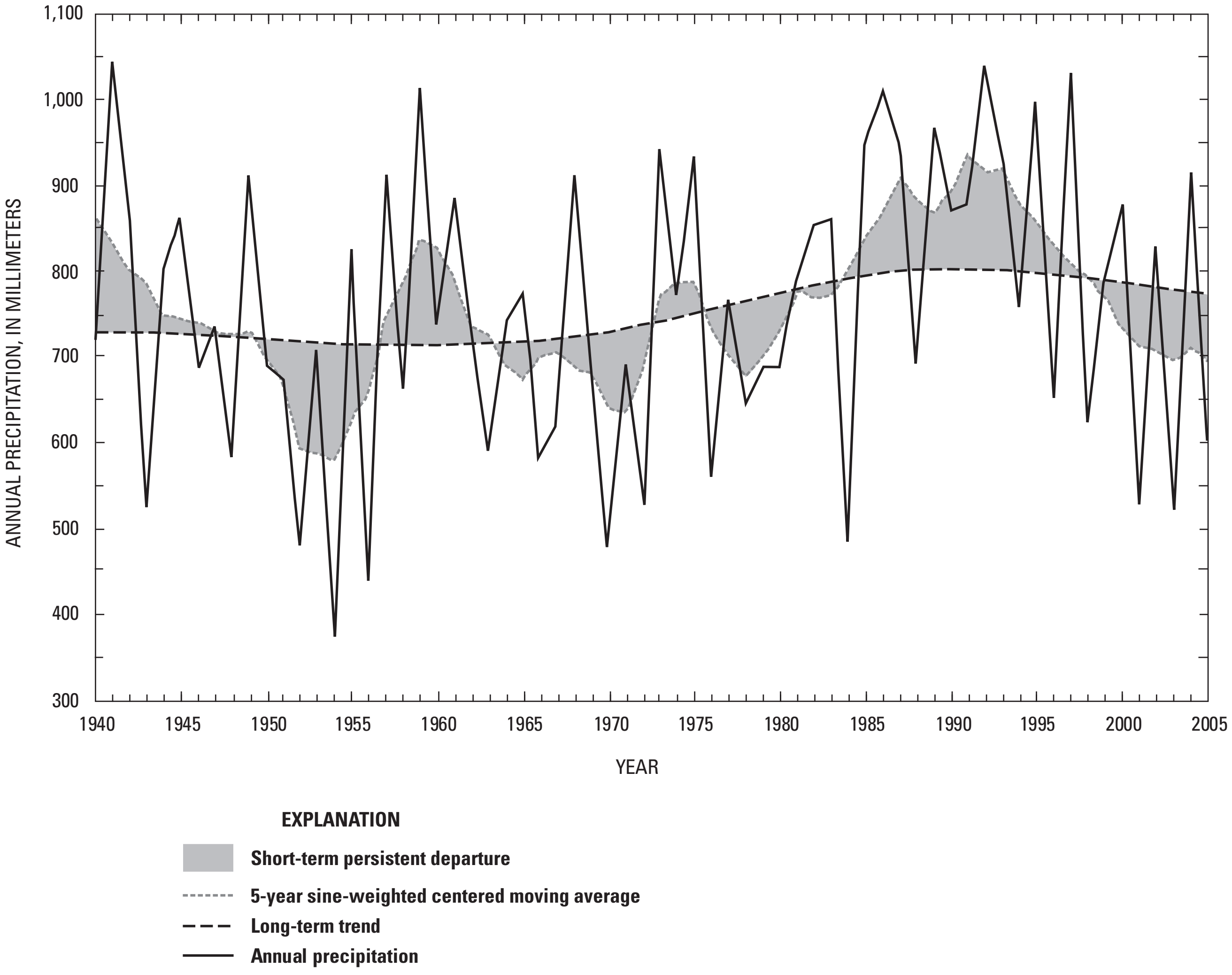


**Figure 3.** Annual precipitation, long-term trend, and short-term persistent departures from long-term trend (1940–2005) in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

In figure 3, the areas between the 5-year SWCMA and the long-term trend line show short-term persistent departures from the long-term trend (non-stationary mean). Such areas below the long-term trend line indicate mostly drier years than the corresponding long-term trend, whereas areas above the long-term trend line identify mostly wetter years than the corresponding long-term trend. Areas that identify persistent wetter and drier years are informative for water-resources management applications that involve balancing water supply and demand.

## Monthly Precipitation

Mean monthly precipitation for 1940 through 2005 has a bimodal distribution, with the first peak in May and a smaller second peak in September (fig. 4). May and June have the highest mean monthly precipitation, and December and January have the lowest mean monthly precipitation. The difference between 25- to 75-percentile of monthly precipitation is generally large and indicates that monthly precipitation is highly variable. Figure 5 shows the mean monthly precipitation for the two periods identified by the long-term precipitation trend as having lower and higher mean annual precipitation. Nine of twelve months had increases in mean precipitation for the period 1980 through 2005, though many of those increases were small (less than 15 millimeters). March and June are the months that incurred the largest increase in mean precipitation for the period 1980 through 2005. The precipitation increase in March may indicate that the spring rainy season (April, May and June) started earlier during the 1980 through 2005 period. Summer months (July, August, and September) do not appear to have had substantially greater mean monthly precipitation since 1980.

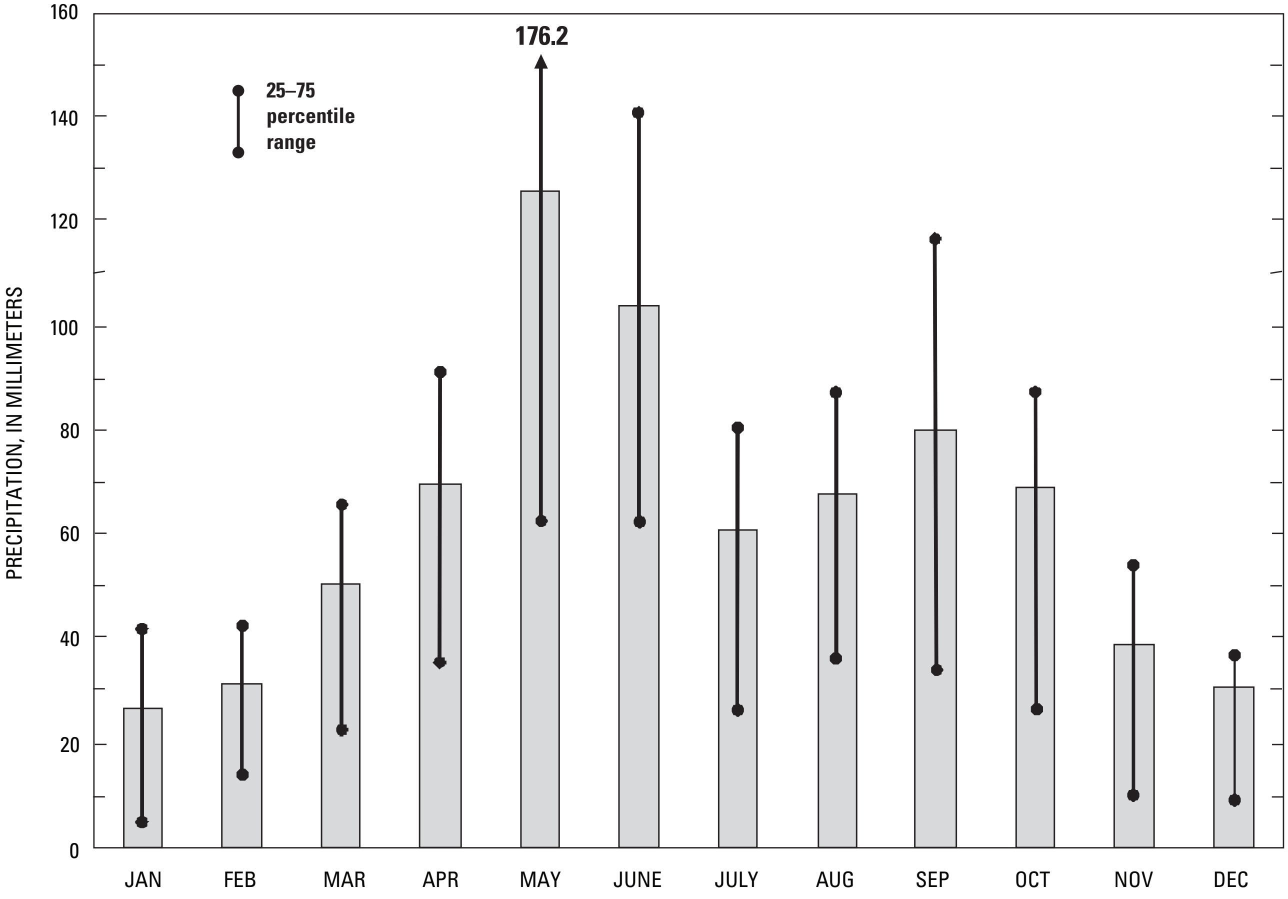


**Figure 4.** Mean monthly precipitation (1940–2005) in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

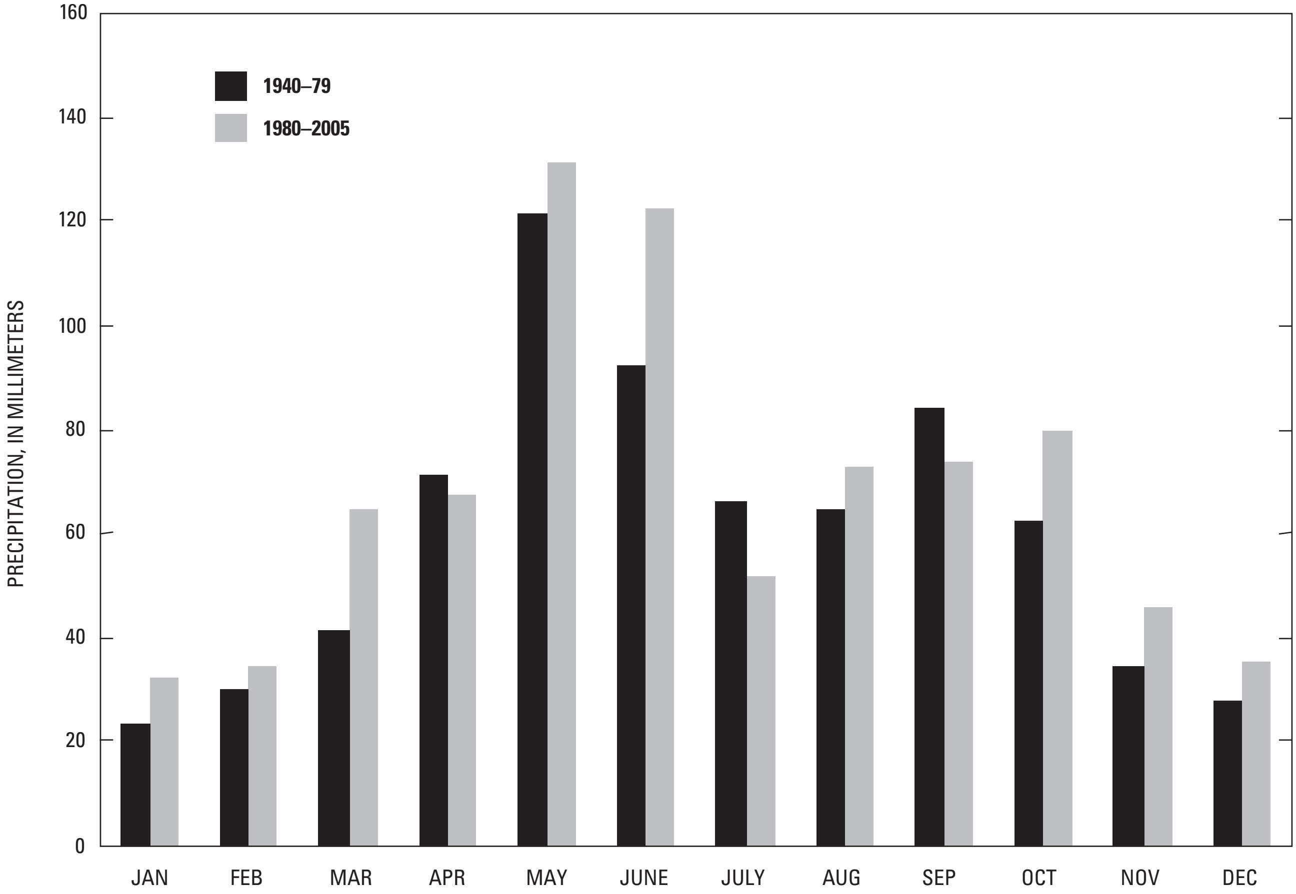


**Figure 5.** Mean monthly precipitation (1940–1979 and 1980–2005) in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

## Annual and Monthly Temperature Characteristics

### Annual Temperature

A time series plot of 1940 through 2005 annual average temperature (fig. 6) displays temperature values as low as 13 degrees Celsius (°C) and as high as 16 °C, with a maximum year-to-year mean variation of 1.9 °C. Basic statistics of annual average temperature are listed in table 2. A long-term downward trend in temperature is apparent for the 1940 through 2005 period (about -0.4 °C for 66 years, fig. 6). Annual average temperature before 1970 was 14.2 °C, and after 1970 it was 13.9 °C. This slight annual temperature trend could be explained in terms of the precipitation trend, station moves, and shifts in climate, yet it may equally be related to land-use changes with time, and an increased number of lakes and reservoirs in the watershed. The magnitude of the trend in annual temperature (-0.6 °C per 100 years) from an immediate hydrologic and agronomic management perspective was of little practical interest, especially when compared to the diurnal and seasonal temperature variations or to the trend in annual precipitation.

Short-term persistent variations in the annual temperature record are visualized by the 5-year SWCMA in figure 7. Some of the short-term persistent variations in annual temperature coincided with corresponding variations

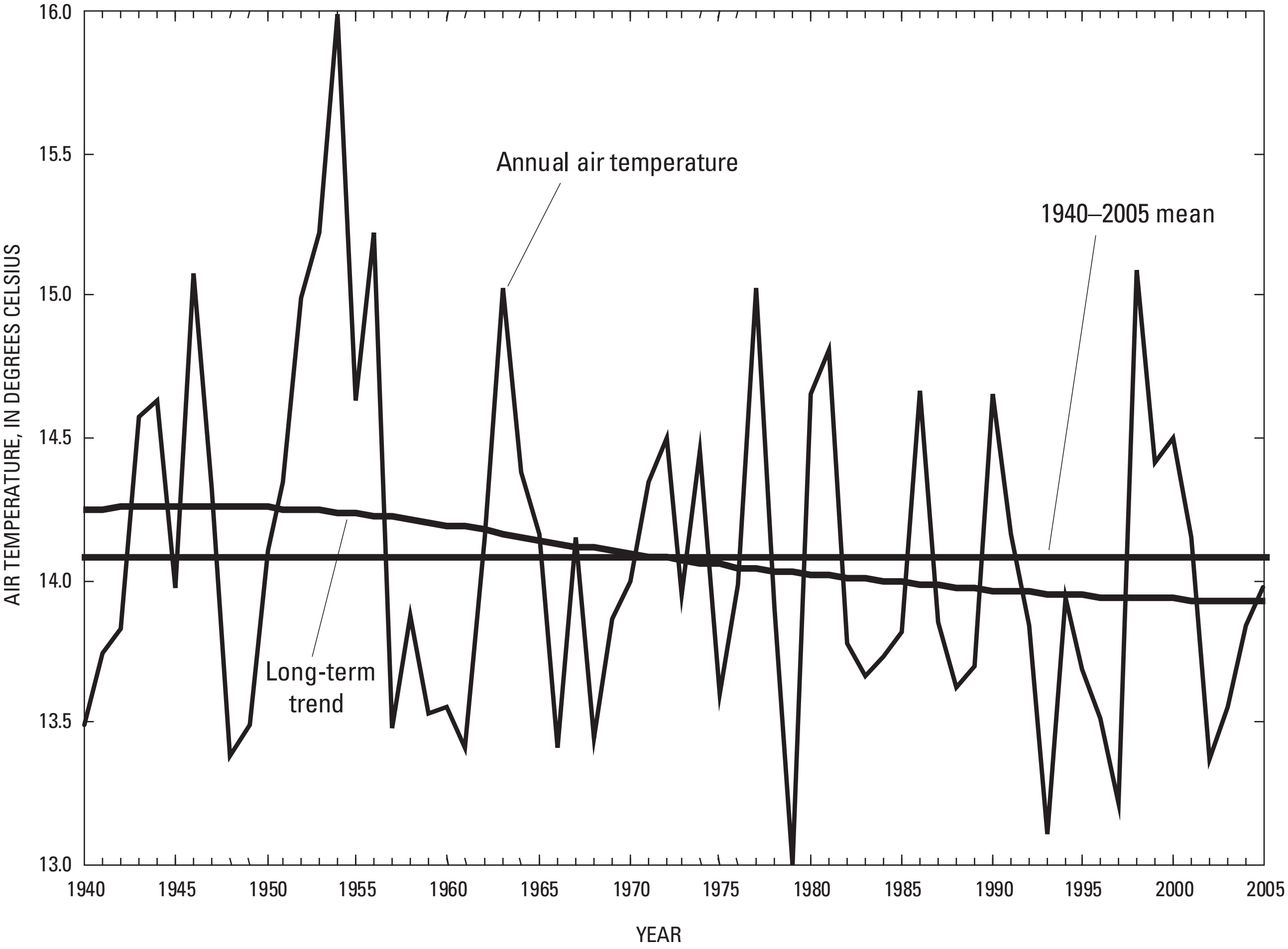


**Figure 6.** Annual average temperature and long-term trend (1940–2005) in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

in precipitation (1950s and 1960s), whereas others did not (1970s). In particular, the short-term persistent increase in precipitation in the late 1980s and early 1990s did not produce a corresponding pattern in the persistent variation of temperature. The lack of a corresponding variation may be due to the fact that temperature is also driven by several other weather and watershed physiographic variables, in addition to precipitation.

## Monthly Temperature

Mean monthly average temperature for the 1940 through 2005 period is displayed in figure 8. The highest mean monthly average temperature values were in July and August, and lowest in January and December. The difference between 25- to 75-percentile was generally small compared to the seasonal and monthly minimum/maximum range (fig. 8), but of the same order of magnitude as calendar-month to calendar-month variations. Monthly temperature differences as a result of the long-term temperature trend were small compared to seasonal variations. Mean monthly minimum and maximum temperatures (fig. 9) indicated a similar seasonal pattern as the mean monthly average temperature in figure 8. Mean monthly minimum temperature ranged from -3.9 $^{o}$C in January to 21.2 $^{o}$C in July, and maximum temperature from 9.5 $^{o}$C to 35.3 $^{o}$C, respectively. The difference between mean monthly minimum and maximum temperature appeared to be nearly constant for all calendar months.

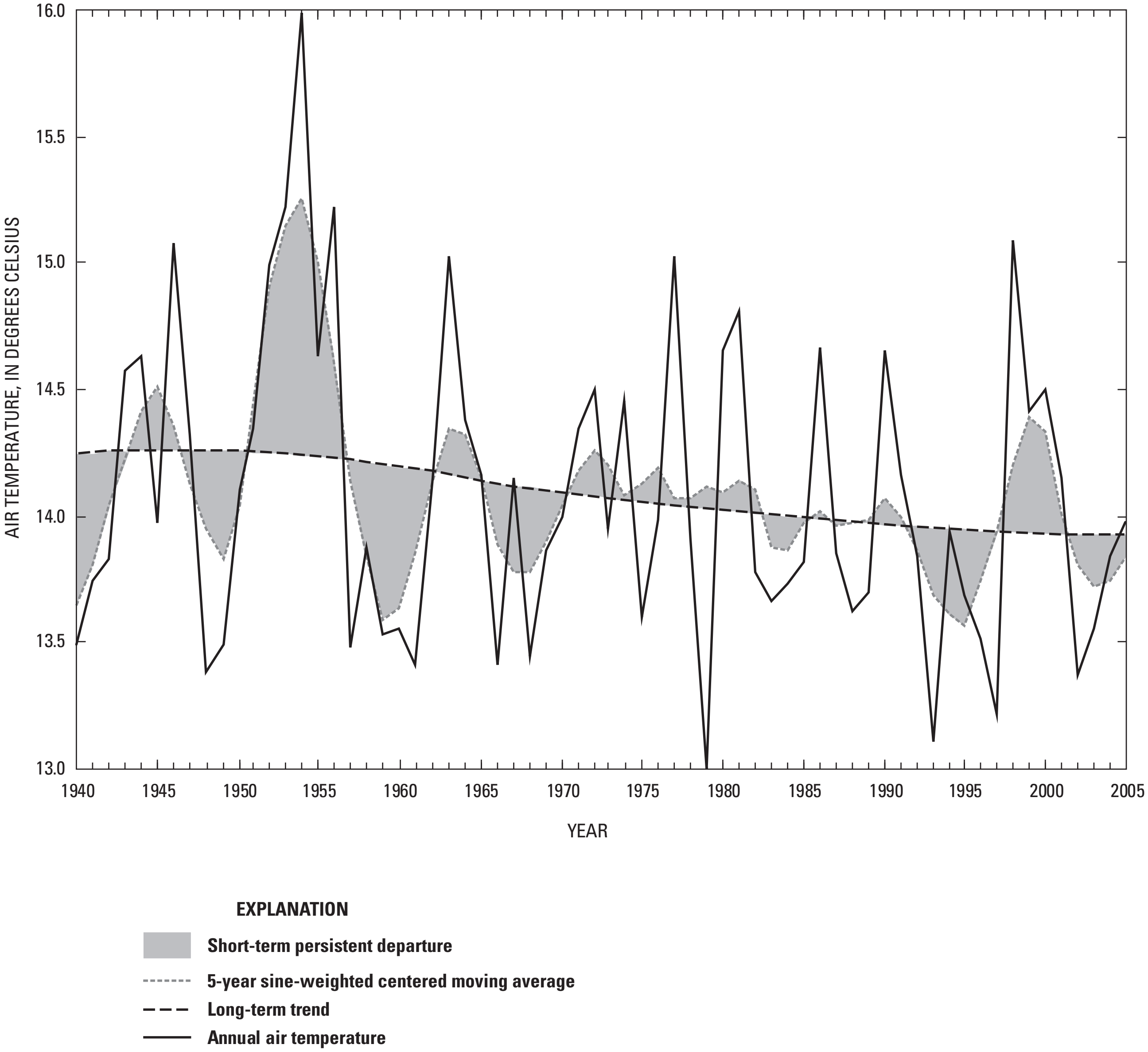


**Figure 7.** Annual average temperature, long-term trend, and short-term persistent departures from long-term trend (1940–2005) in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

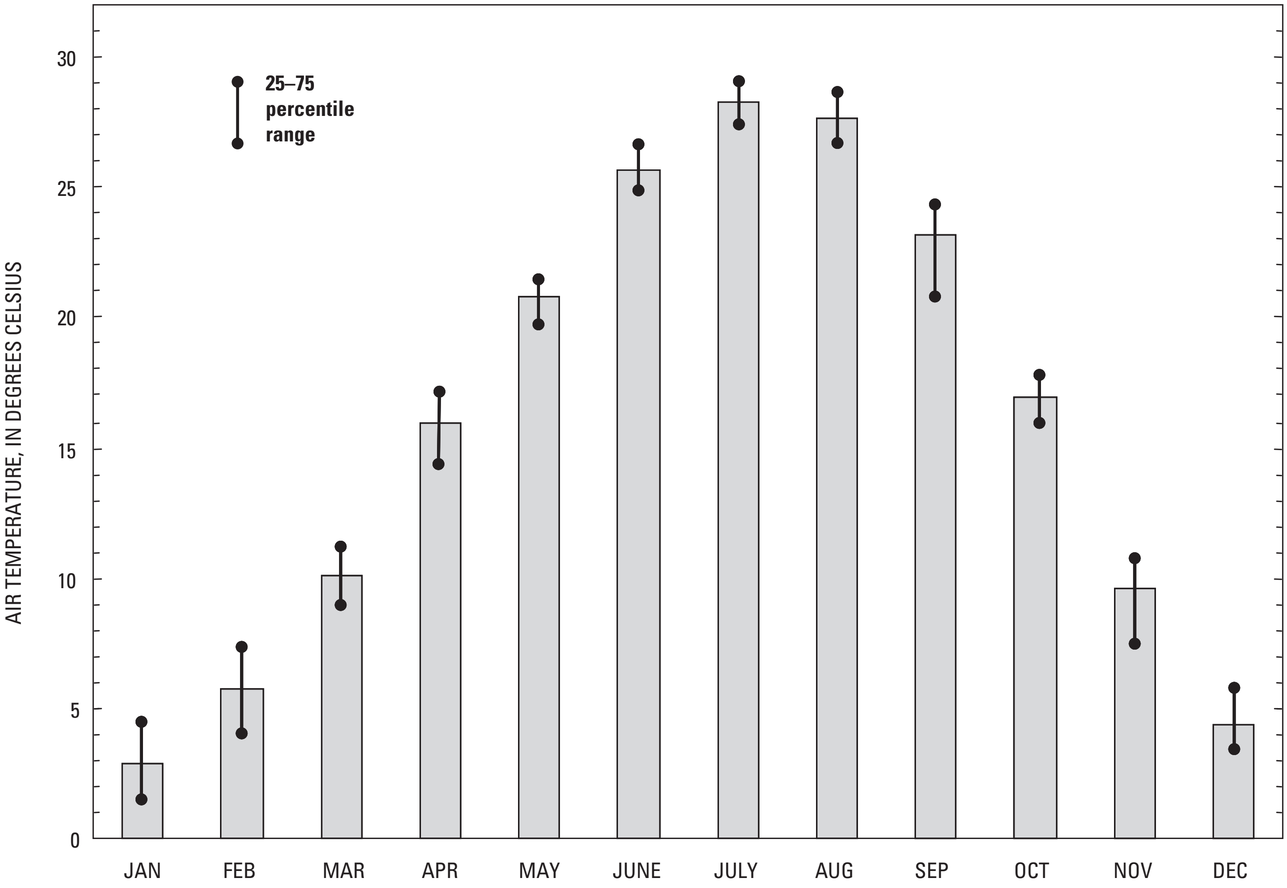


**Figure 8.** Mean monthly average temperature (1940–2005) in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

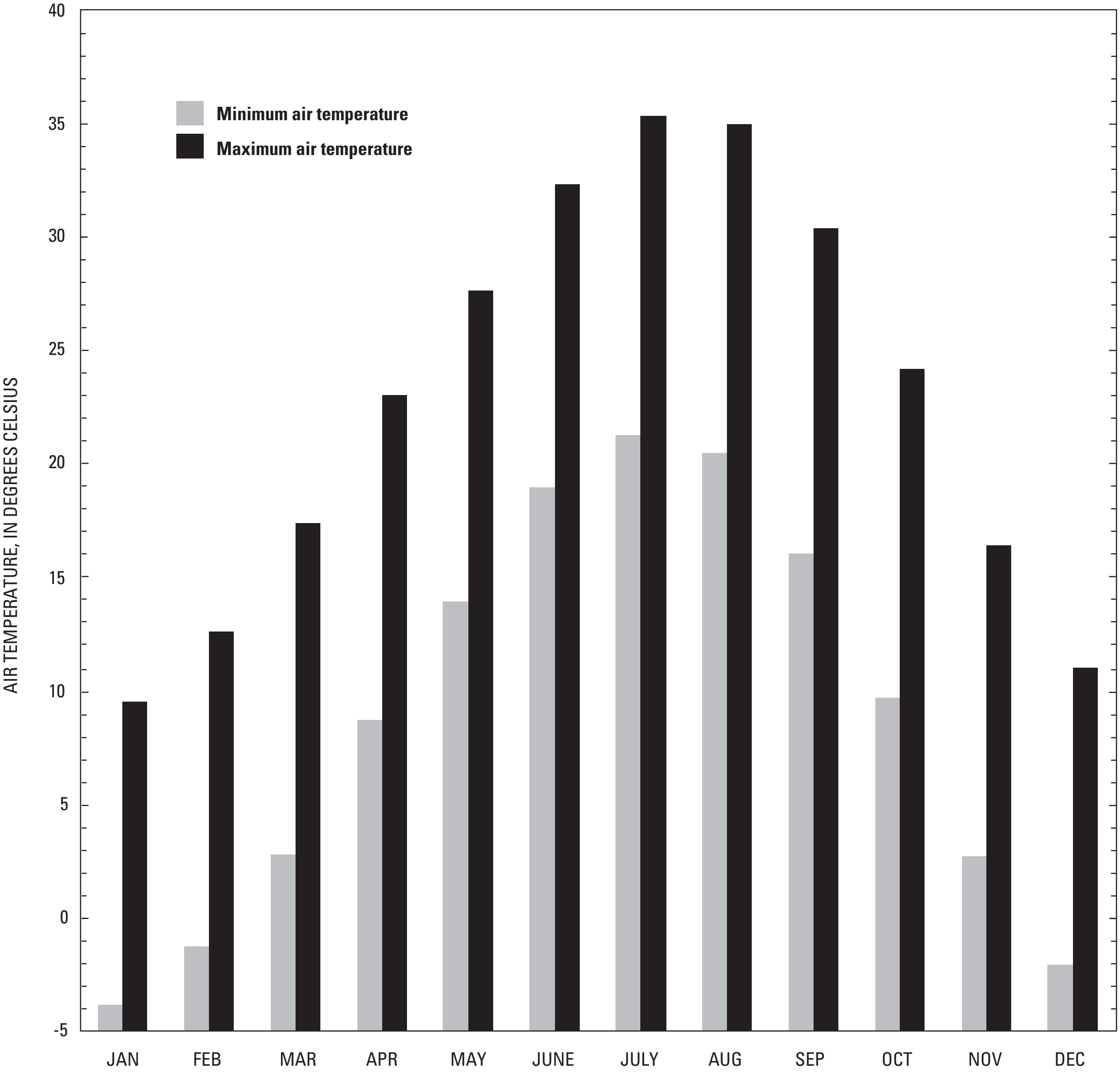


**Figure 9.** Mean monthly minimum and maximum temperature (1940–2005) in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

# 2005 Through 2007 Daily and Monthly Precipitation and Temperature

## ARS Micronet Data

In 2005 the Fort Cobb Reservoir watershed was equipped with 15 automated weather stations, called the ARS Micronet (table 3, fig. 1). The weather stations are operated and maintained by the U.S. Department of Agriculture, ARS, Grazinglands Research Laboratory, El Reno, Okla., in cooperation with Oklahoma State University and the Oklahoma Climatological Survey. Micronet data consist of accumulated rainfall, relative humidity, air temperature, solar radiation, soil temperature, and volumetric soil water content. A detailed description of instruments and specifications, and a description of the database and quality assurance, can be found at Agricultural Research Service (2010). Only precipitation and air temperature data collected from 2005 through 2007 are described here, and air temperature is referred to as temperature.

## Data Source and Preparation

### Precipitation

Daily precipitation data at the Micronet stations, beginning August 1, 2005, through September 30, 2007, were used for this study. Missing daily precipitation values were substituted with daily precipitation values from the nearest station, and daily precipitation at each ARS Micronet station was summed into monthly values. Based on this record, the 30 largest daily precipitation events from September through

**Table 3.** Location information and commissioning dates of the Agricultural Research Service Micronet weather stations in the Fort Cobb Reservoir watershed, southwestern Oklahoma.

| Station name | Latitude[1] | Longitude | Elevation[2] (meters) | Commissioning date |
|---|---|---|---|---|
| F101 | 35.4551 | -98.6064 | 504 | June 30, 2005 |
| F102 | 35.4504 | -98.5443 | 524 | May 25, 2005 |
| F103 | 35.4237 | -98.7087 | 484 | July 12, 2005 |
| F104 | 35.3923 | -98.6233 | 484 | June 30, 2005 |
| F105 | 35.4072 | -98.5710 | 493 | May 24, 2005 |
| F106 | 35.3915 | -98.5138 | 472 | June 30, 2005 |
| F107 | 35.3764 | -98.4650 | 500 | June 30, 2005 |
| F108 | 35.3611 | -98.5712 | 492 | May 24, 2005 |
| F109 | 35.3123 | -98.5675 | 466 | July 08, 2005 |
| F110 | 35.3303 | -98.5202 | 430 | July 08, 2005 |
| F111 | 35.3343 | -98.4383 | 481 | June 30, 2005 |
| F112 | 35.3051 | -98.4914 | 470 | July 12, 2005 |
| F113 | 35.2910 | -98.6357 | 465 | May 25, 2005 |
| F114 | 35.2830 | -98.4371 | 456 | June 30, 2005 |
| F115 | 35.2294 | -98.6063 | 449 | May 24, 2005 |

[1] Latitude and longitude are in decimal degrees.

[2] Elevation is meters above sea level.

April (cool season) and the 30 largest daily precipitation events from May through August (warm season) were selected for study of spatial and seasonal precipitation variability. Cool season precipitation events included days with at least one Micronet station having or exceeding 11 mm of precipitation, whereas warm season events included days with at least one Micronet station having or exceeding 27 mm of precipitation.

### Temperature

Daily minimum and maximum temperatures from July 2005 through September 2007 at the ARS Micronet stations were used to investigate daily and monthly spatial temperature variability. Missing temperature values were substituted with values from the nearest station, and monthly average of daily minimum and maximum temperature at each station was computed as an average of daily values. Daily temperature also was grouped by spring, summer, autumn, and winter season to determine spatial variability of seasonal temperature. Spring was defined as March, April, and May; summer as June, July, and August; autumn as September, October, and November; and winter as December, January, and February. Monthly average of daily minimum and maximum temperature is referred to as monthly minimum and maximum temperature in this chapter.

## Methodology

Spatial variability is defined as the greatest difference in daily or monthly precipitation or temperature between any two stations of the ARS Micronet (fig. 1). This statistic was selected because of easy interpretation. If the greatest difference among all Micronet stations is small, then a single weather station would be representative for the entire watershed, otherwise use of data from several stations is preferred. Mean and standard deviation of the daily or monthly spatial variability were also computed.

## Spatial Variability of Monthly and Daily Precipitation

Mean and standard deviation of spatial variability for precipitation are listed in table 4. The standard deviation values indicated the spread of spatial variability values.

### Monthly Precipitation

Mean spatial variability of monthly precipitation was greater for the warm season (69.29 mm) compared to the cool season (26.13 mm) (table 4), mostly attributable to heavy localized convective storms during the warm season. Mean spatial variability of monthly precipitation for warm and cool seasons was 41.07 mm. The precision of tipping-bucket rain gages used in the Micronet stations was ± 5 percent (Agricultural Research Service, 2010) and that precision was not believed to have substantially contributed to the spatial variability of monthly precipitation.

### Daily Precipitation

Daily precipitation indicated a greater mean spatial variability during the warm season (39.55 mm) than during the cool season (18.56 mm) (table 4). Mean spatial variability for warm and cool seasons was 29.05 mm. Most notably, mean spatial variability of daily and monthly precipitation was large compared to the accuracy range of the rain gauges, and is believed to be relevant for modeling hydrologic and conservation affects at the watershed scale, and for interpretation of water-quality data collected from streams in the watershed.

## Spatial Variability of Temperature

Mean spatial variability of monthly and daily temperature is displayed in table 4. The precision of the temperature gage may be as large as ± 3.0 ºC, depending on the wind speed (Agricultural Research Service, 2010).

### Monthly Minimum and Maximum Temperature

Mean spatial variability of monthly minimum temperature was 2.36 ºC with standard deviation of 1.27 ºC, and monthly maximum temperature was 0.97 ºC with standard deviation of 0.30 ºC. However, these values for mean spatial variability of monthly temperature are within the accuracy range of the temperature gage, and, therefore, cannot conclusively be attributed to spatial variability.

### Daily Minimum and Maximum Temperature

Mean spatial variability of daily minimum temperature was greater during autumn (6.30 ºC) and winter (4.02 ºC) than during spring (3.11 ºC) and summer (2.29 ºC) with highest variability occurring during autumn and least variability occurring during summer (table 4). For all seasons combined, mean spatial variability of daily minimum temperature was 3.43 ºC, which is slightly greater than the instrument accuracy. Mean spatial variability for daily maximum temperature was similar for spring (1.76 ºC), summer (1.76 ºC), autumn (1.63 ºC), and winter (1.57 ºC) (table 4). For all seasons combined, mean spatial variability of temperature was (1.68 ºC) (table 4). Mean spatial variability values of temperature were mostly within the accuracy range of the temperature gage, and, therefore, may or may not be related to spatial daily temperature variability.

**Table 4.** Mean and standard deviation of spatial variability of precipitation and temperature for the Agricultural Research Service Micronet weather stations in the Fort Cobb Reservoir watershed, southwestern Oklahoma, 2005.

[mm, millimeters; °C, degrees Celsius]

| Time step | Component | Mean spatial variability | Standard deviation of spatial variability | Sample size |
|---|---|---|---|---|
| | | Precipitation | | |
| Monthly | All season precipitation (mm) | 41.07 | 35.17 | 26 |
| | Warm season precipitation (mm) | 69.29 | 34.24 | 9 |
| | Cool season precipitation (mm) | 26.13 | 25.71 | 17 |
| Daily | All season precipitation (mm) | 29.05 | 22.93 | 60 |
| | Warm season precipitation (mm) | 39.55 | 25.42 | 30 |
| | Cool season precipitation (mm) | 18.56 | 13.98 | 30 |
| | | Air temperature | | |
| Monthly | Minimum air temperature (°C) | 2.36 | 1.27 | 27 |
| | Maximum air temperature (°C) | 0.97 | 0.30 | 27 |
| Daily | All season minimum air temperature (°C) | 3.43 | 3.64 | 822 |
| | Spring minimum air temperature (°C) | 3.11 | 2.31 | 184 |
| | Summer minimum air temperature (°C) | 2.29 | 1.44 | 246 |
| | Autumn minimum air temperature (°C) | 6.30 | 5.43 | 212 |
| | Winter minimum air temperature (°C) | 4.02 | 2.51 | 180 |
| | All season maximum air temperature (°C) | 1.68 | 0.88 | 822 |
| | Spring maximum air temperature (°C) | 1.76 | 1.42 | 184 |
| | Summer maximum air temperature (°C) | 1.76 | 0.67 | 246 |
| | Autumn maximum air temperature (°C) | 1.63 | 0.56 | 212 |
| | Winter maximum air temperature (°C) | 1.57 | 0.70 | 180 |

# Summary and Conclusions

Analysis of the climate record of the Fort Cobb Reservoir watershed revealed a long-term upward trend in annual precipitation with lower average annual precipitation prevailing before 1980, with a higher average value since 1980. Several 5- to 20-year persistent variations in moving-average annual precipitation were also identified. Starting about 1995, a slow and gradual decrease in annual precipitation was observed.

Mean monthly precipitation for 1940-2005 shows a bimodal distribution with the first peak in May and a smaller second peak in September. Although most calendar months experienced an increase in precipitation as a result of the long-term annual precipitation trend, the large increase in March precipitation indicated that the spring rainy season may be starting earlier during the 1980-2005 period. July, August and September, the hottest months of the year, did not appear to have substantially higher mean annual precipitation during the 1980-2005 period.

Annual air temperature also indicated a long-term trend, but the magnitude was small and of little practical interest for analysis of recent and current hydrologic conditions. Short-term persistent variations were also seen in the annual temperature record, but they did not consistently coincide with corresponding variations in the precipitation record, most likely because a number of atmospheric and watershed physiographic variables, in addition to precipitation, control air temperature. Long-term trend in monthly air temperature was small and of little practical relevance for short-term hydrologic applications. Of interest was the near constant difference between mean monthly minimum and maximum temperature for all calendar months.

Mean spatial variability of monthly and daily precipitation during 2005-2007 was large. More intense precipitation events were recorded during summer months than during winter months. Therefore, the ARS Micronet climate stations in the Fort Cobb Reservoir watershed provided spatial precipitation distribution information required for accurate assessment of local and watershed wide hydrology, including effects on soil erosion, agricultural nutrient movement, and water quality. Mean spatial variability of monthly and daily air temperature was within or close to the accuracy range of the temperature gage. Such small variations in the spatial variability of monthly air temperature are of little practical significance for most hydrologic applications. Therefore, air temperature at any Micronet station is a representative approximation of temperature within the whole watershed.

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