

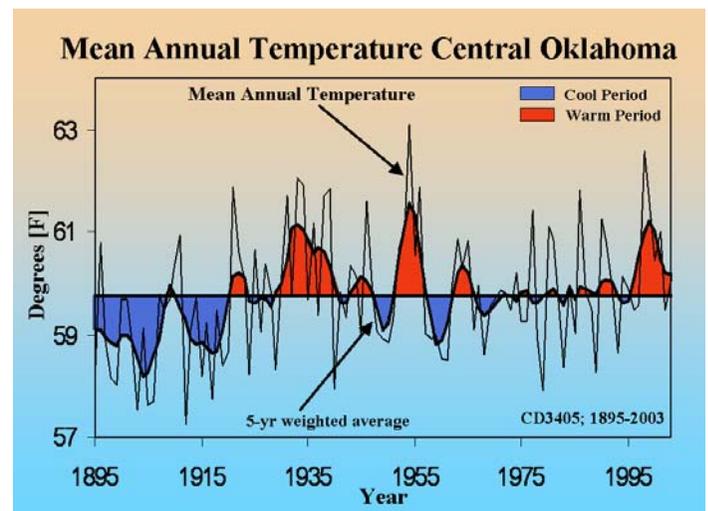
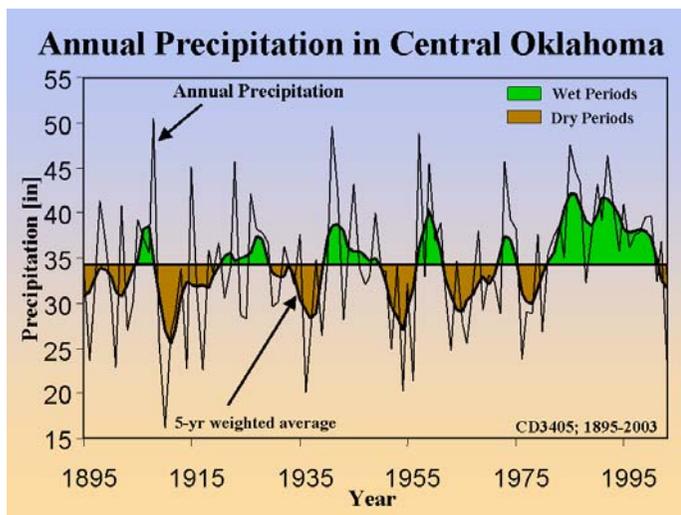


United States Department of Agriculture  
Agricultural Research Service



# Variations of Annual Precipitation and Air Temperature in Oklahoma, Kansas and Texas 1895-2003

by  
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and  
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U.S. Department of Agriculture, Agricultural Research Service  
Grazinglands Research Laboratory, 7207 West Cheyenne Street  
El Reno, Oklahoma, 73036

**U**nited **S**tates **D**epartment of **A**griculture  
**A**gricultural **R**esearch **S**ervice

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Copies of this publication are available on the web page of the Grazinglands Research Laboratory, El Reno, Oklahoma, <http://ars.usda.gov/Main/docs.htm?docid=11617>

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## **Objective**

This publication presents graphical displays of persistent variations in annual precipitation and mean air temperature during 1895-2003 over large climate regions in Oklahoma, Kansas, and Texas. Recognition and consideration of such persistent variations can assist with agricultural planning and development of management strategies for sustainable water resources utilization.

## **Background**

Persistent, multi-year variations in annual precipitation and mean air temperature can have significant implications for agriculture and water resources management. For example, the multi-year dry spell of the Dust Bowl in the 1930s, in combination with land mismanagement, destroyed the agricultural economy of the Great Plains during that time and forced the migration of thousands of farm families. Recent sustained dry conditions in western Kansas, combined with depleted water tables, forced many agricultural producers to reconsider the continued viability of crops that were once profitable during wetter climate conditions in the 1980s and 1990s. And, from the water resources point of view, droughts in the 1930s, 1950s and 1960s and population growth prompted Oklahoma officials to plan and build a number of water supply reservoirs, such as the Atoka reservoir and pipeline in southeastern Oklahoma that augment the water supply for Oklahoma City. Sustained wet conditions, though usually welcome in the semi-arid Great Plains, can also have significant, detrimental consequences. Recurring floods in the 1940s and 1950s prompted the Soil Conservation Service to construct over 2000 flood retarding structures in Oklahoma alone. Similar impacts of climate fluctuations are noted throughout recorded history, and continue today in many parts of the country.

Traditionally, assessment of climate effects on water resources management and agricultural production have been based on long-term averages, short-term seasonal-to-interannual variations, and on extreme events. Less attention has been given to persistent variations in precipitation and air temperature that last 5 years and longer. This is unfortunate, since these variations can have significant economic and environmental impacts, as noted above. Research is being conducted at the ARS Grazinglands Research Laboratory to identify long-term precipitation and air temperature variations, assess their impact on agricultural productivity and water resources availability, and produce climate-related decision information in support of agricultural and water resource planning and management. The first task in this effort is to identify and share information on the existence, duration and geographical extent of past precipitation and air temperature variations, which can be used as a guide to what might happen in the future.

## **Data Sources**

Annual precipitation and air temperature variations were calculated from monthly precipitation and mean air temperature data that were averaged over large regions called climate divisions. Climate divisions were defined by the U.S. Weather Bureau in the 1940s. Often these climate divisions coincide with crop reporting districts. Maps outlining the climate divisions in

Oklahoma, Kansas, and Texas are provided in this publication. The weather statistics from a number of cooperative weather service stations within each climate division are averaged to produce the monthly precipitation and mean air temperature for the climate division. These monthly precipitation and mean air temperature data for climate divisions are calculated and published by NOAA's National Climatic Data Center in Asheville, North Carolina (available at [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)).

## **Data Processing**

Monthly precipitation and mean air temperature were summed for each climate division and over each year from 1895 through 2003. These annual values were then plotted as time series for each climate division.

To highlight multi-year variations in annual climate variables, a weighted moving average filter was applied to each time series. The length of the filter was 5 years, and the weights were 0.13, 0.23, 0.28, 0.23 and 0.13. Two years of climate values were added at the beginning and end of the original 1895-2003 time series, thereby ensuring a value for the filtered time series on the first and last year (1895 and 2003, respectively). The two years prior to 1895 were assigned the mean of the climate values for 1985, 1986 and 1987, and the two years after 2003 were assigned the mean of the climate values for 2001, 2002 and 2003. This methodology was found to work well to highlight multi-year variations and long-term trends. Large departures in the 5-year moving average are believed to be relevant for agricultural and water resources applications, while small departures are likely to have less significance.

## **Figure Explanation**

Annual precipitation is plotted in inches [in] along the left side of precipitation variation graphs, mean annual air temperature is plotted in degrees Fahrenheit [F] along the left side of air temperature graphs, and year is plotted at the bottom of the graph. Each graph consists of four elements, as illustrated on next page for the central Oklahoma climate division. First, annual precipitation and air temperature values are connected by thin, black lines. Second, the filtered annual precipitation and air temperature time series is represented by a heavy, black line. Third, the long-term average (1895-2003) is plotted as a horizontal heavy, black line. And, fourth, relevant and persistent climate variations (wet/dry and warm/cold periods) are identified by colored areas between the long-term average and the filtered time series.

## **Example Interpretation**

The plot of annual precipitation for Central Oklahoma (Climate Division 3405) on the next page is used to illustrate the interpretation of persistent precipitation variations lasting 5 years and longer. Referring to the filtered time series (heavy, black line) and the green and brown shaded areas, it is easy to find the drought of the early 1910s and the 1930s Dust Bowl years. But there were similar dry periods during 1950s, the 1960s, and even the late 1970s. Attention is also

called to the period of sustained above-average precipitation during the 1980s and 1990s. It appears that producers and managers in central Oklahoma had above normal precipitation for those 20 years, at least relative to annual rainfall.

There are subtle differences in intensity and duration of dry and wet periods as one shifts from one climate division to an adjacent climate division. However, persistent wet and dry periods cover large areas and can be recognized across several climate divisions. For example, the Dust Bowl drought of the 1930s can be identified in all of Oklahoma's climate divisions, and was most pronounced in the Oklahoma Panhandle and the least in southeastern Oklahoma.

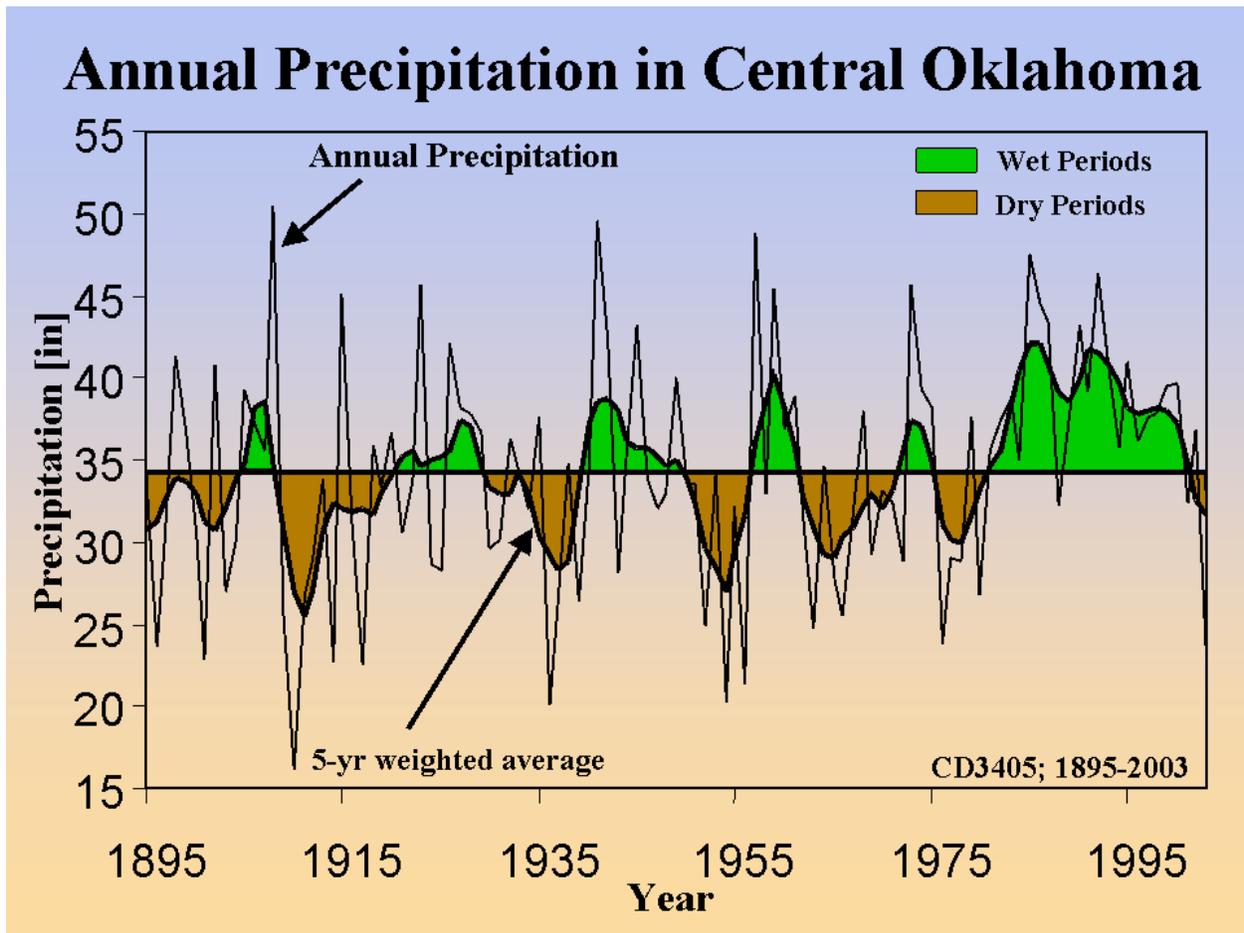
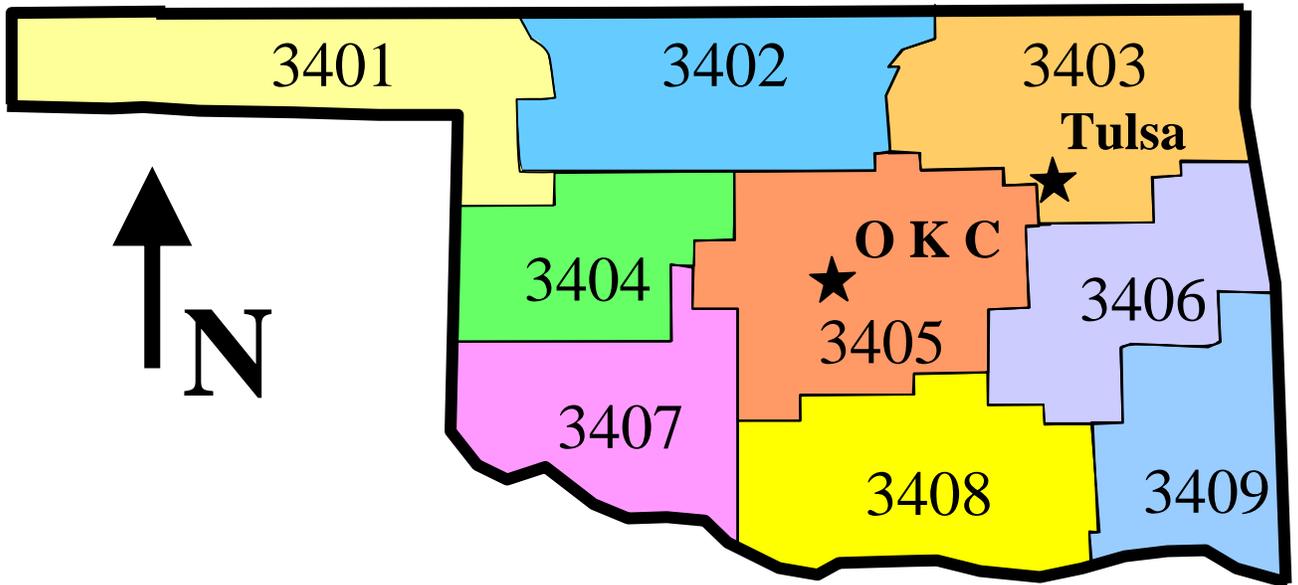


Figure 1. Annual precipitation and variability for Central Oklahoma.

# Climate Divisions of Oklahoma



3401: Panhandle

3402: North Central

3403: Northeast

3404: West Central

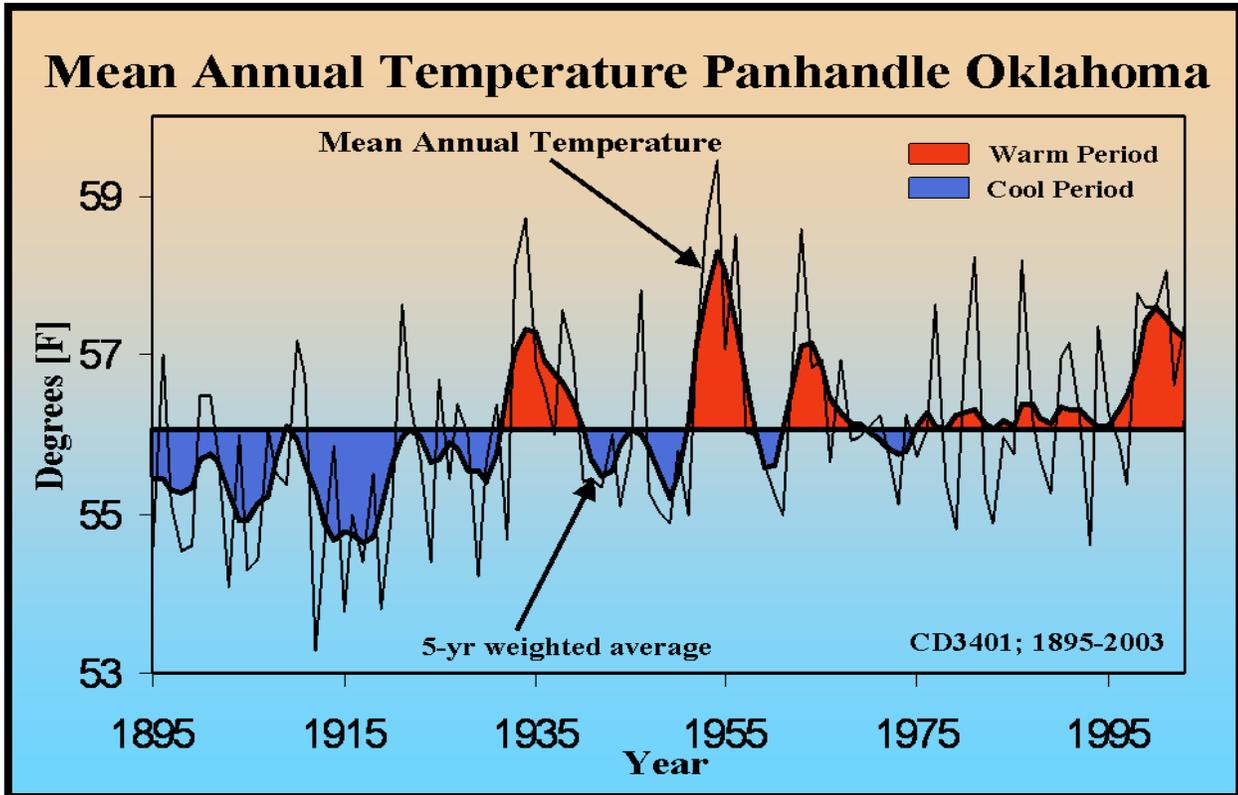
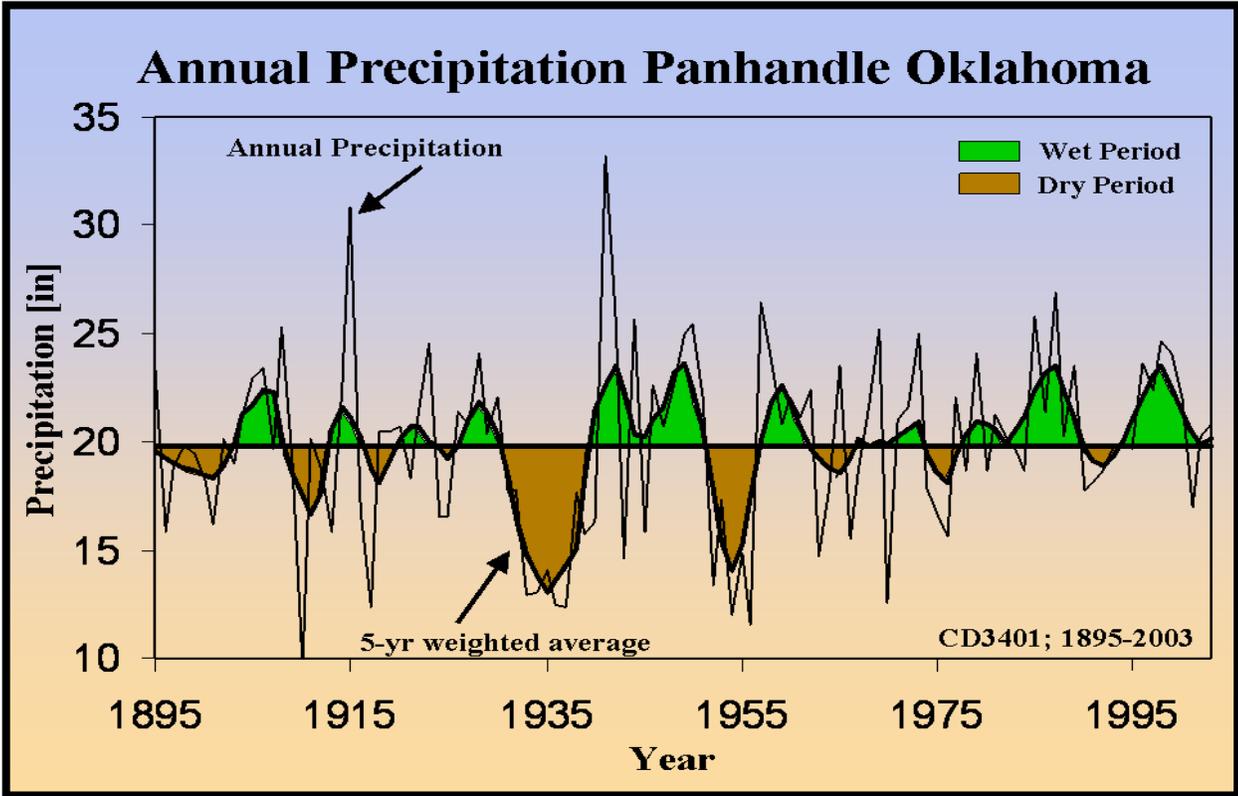
3405: Central

3406: East Central

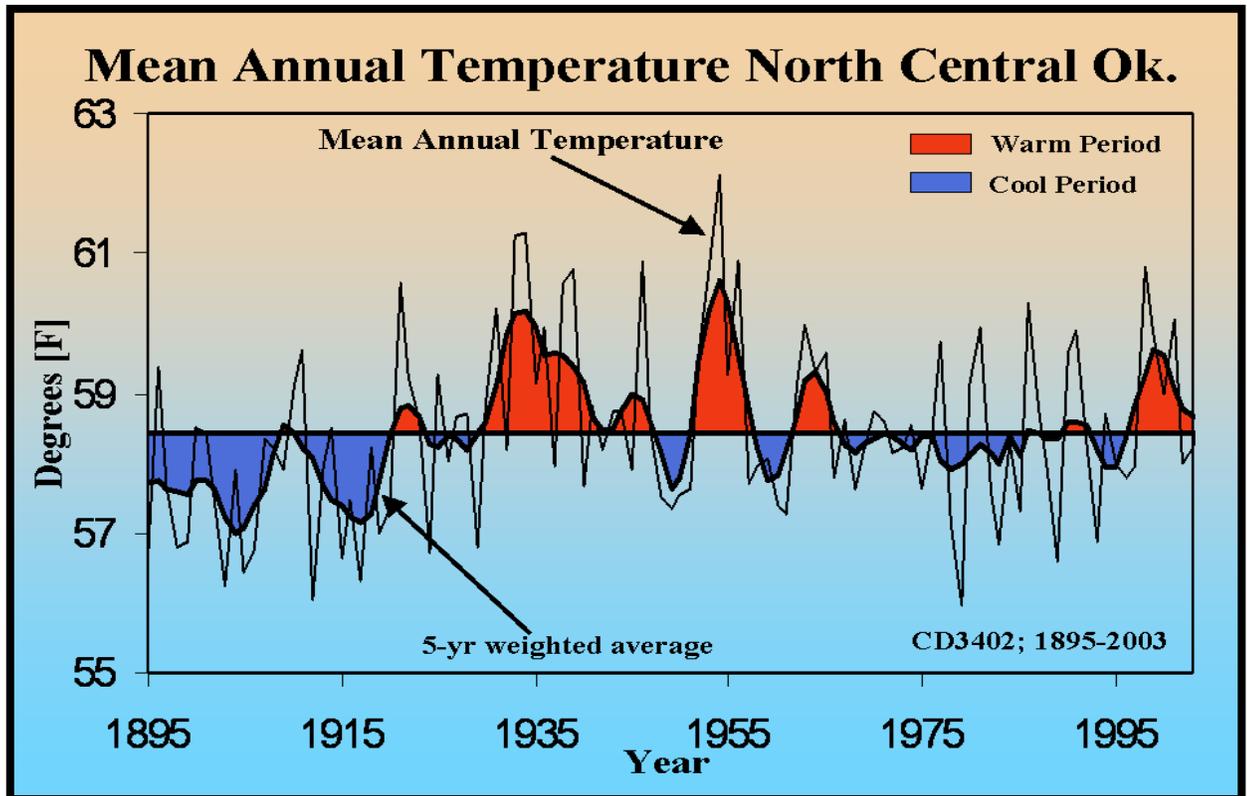
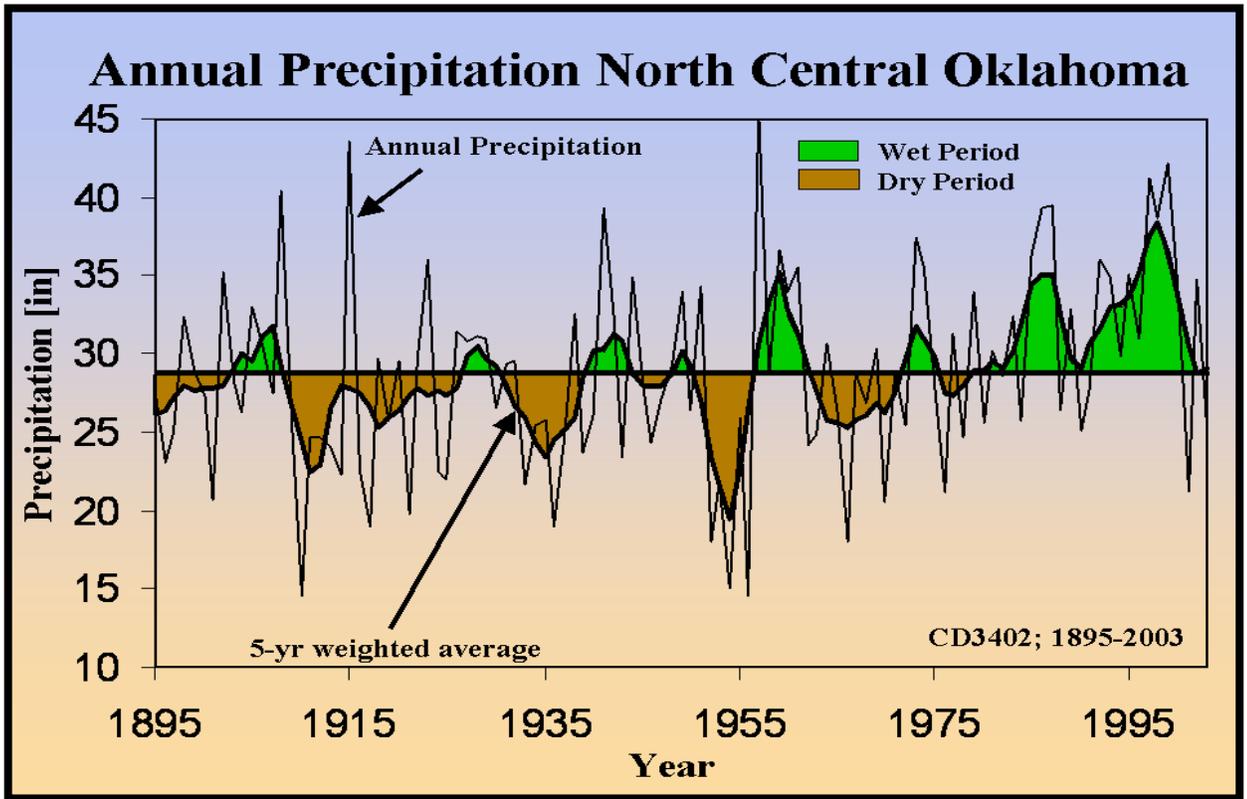
3407: Southwest

3408: South Central

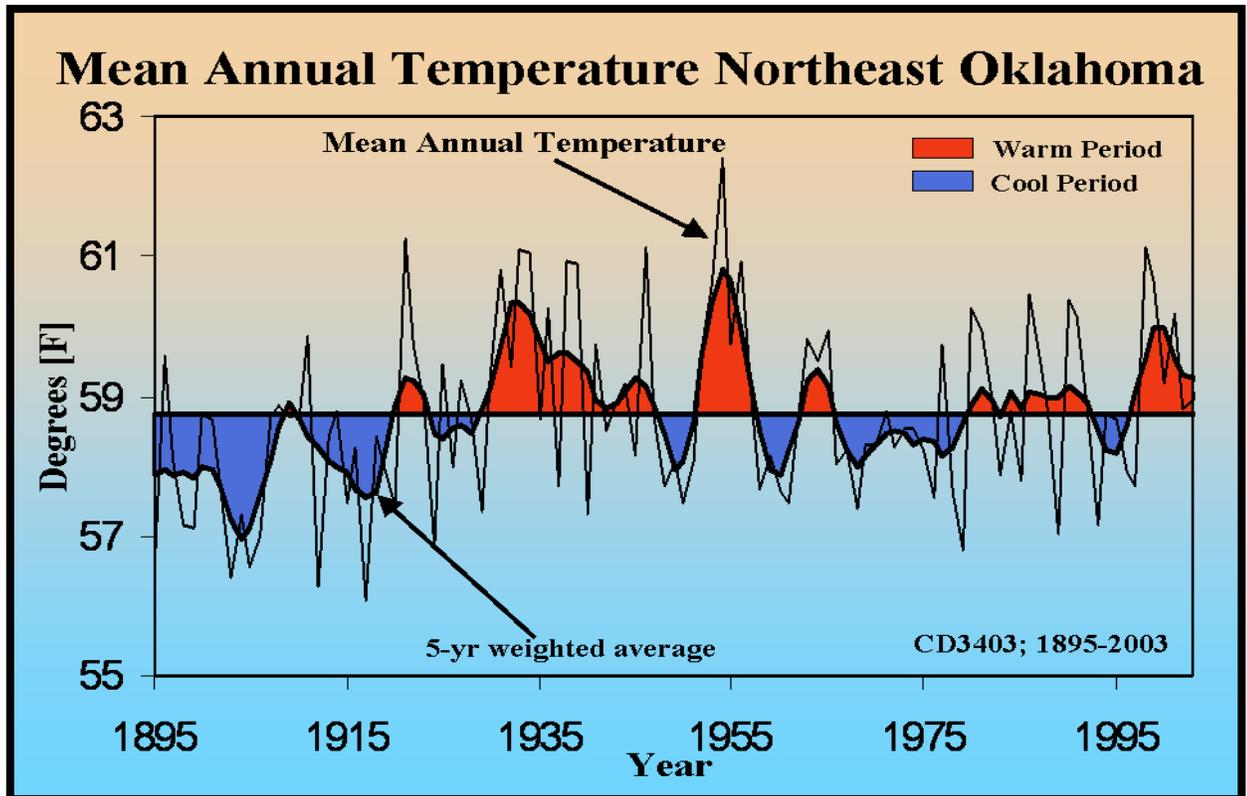
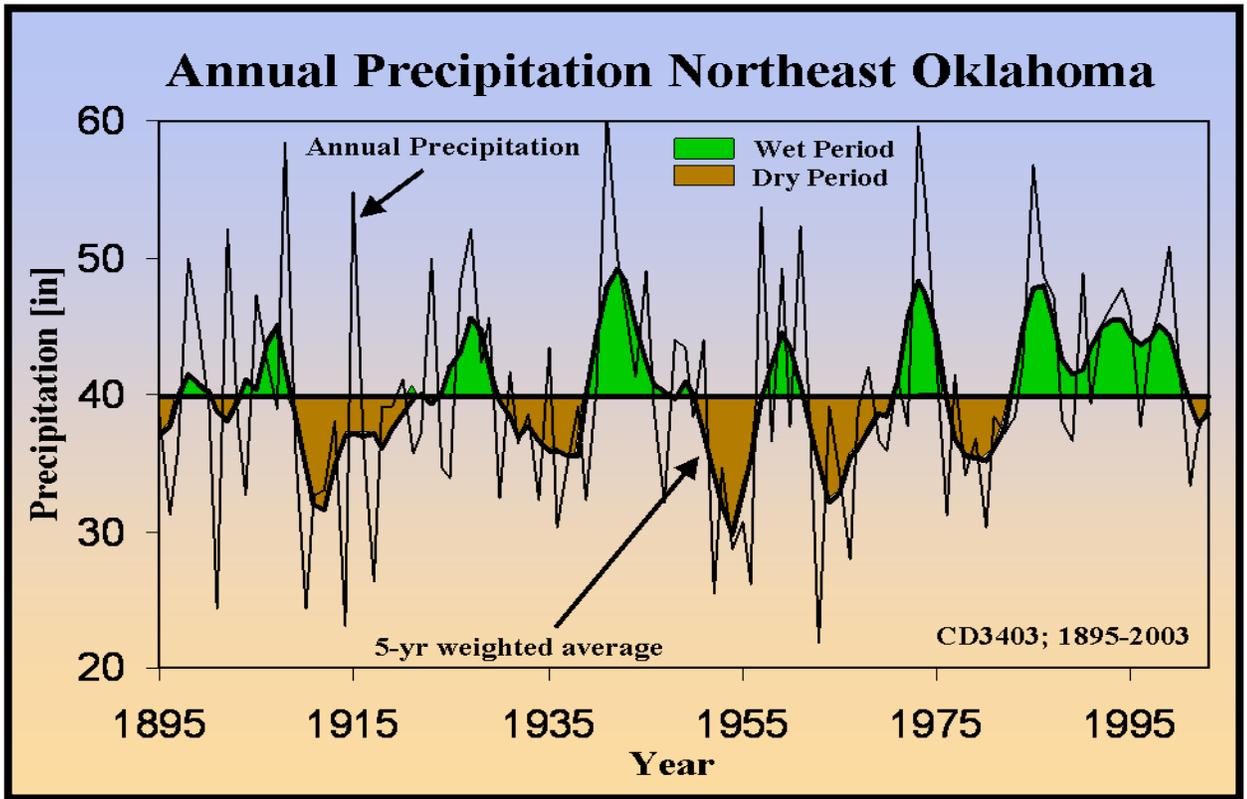
3409: Southeast



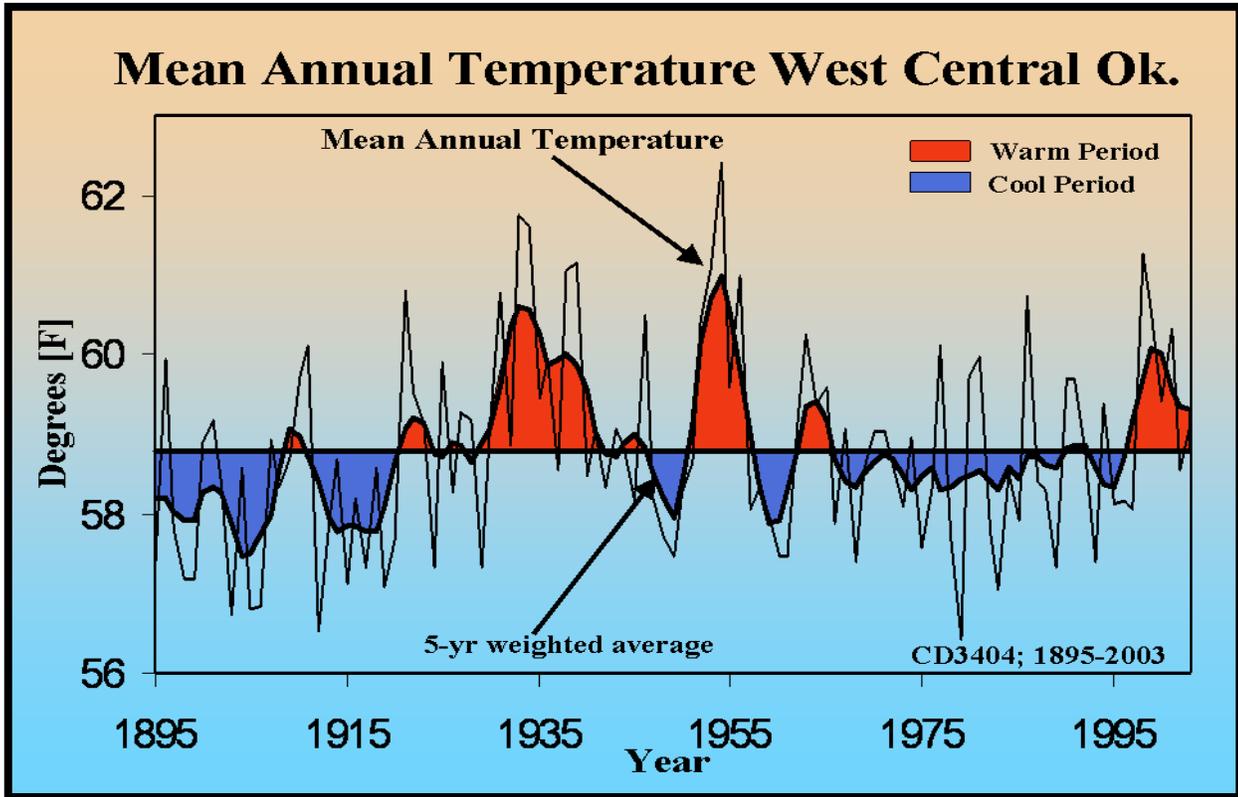
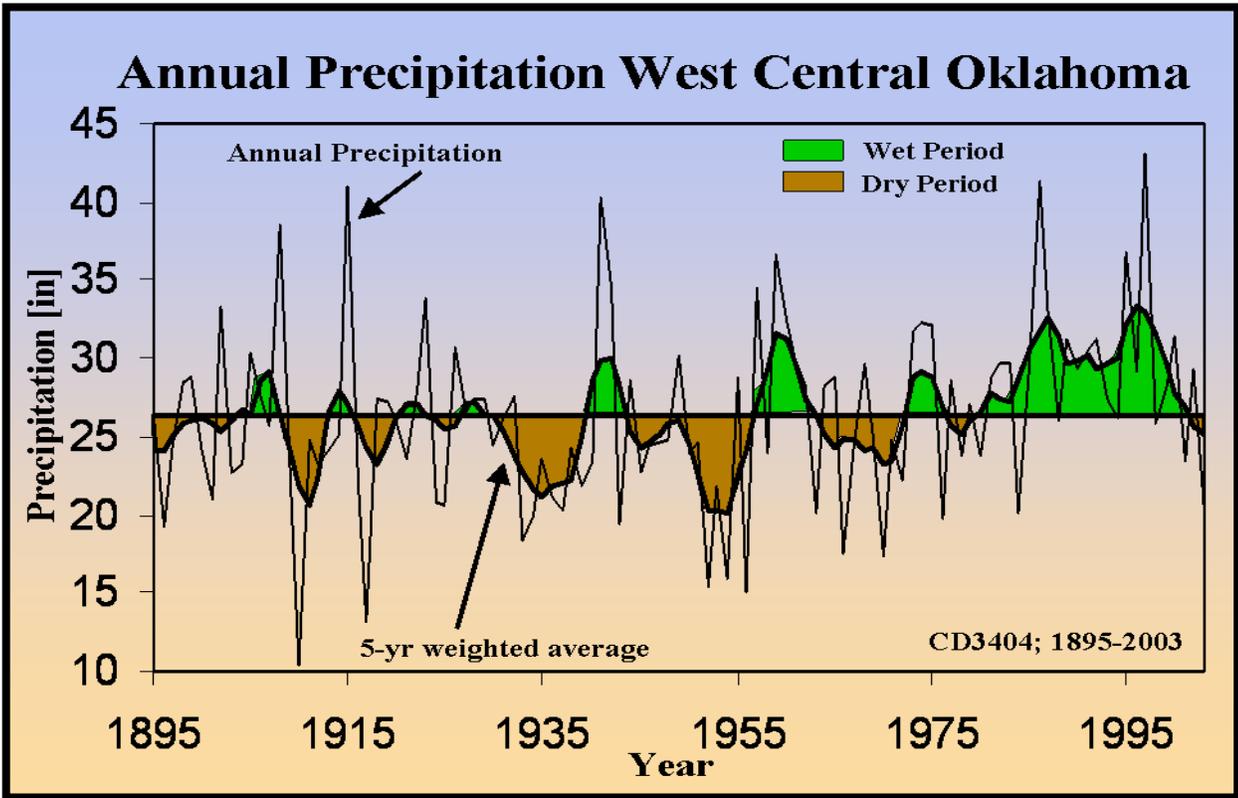
Annual precipitation (top) and mean air temperature (bottom)  
Panhandle Oklahoma, Climate Division 3401



Annual precipitation (top) and mean air temperature (bottom)  
North Central Oklahoma, Climate Division 3402

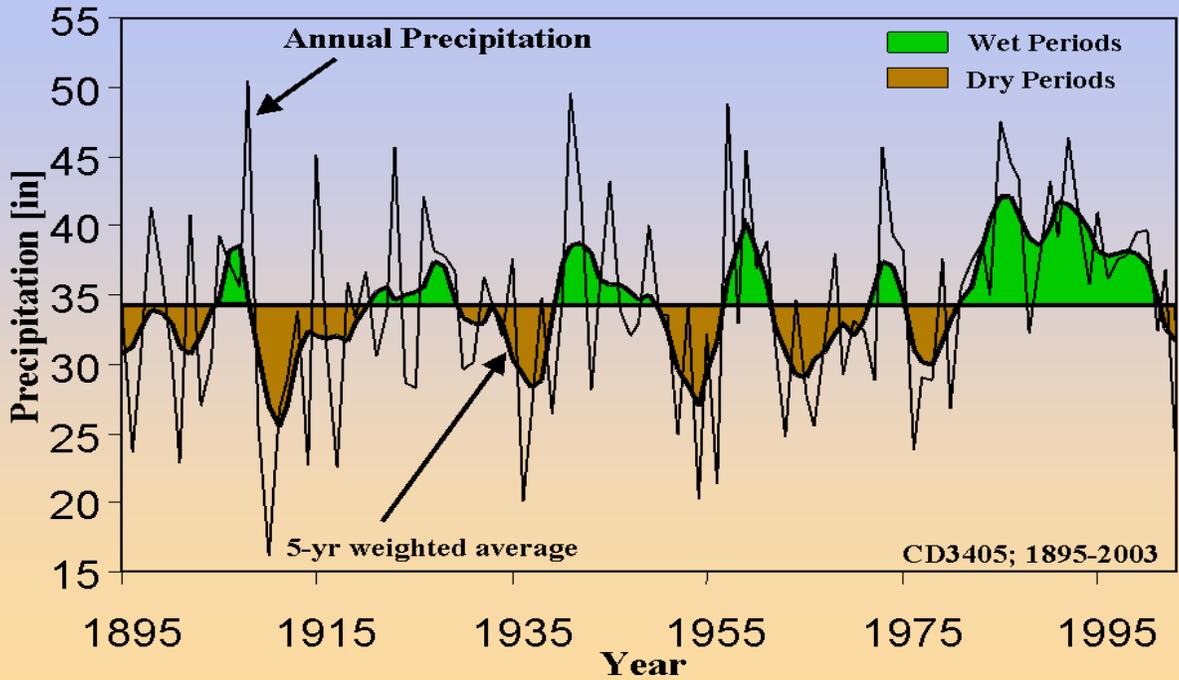


Annual precipitation (top) and mean air temperature (bottom)  
 Northeast Oklahoma, Climate Division 3403

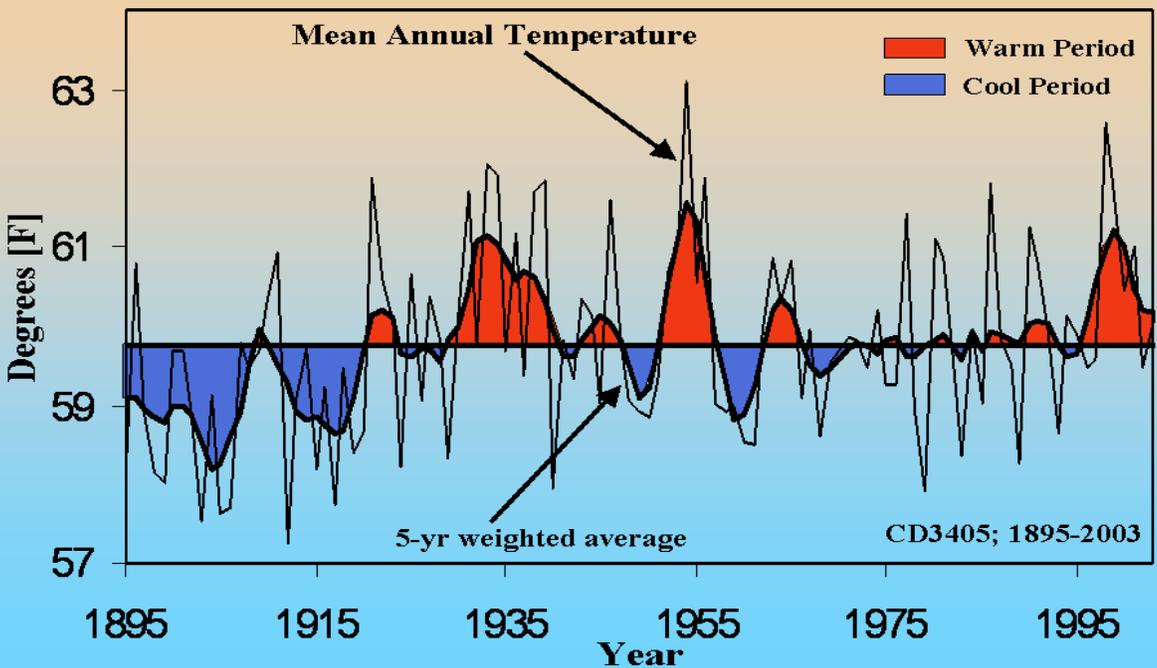


Annual precipitation (top) and mean air temperature (bottom)  
West Central Oklahoma, Climate Division 3404

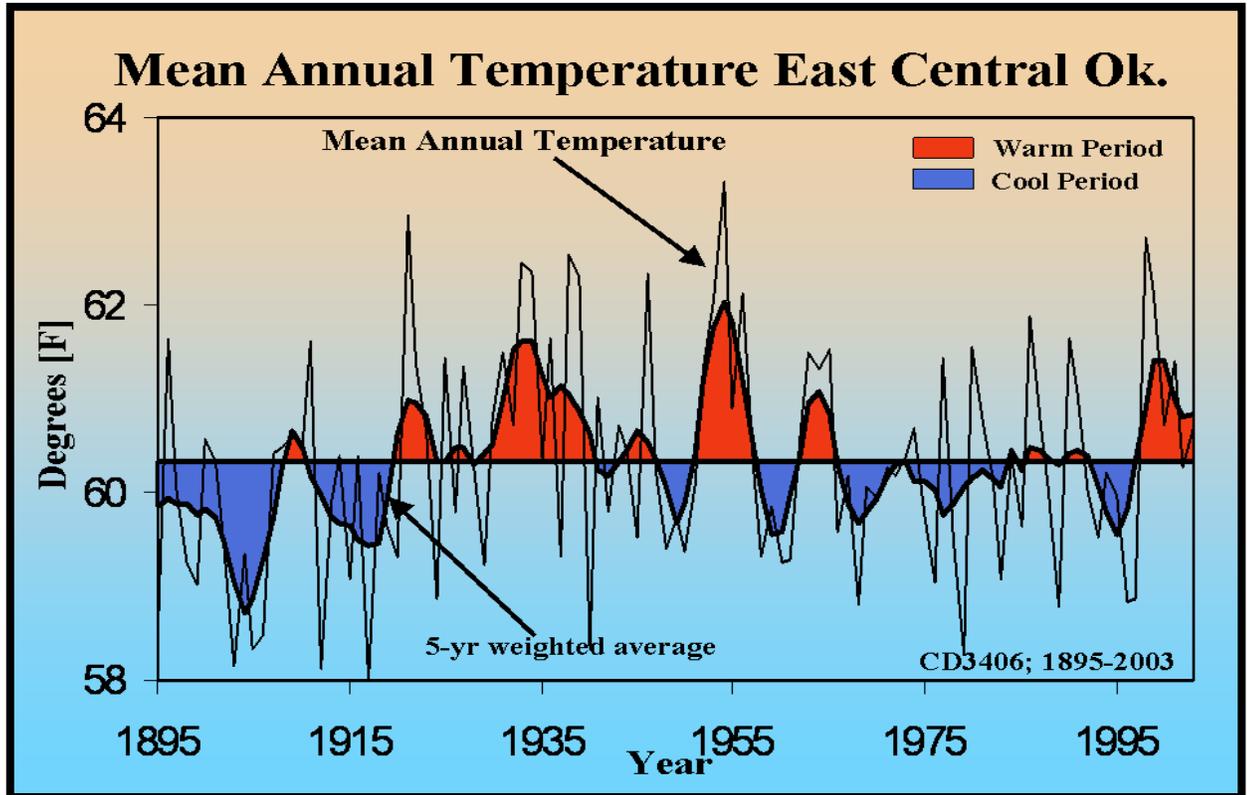
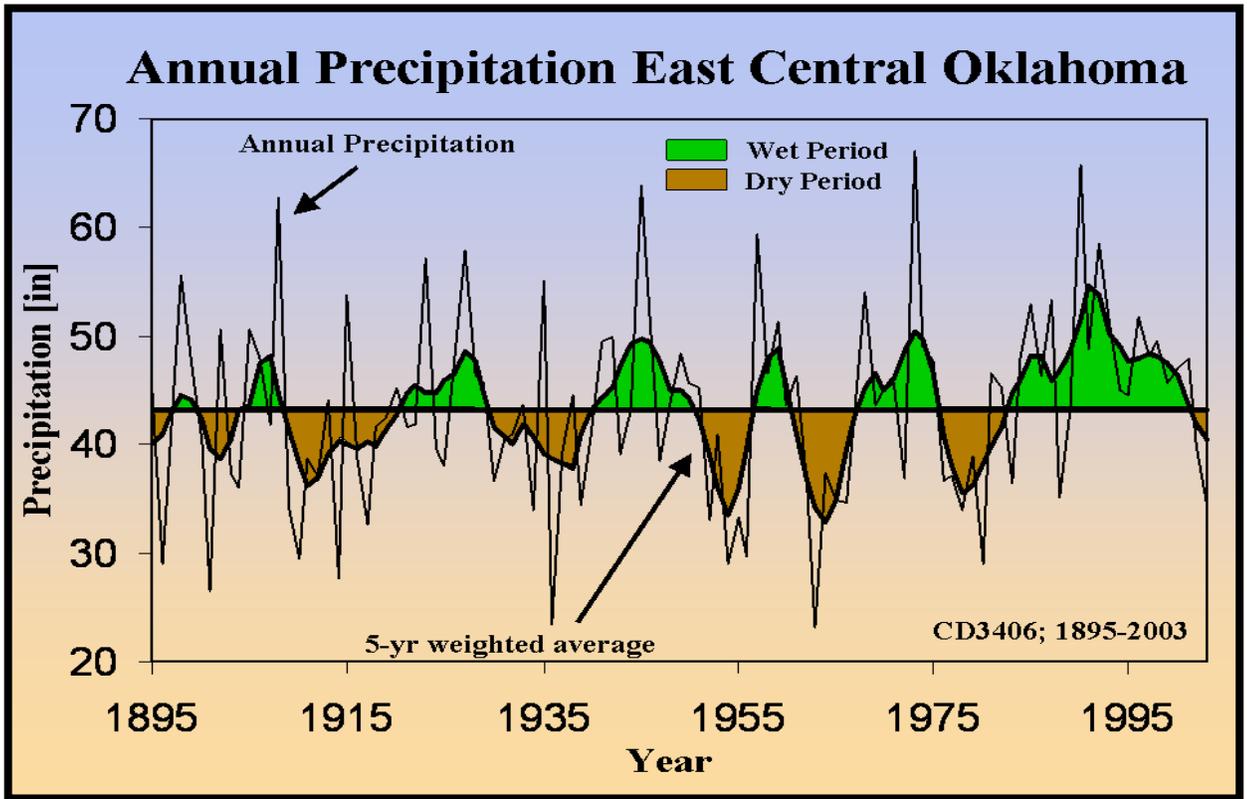
# Annual Precipitation in Central Oklahoma



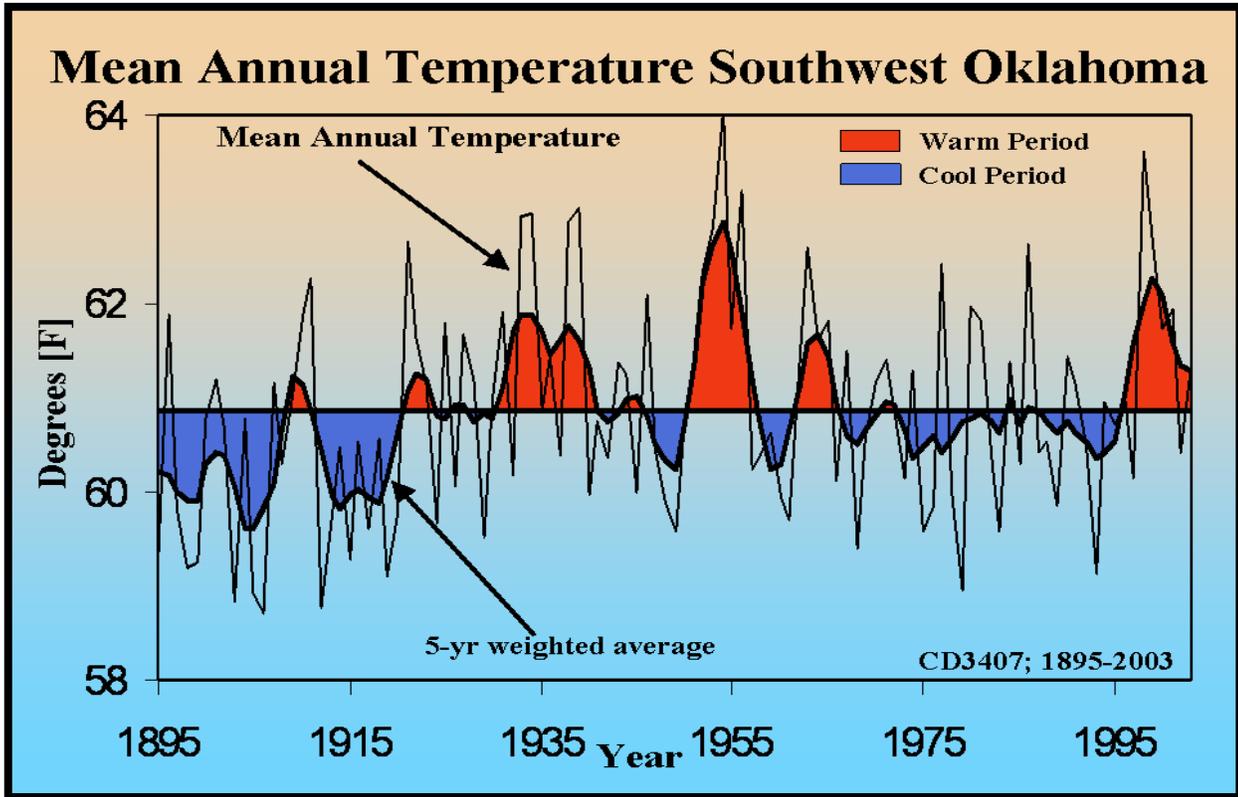
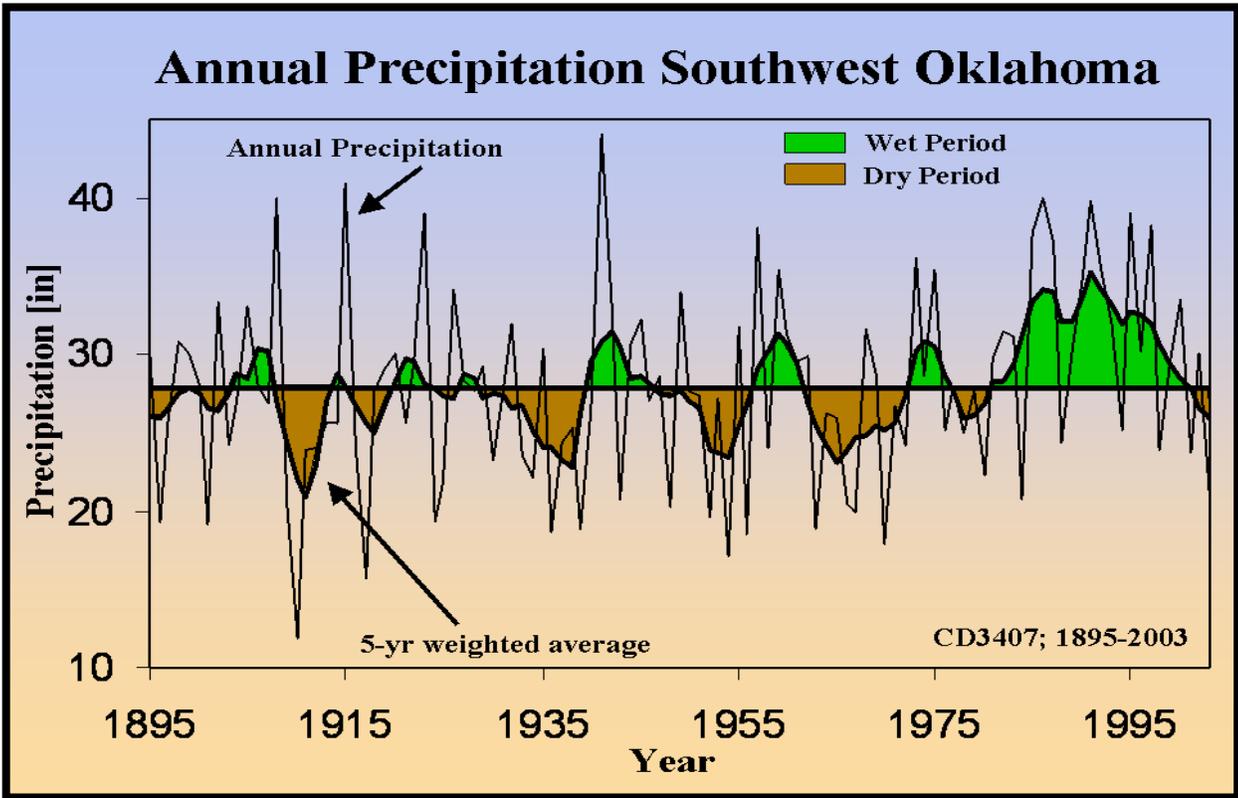
# Mean Annual Temperature Central Oklahoma



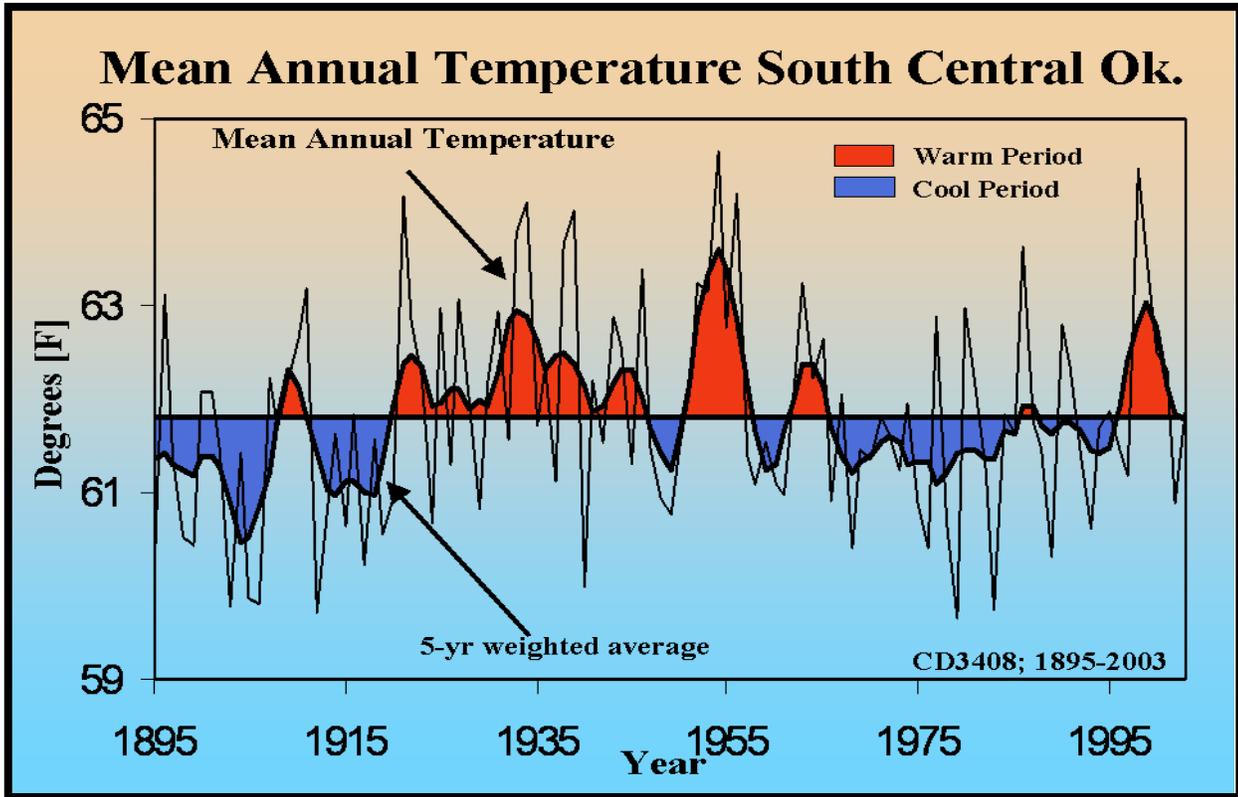
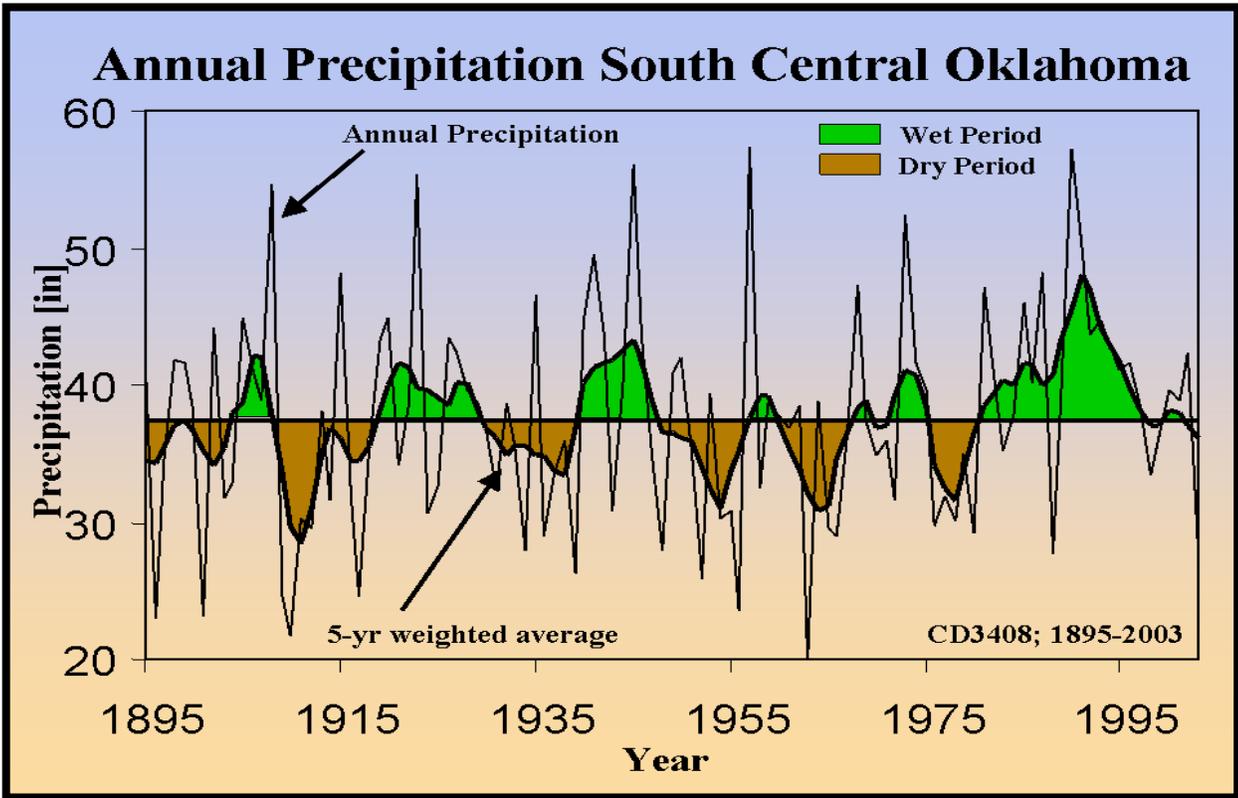
Annual precipitation (top) and mean air temperature (bottom)  
Central Oklahoma, Climate Division 3405



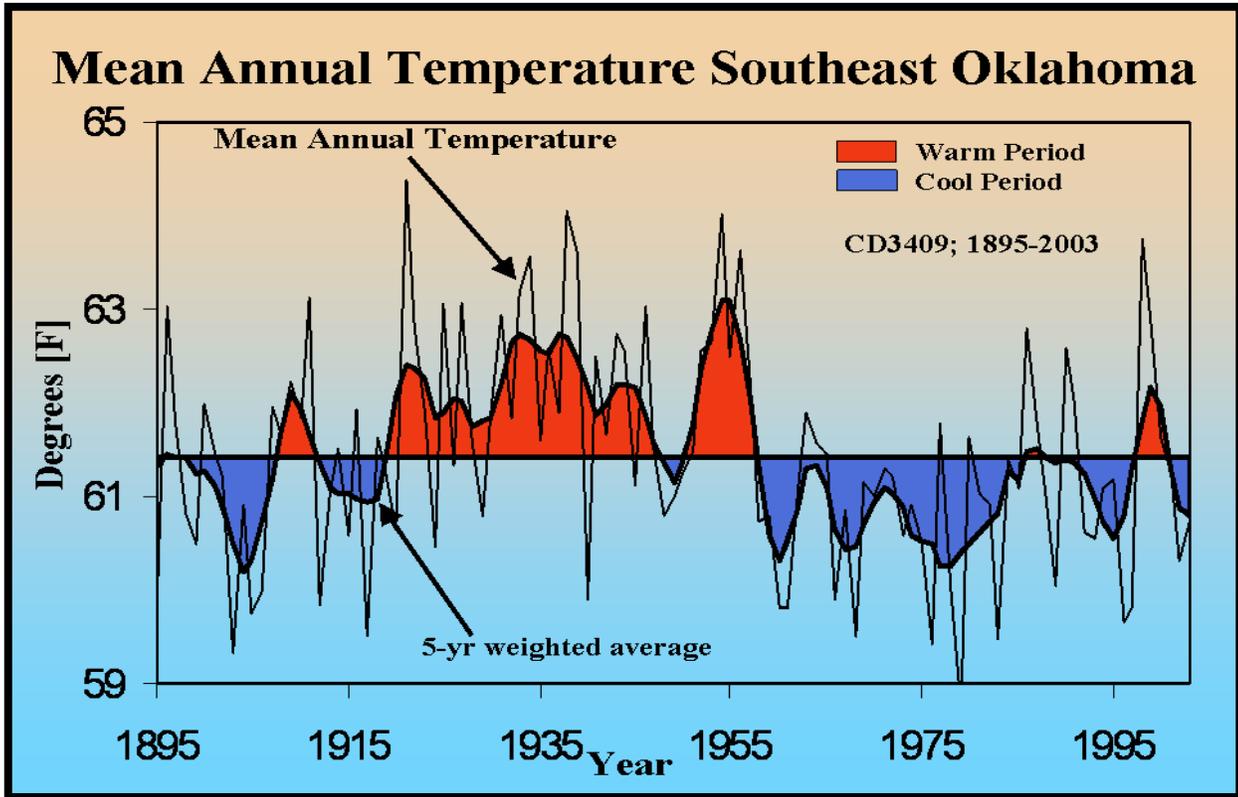
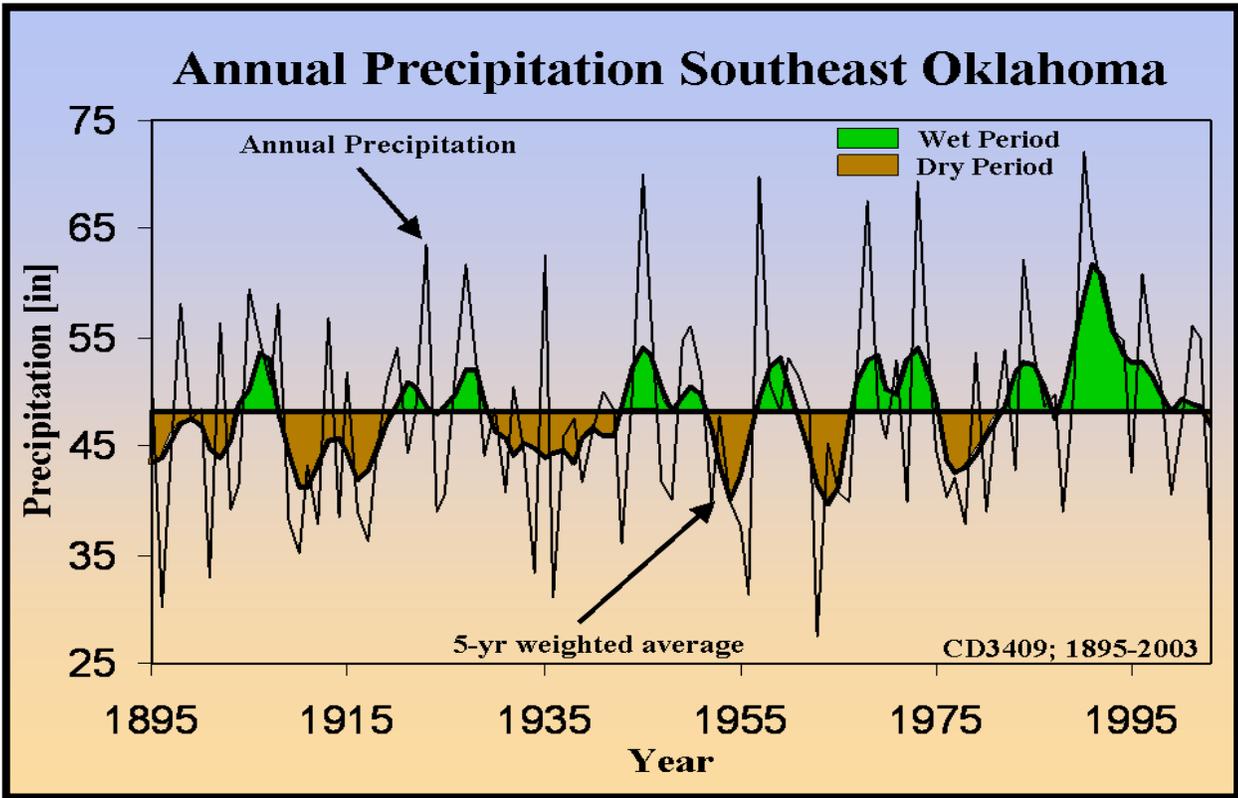
Annual precipitation (top) and mean air temperature (bottom)  
 East Central Oklahoma, Climate Division 3406



Annual precipitation (top) and mean air temperature (bottom)  
Southwest Oklahoma, Climate Division 3407

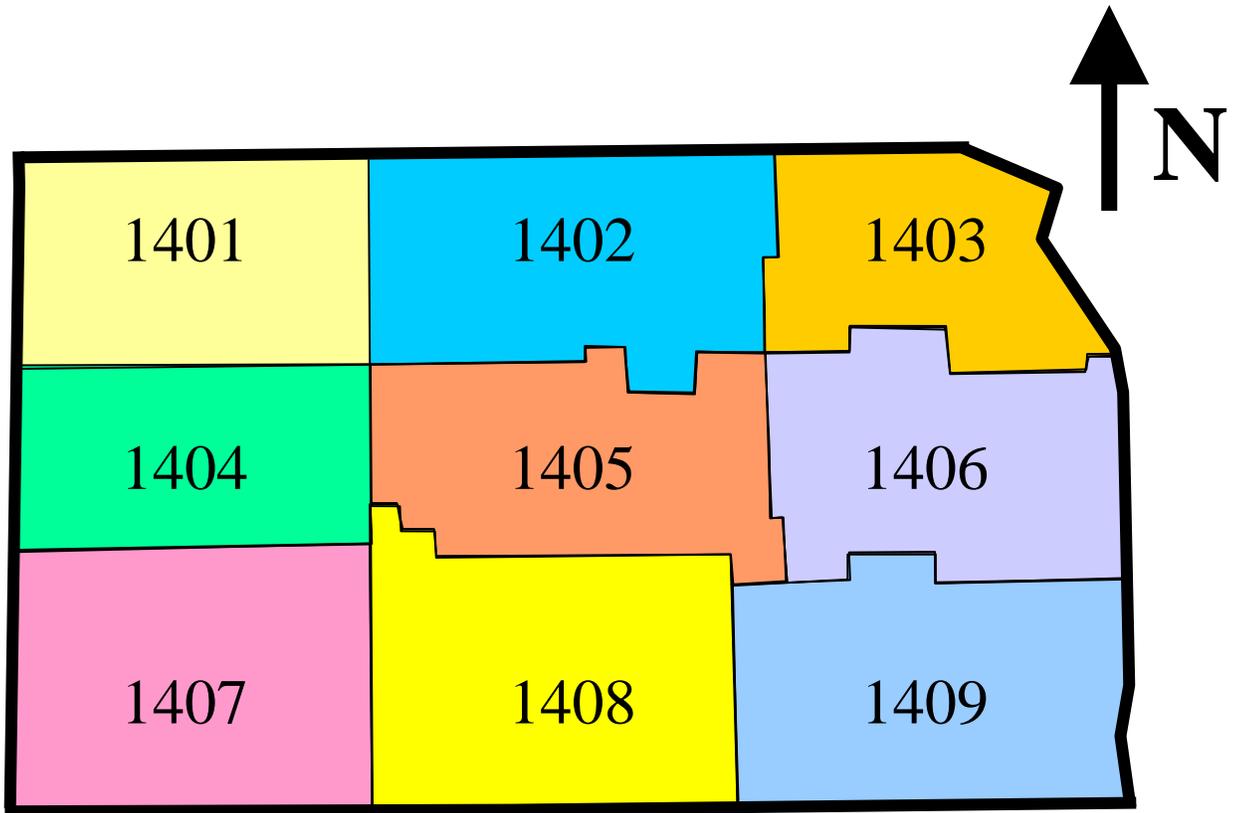


Annual precipitation (top) and mean air temperature (bottom)  
 South Central Oklahoma, Climate Division 3408



Annual precipitation (top) and mean air temperature (bottom)  
 Southeast Oklahoma, Climate Division 3409

# Climate Divisions of Kansas



3401: Northwest

3406: East Central

3402: North Central

3407: Southwest

3403: Northeast

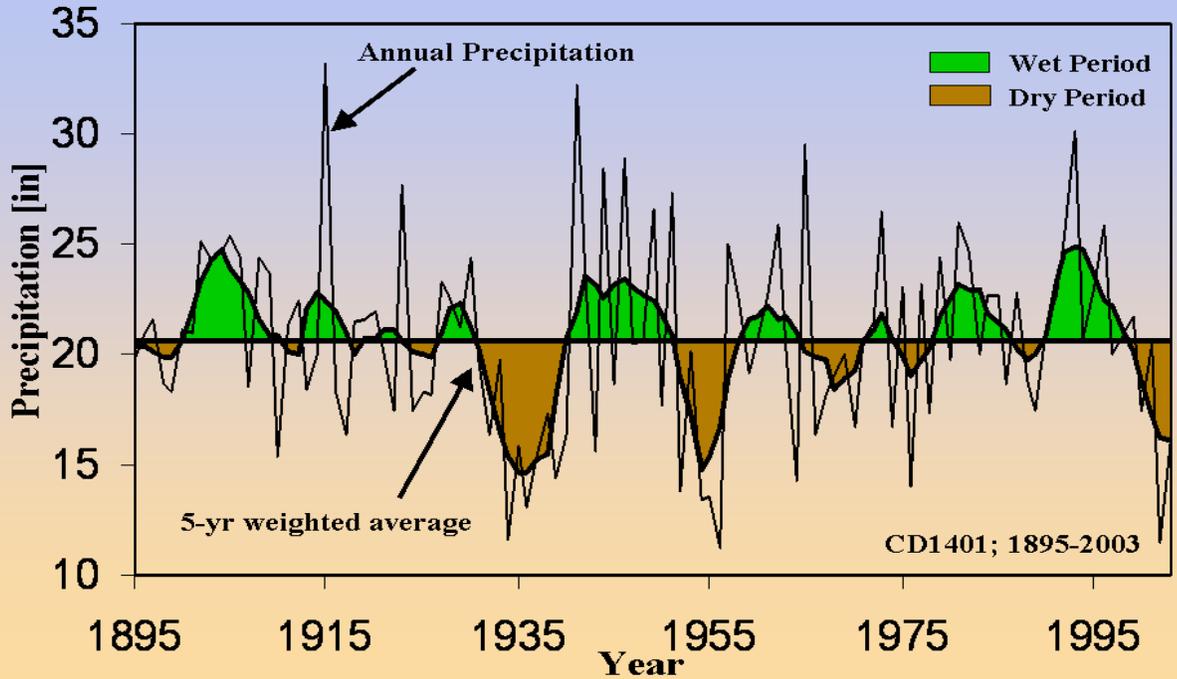
3408: South Central

3404: West Central

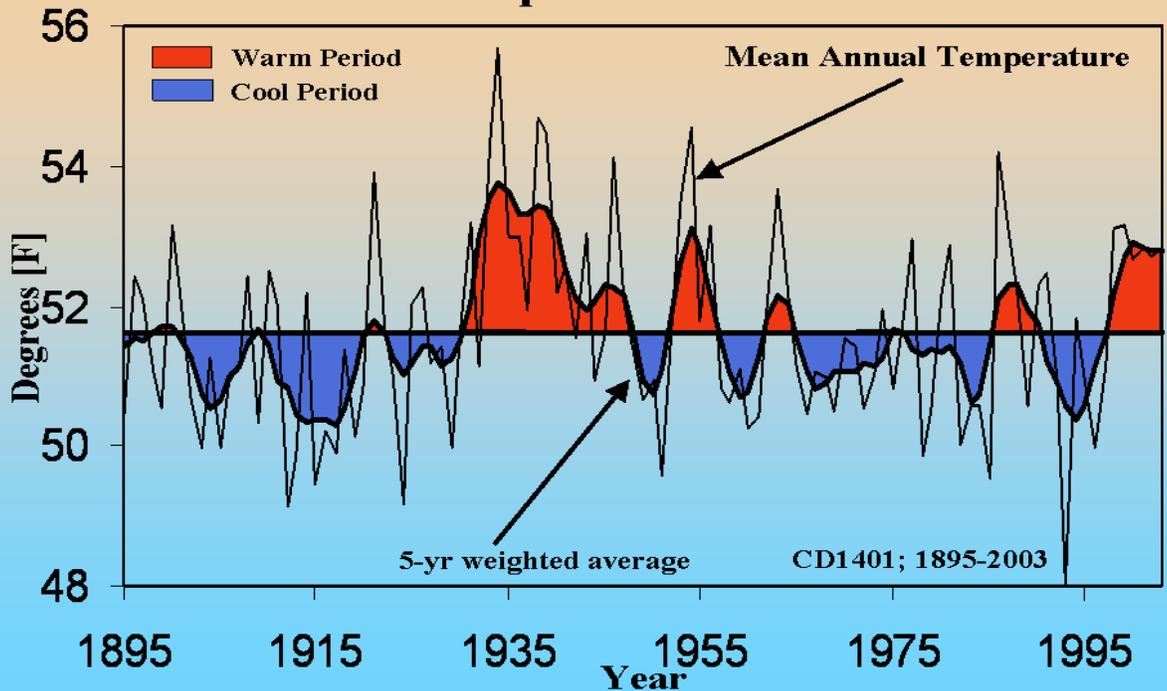
3409: Southeast

3405: Central

## Annual Precipitation Northwest Kansas

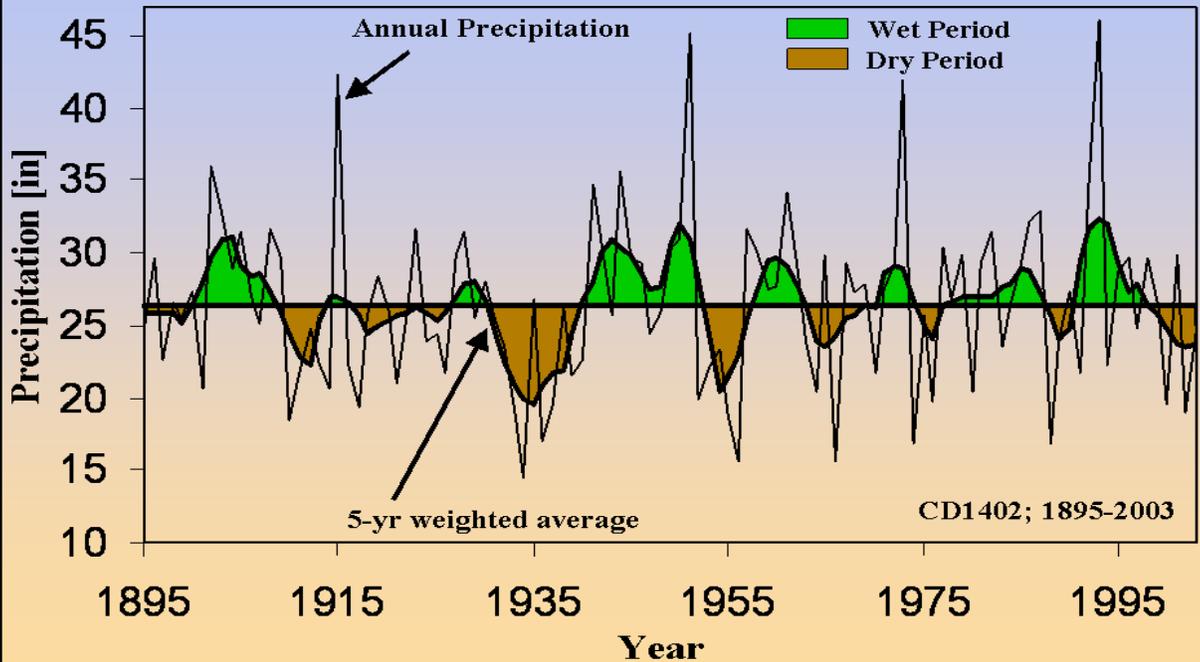


## Mean Annual Temperature Northwest Kansas

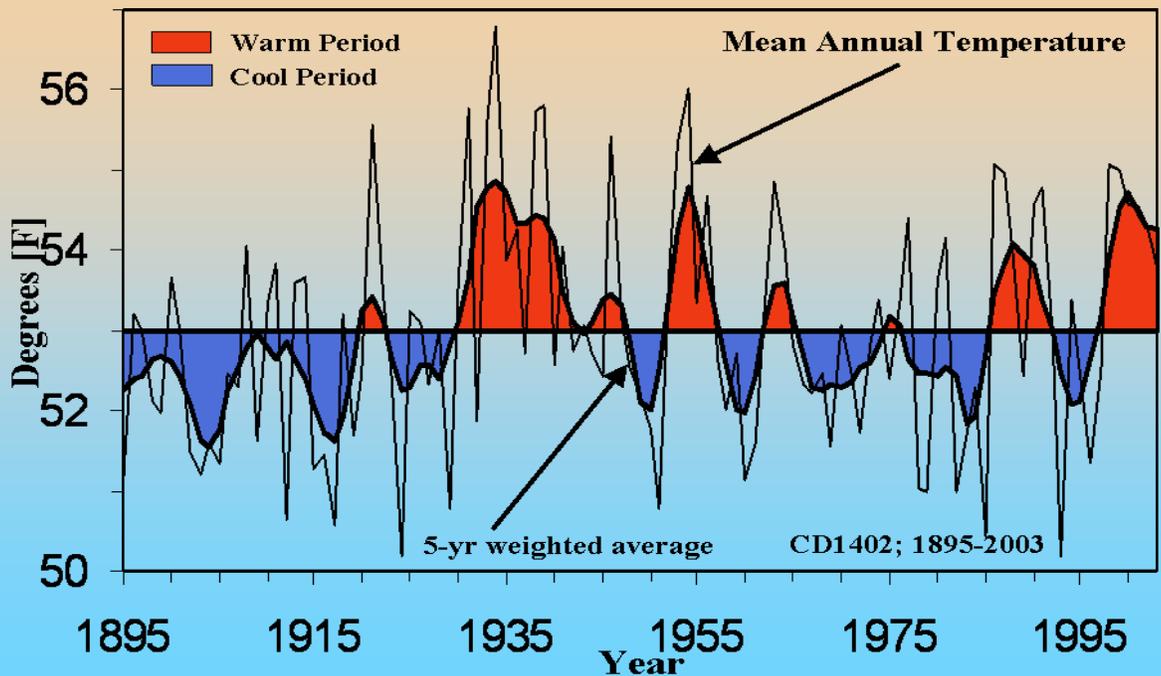


Annual precipitation (top) and mean air temperature (bottom)  
Northwest Kansas, Climate Division 1401

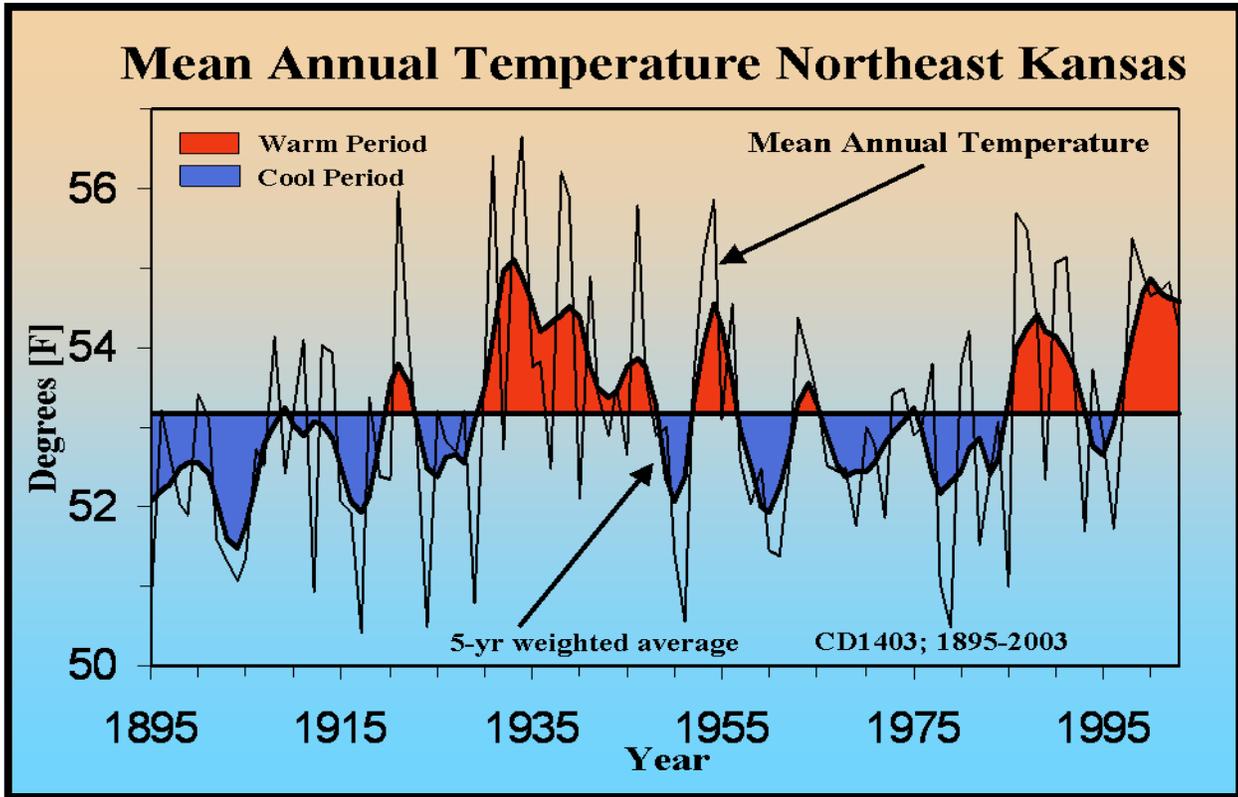
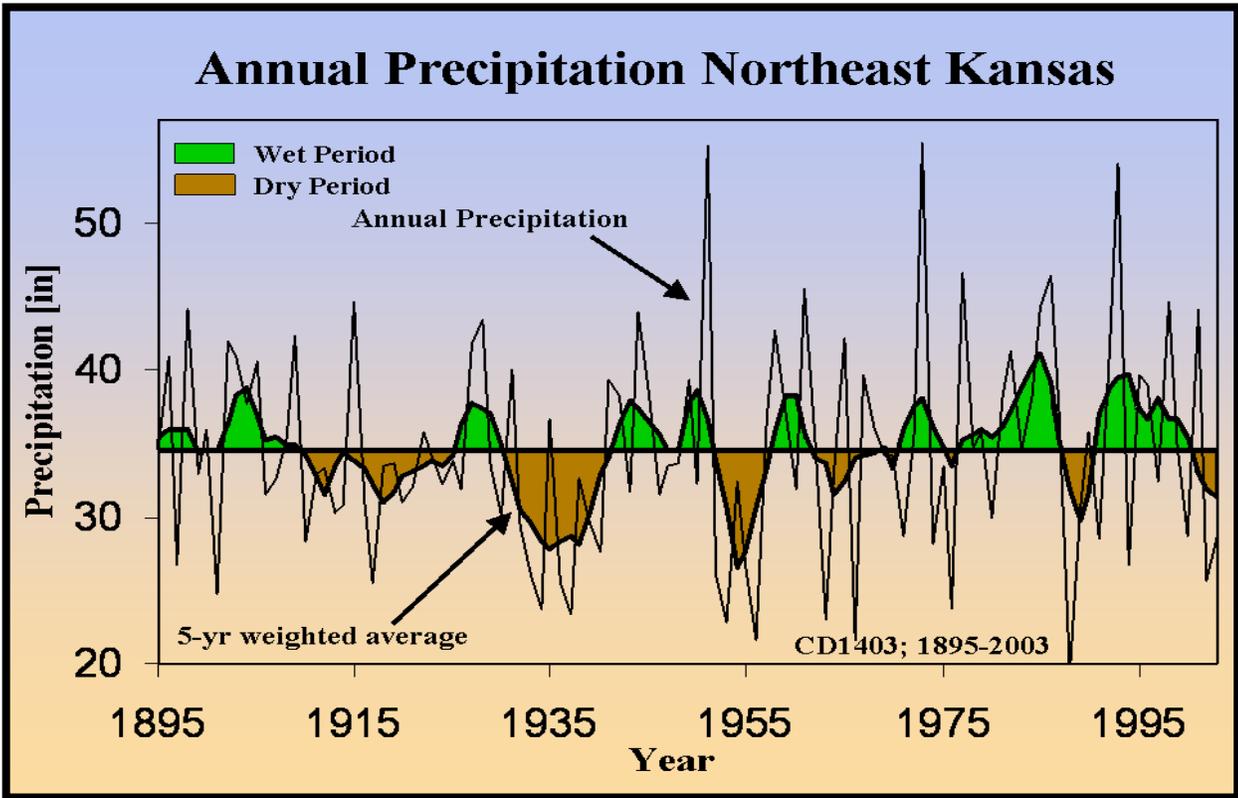
## Annual Precipitation North Central Kansas



## Mean Annual Temperature North Central Kansas

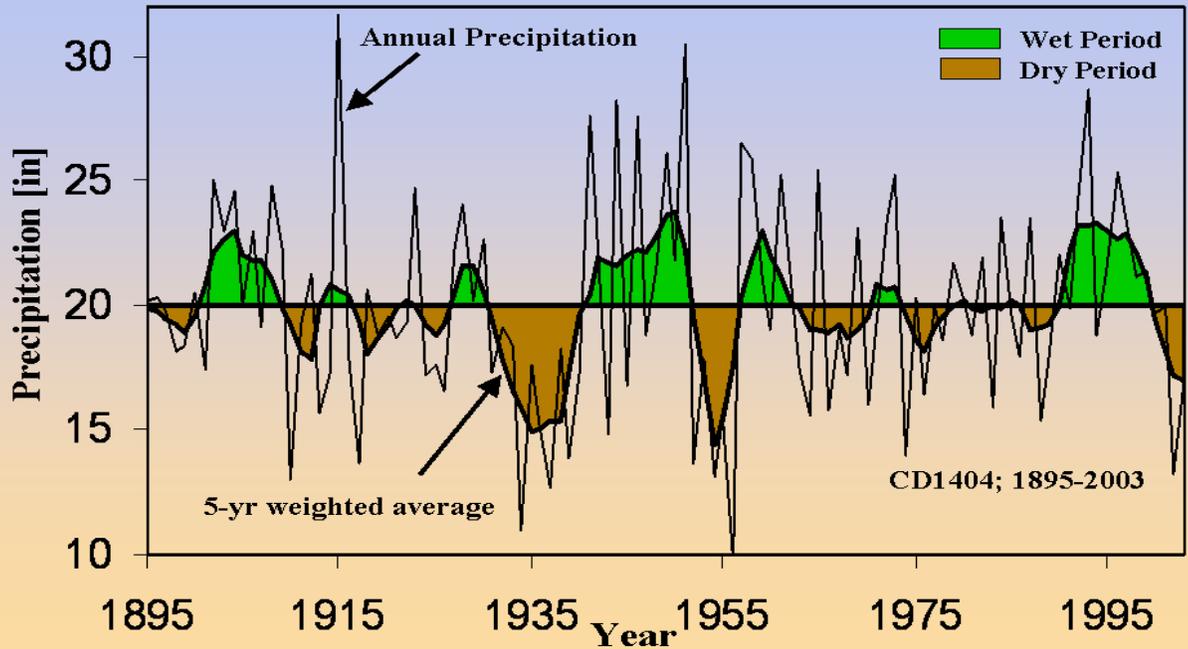


Annual precipitation (top) and mean air temperature (bottom)  
North Central Kansas, Climate Division 1402

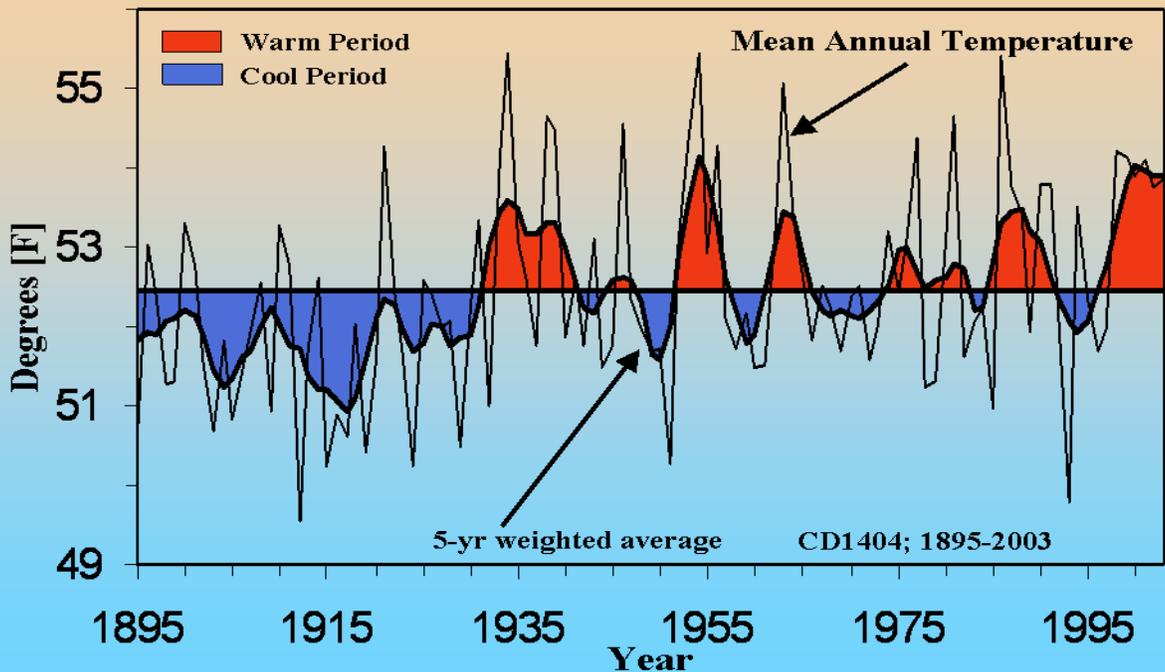


Annual precipitation (top) and mean air temperature (bottom)  
 Northeast Kansas, Climate Division 1403

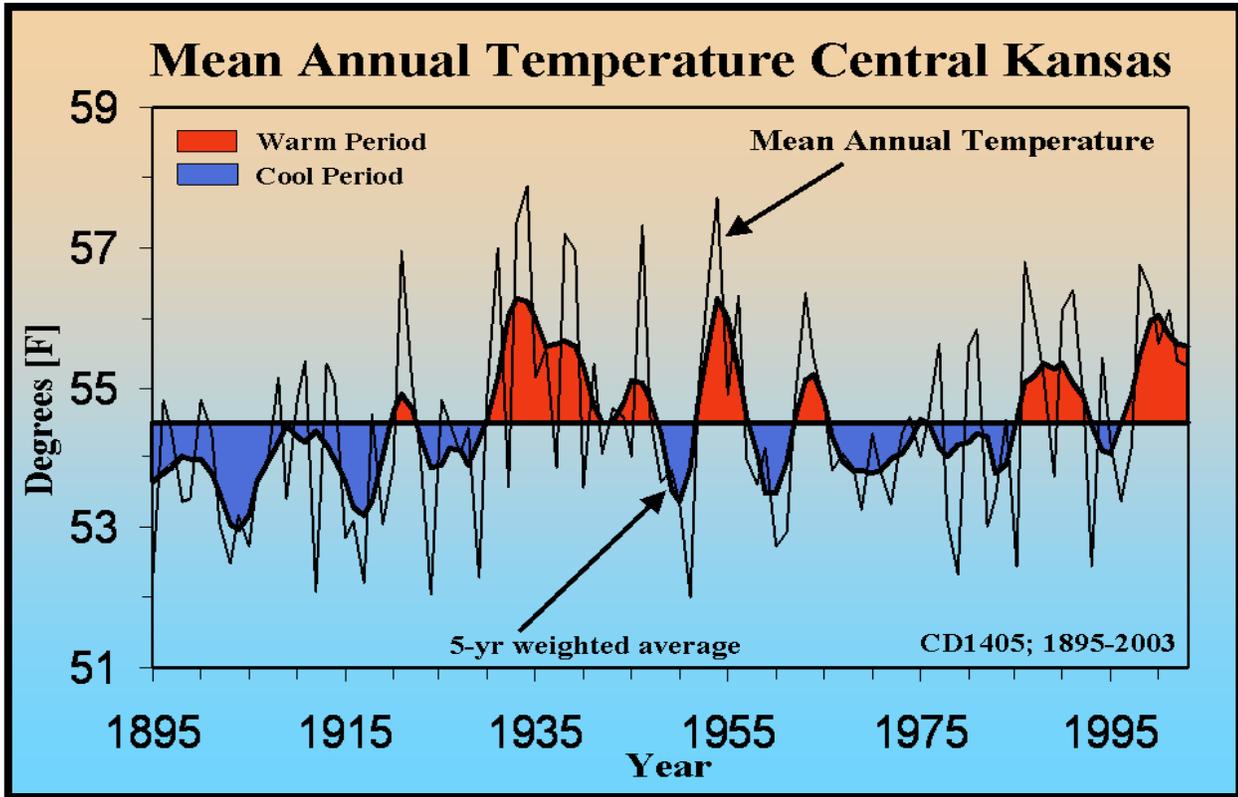
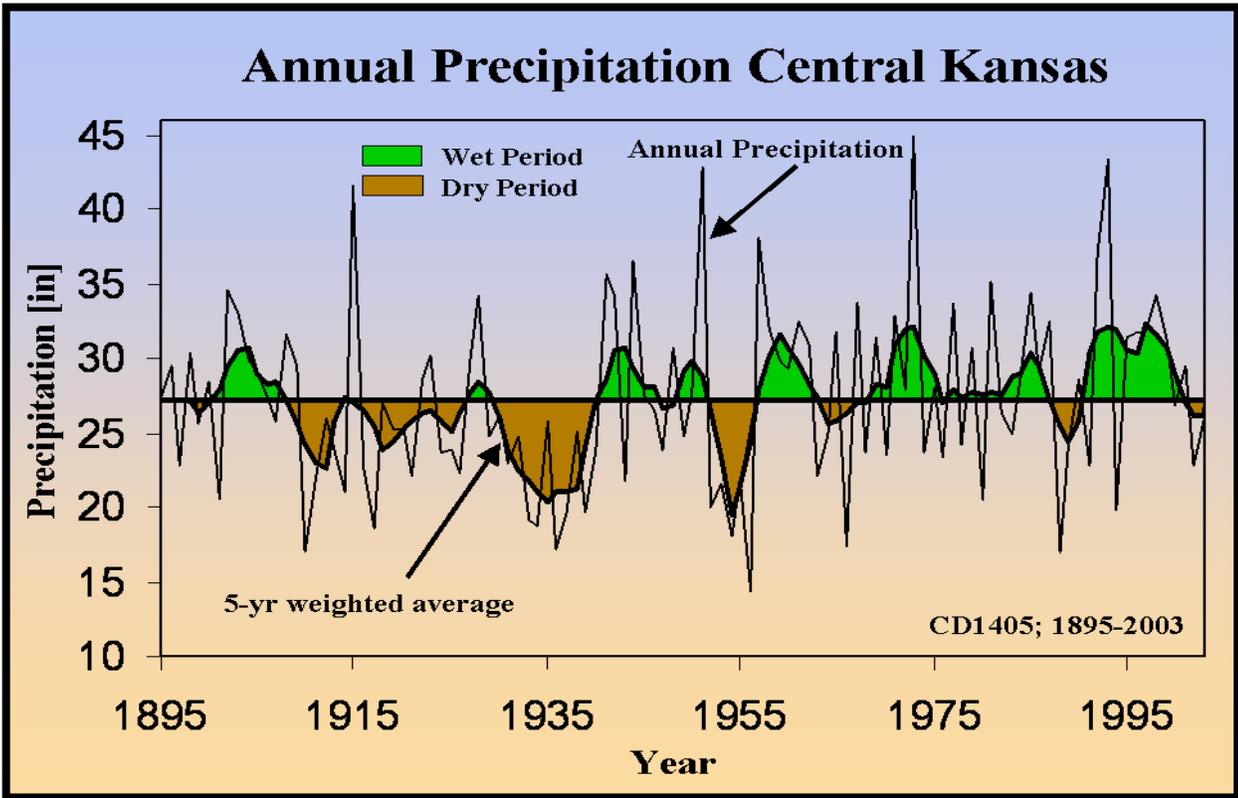
## Annual Precipitation West Central Kansas



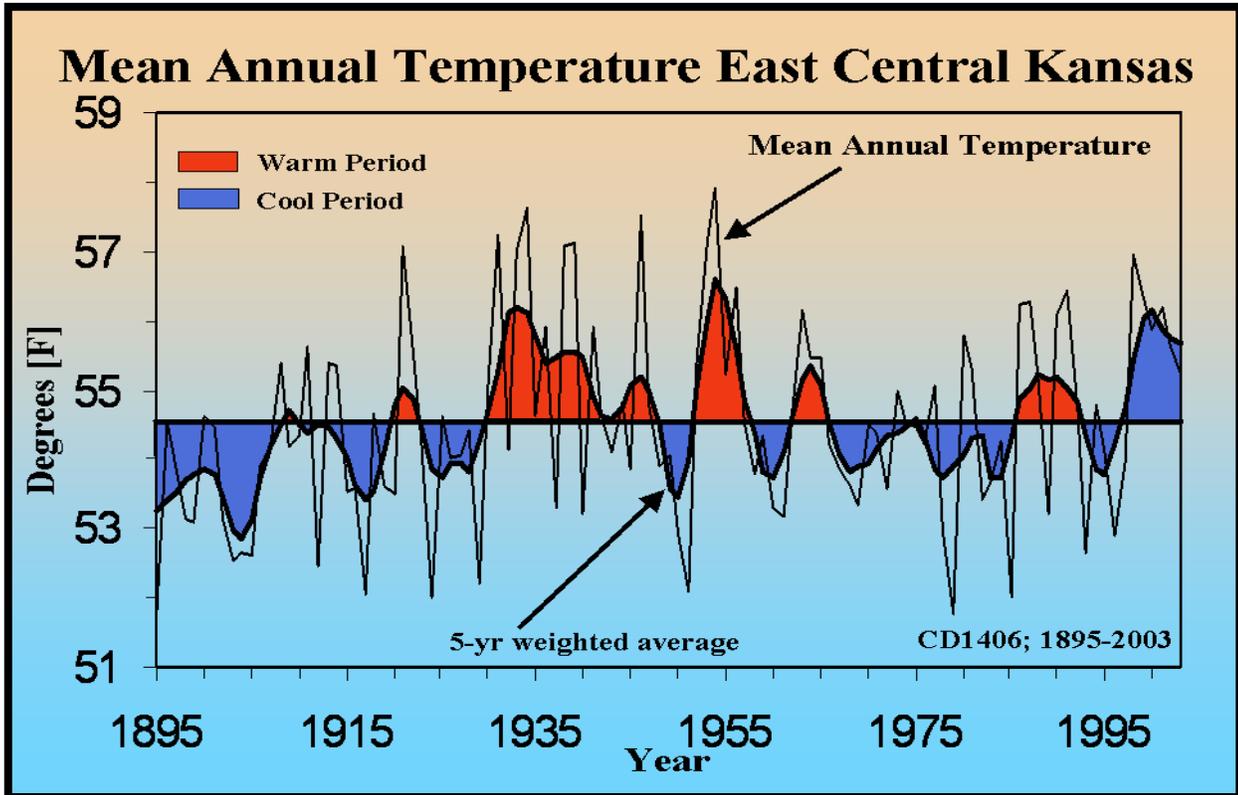
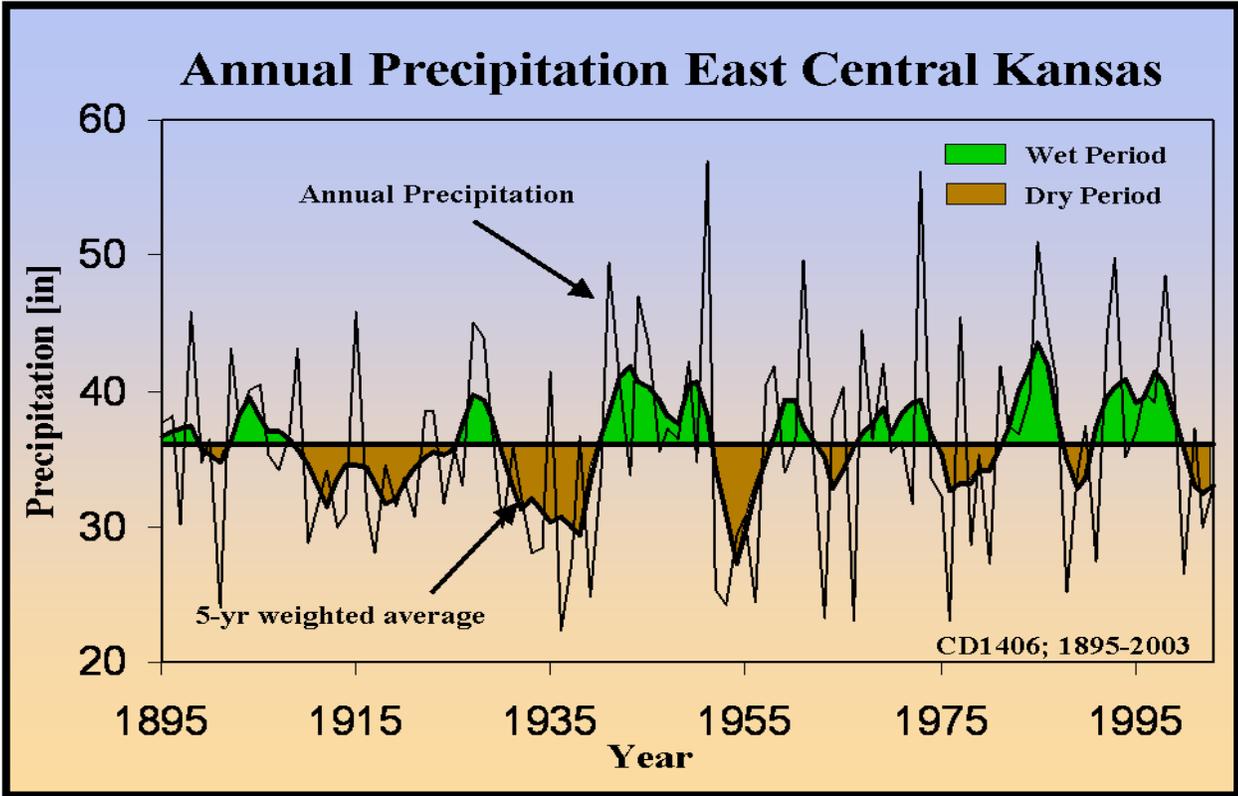
## Mean Annual Temperature West Central Kansas



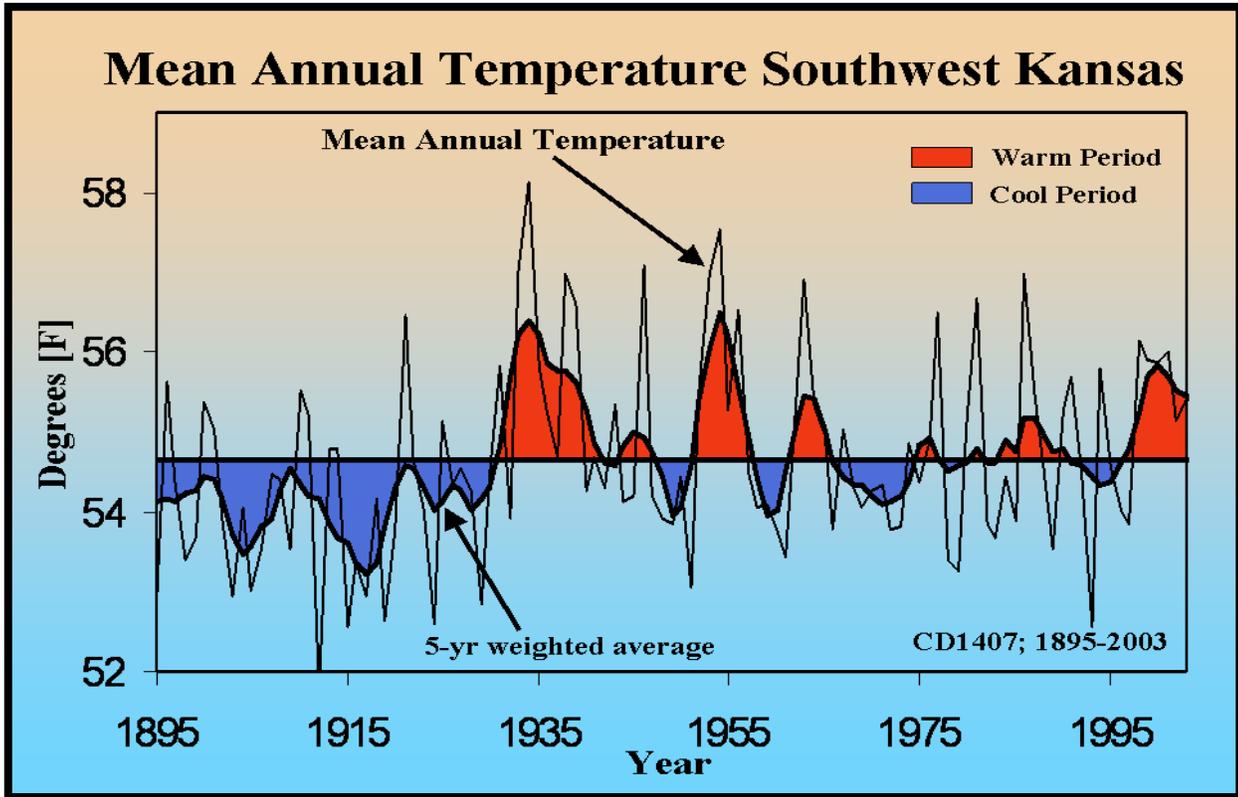
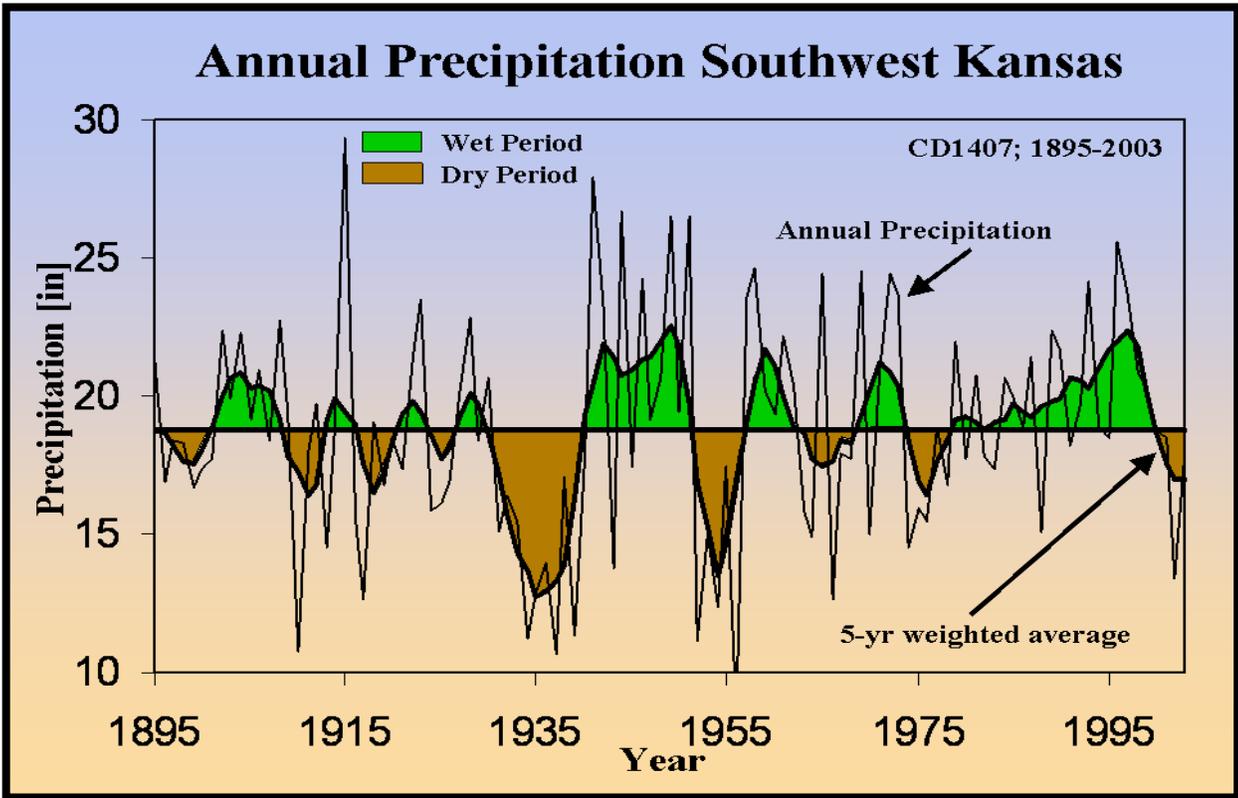
Annual precipitation (top) and mean air temperature (bottom)  
West Central Kansas, Climate Division 1404



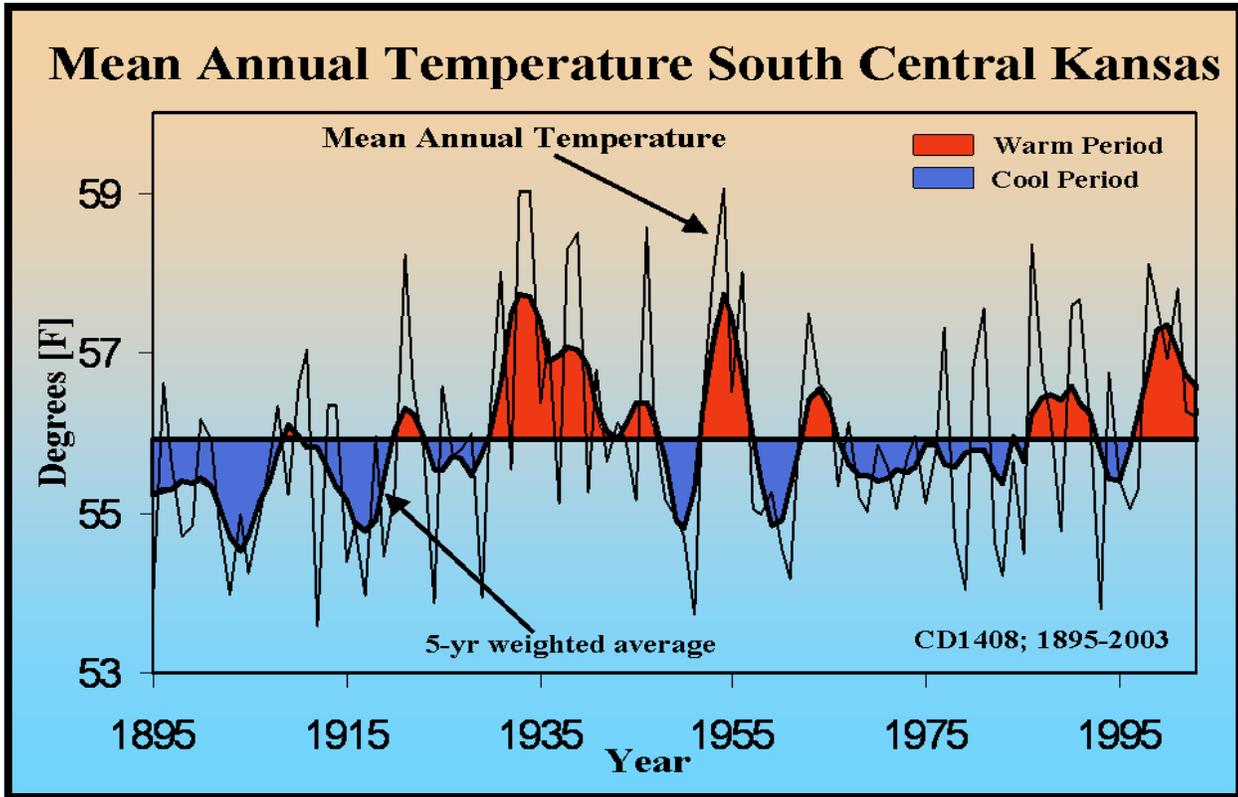
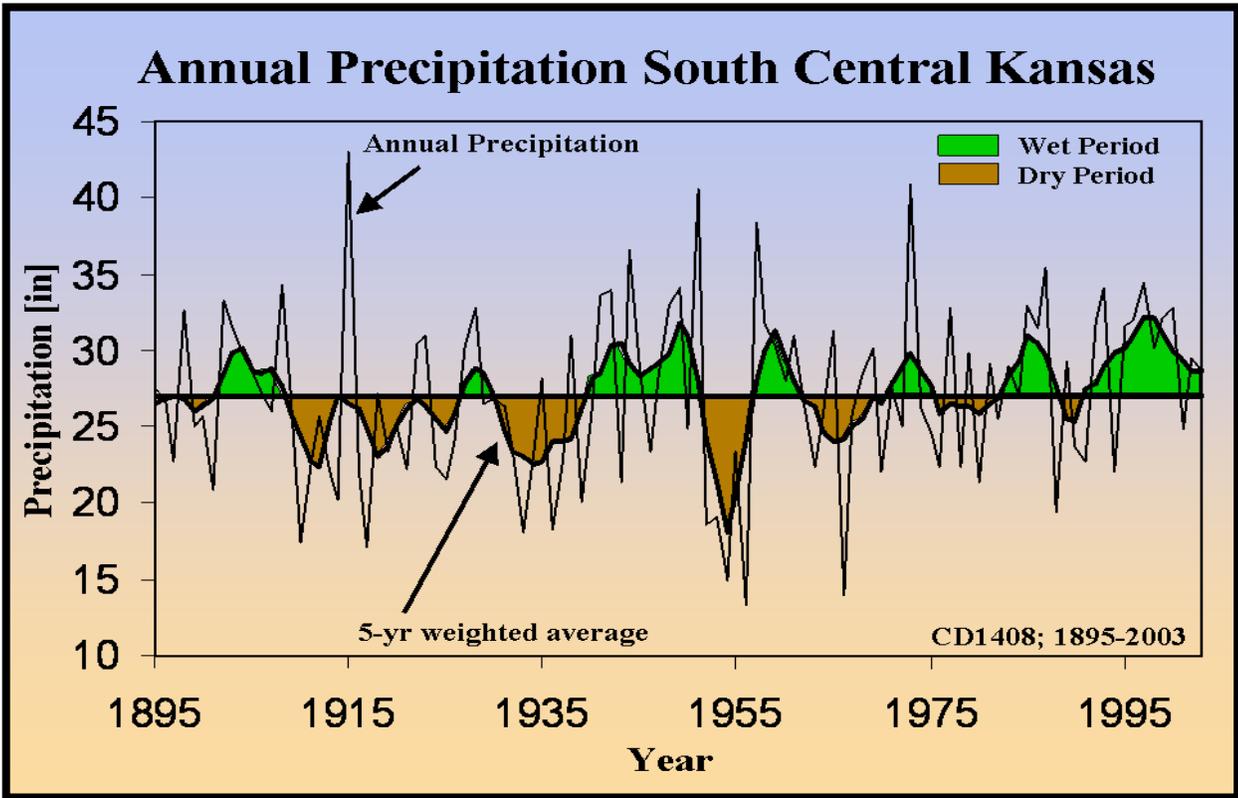
Annual precipitation (top) and mean air temperature (bottom)  
 Central Kansas, Climate Division 1405



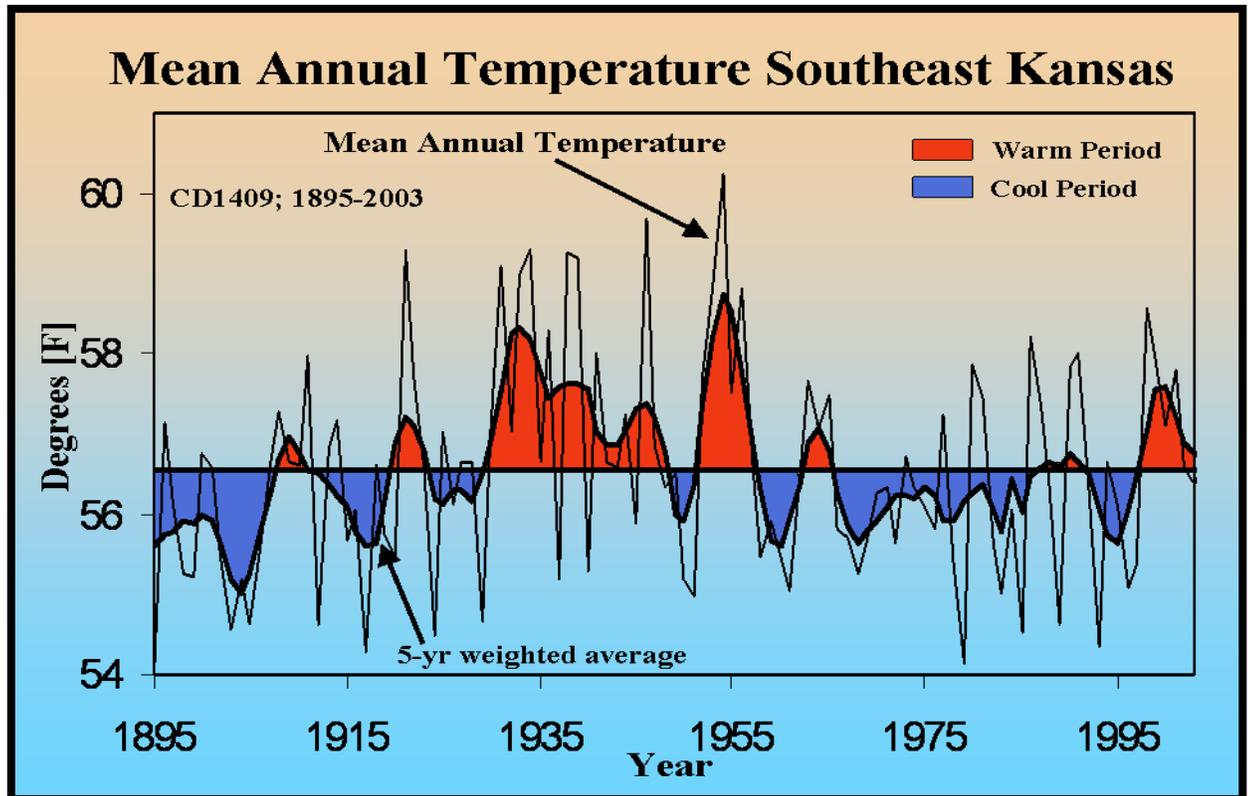
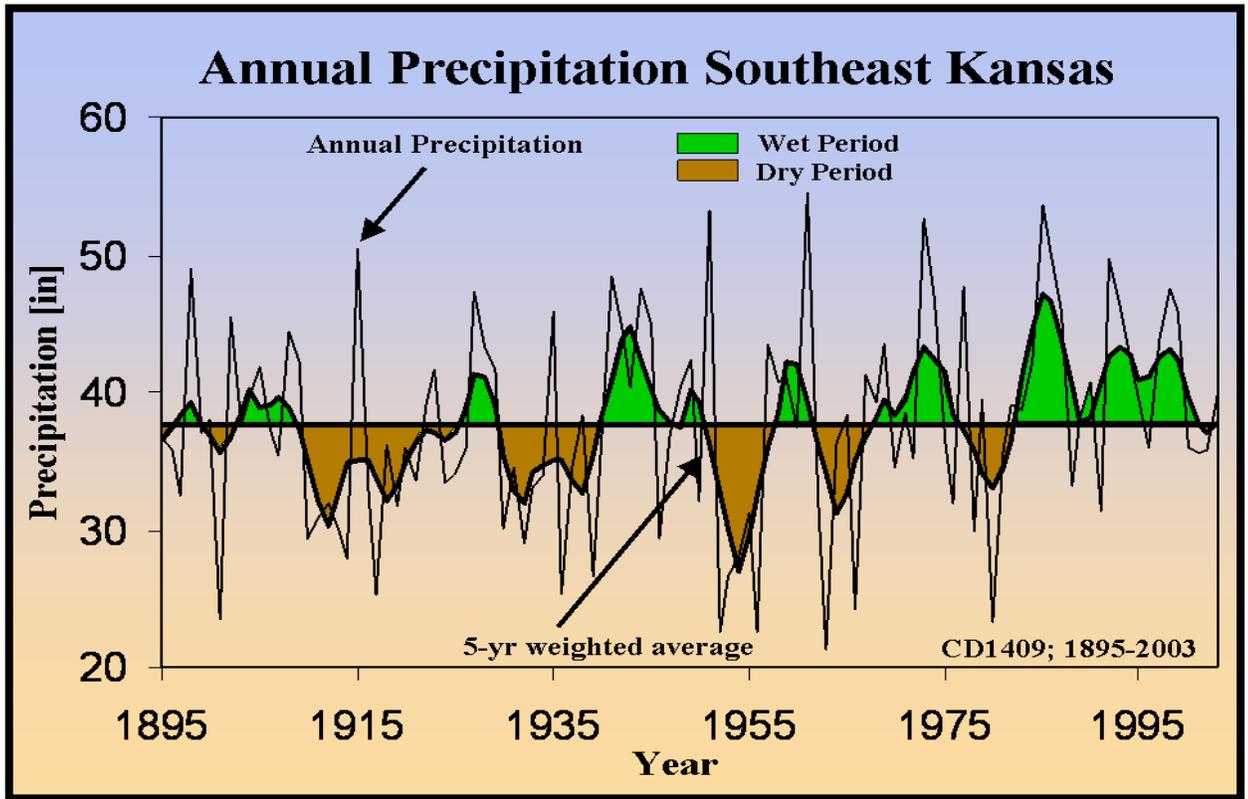
Annual precipitation (top) and mean air temperature (bottom)  
 East Central Kansas, Climate Division 1406



Annual precipitation (top) and mean air temperature (bottom)  
 Southwest Kansas, Climate Division 1407

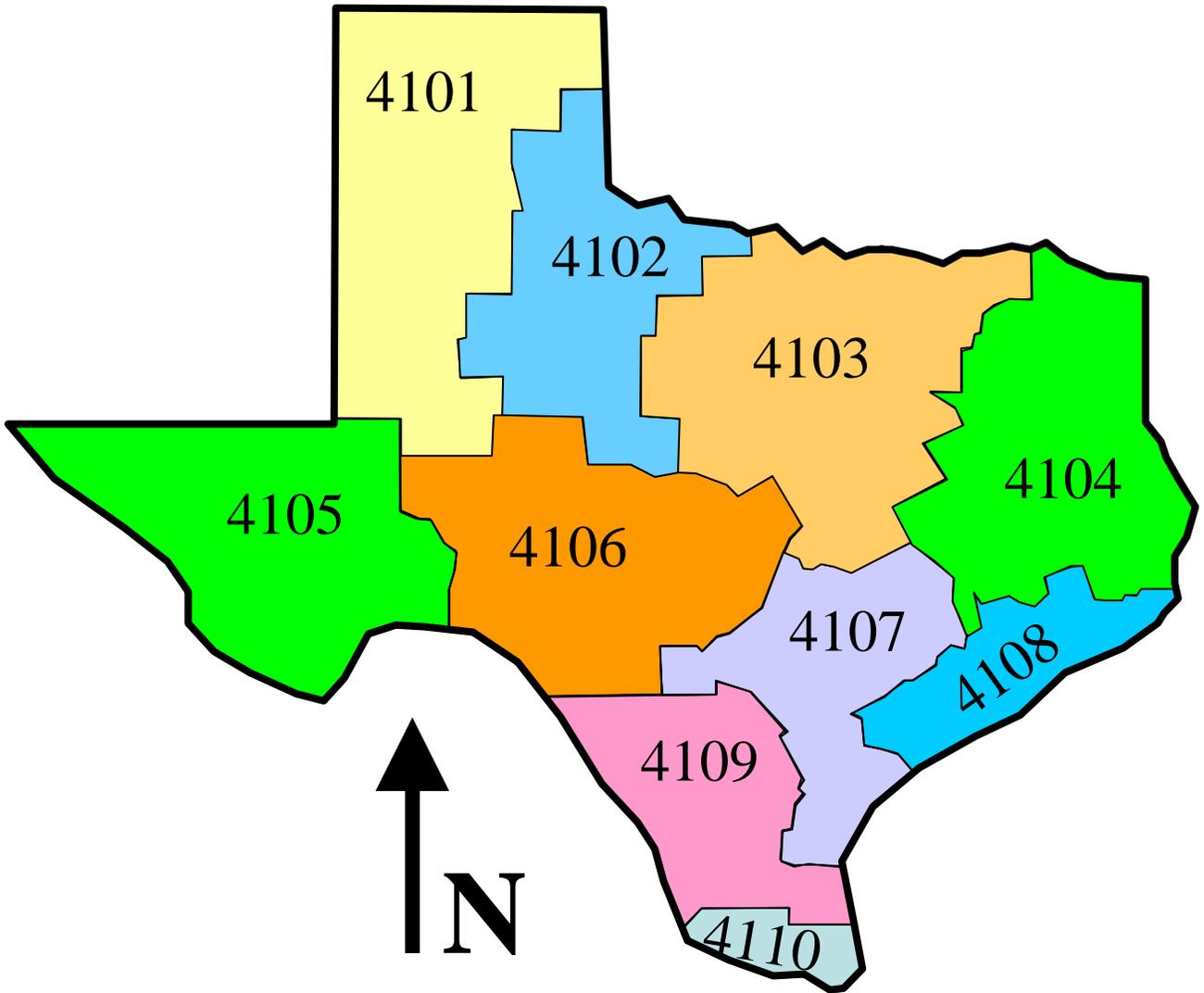


Annual precipitation (top) and mean air temperature (bottom)  
South Central Kansas, Climate Division 1408



Annual precipitation (top) and mean air temperature (bottom)  
Southeast Kansas, Climate Division 1409

# Climate Divisions of Texas



3401: High Plains

3402: Low Rolling Plains

3403: North Central

3404: East Texas

3405: Trans Pecos

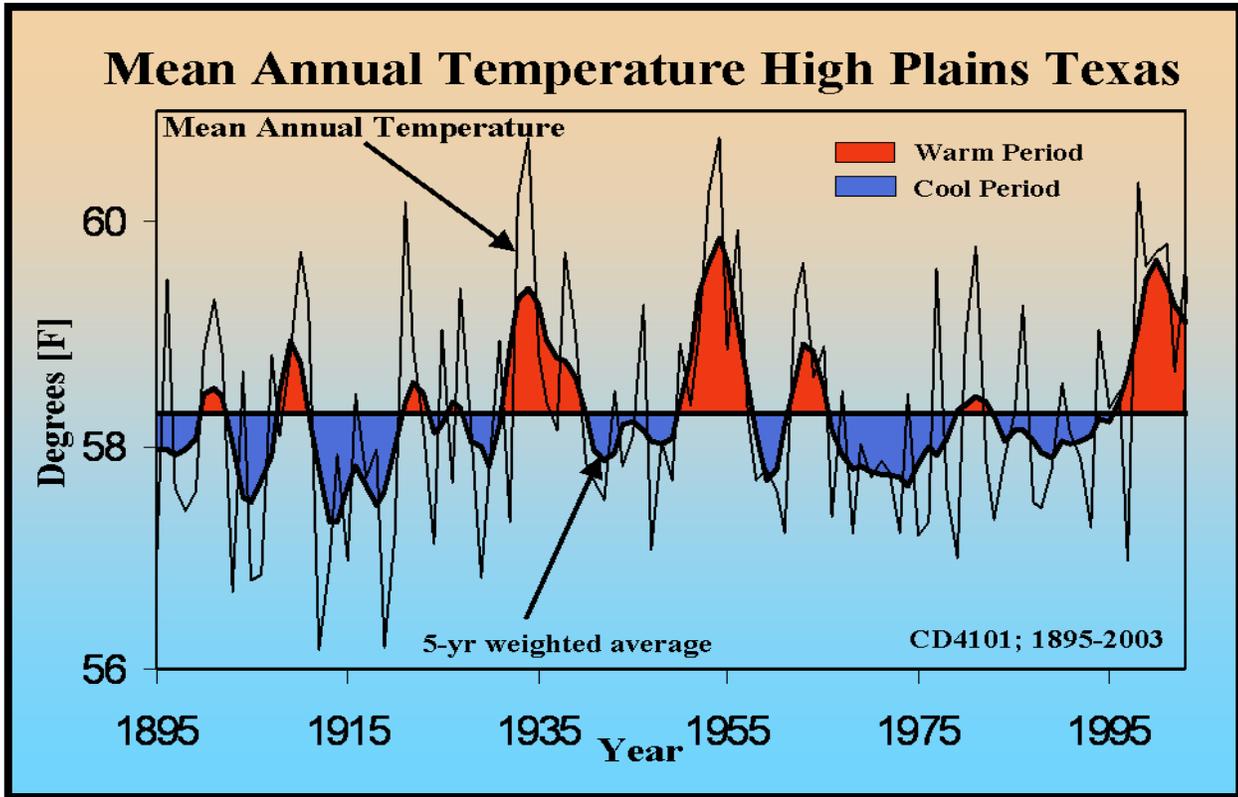
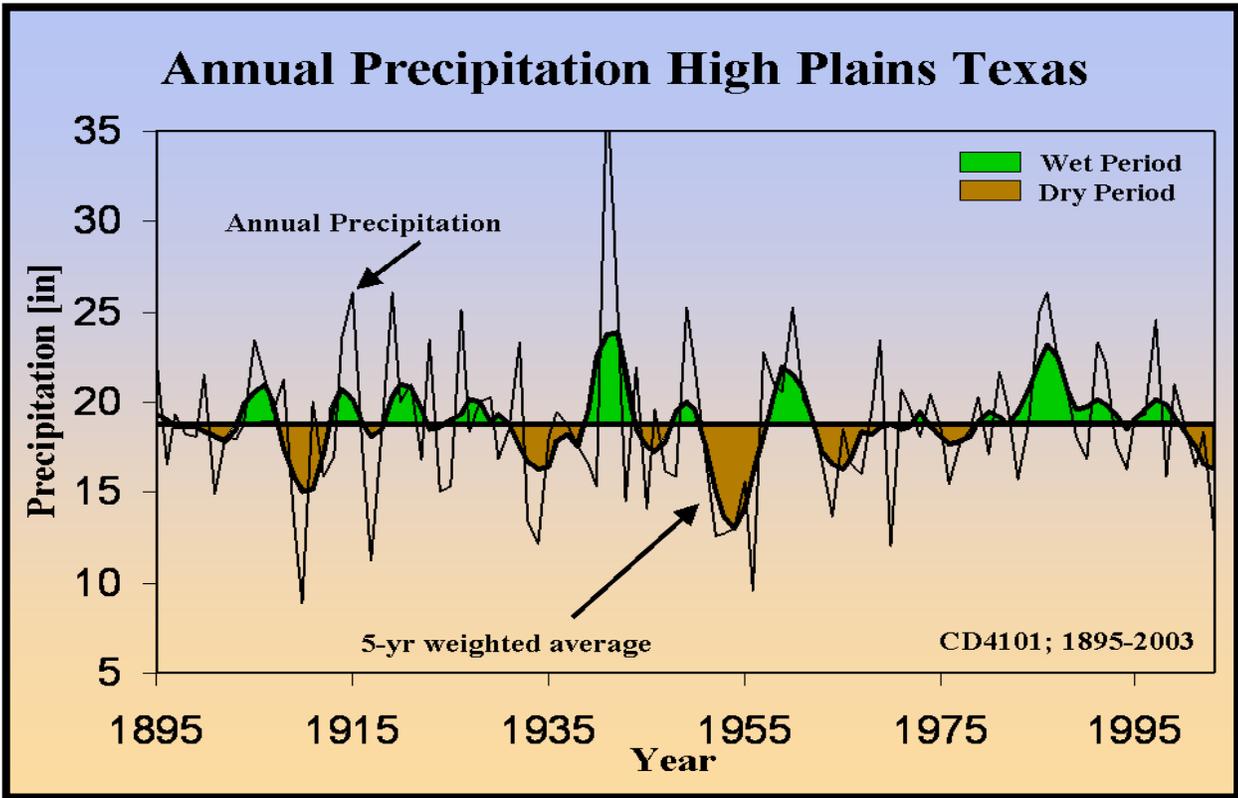
3406: Edwards Plateau

3407: South Central

3408: Upper Coast

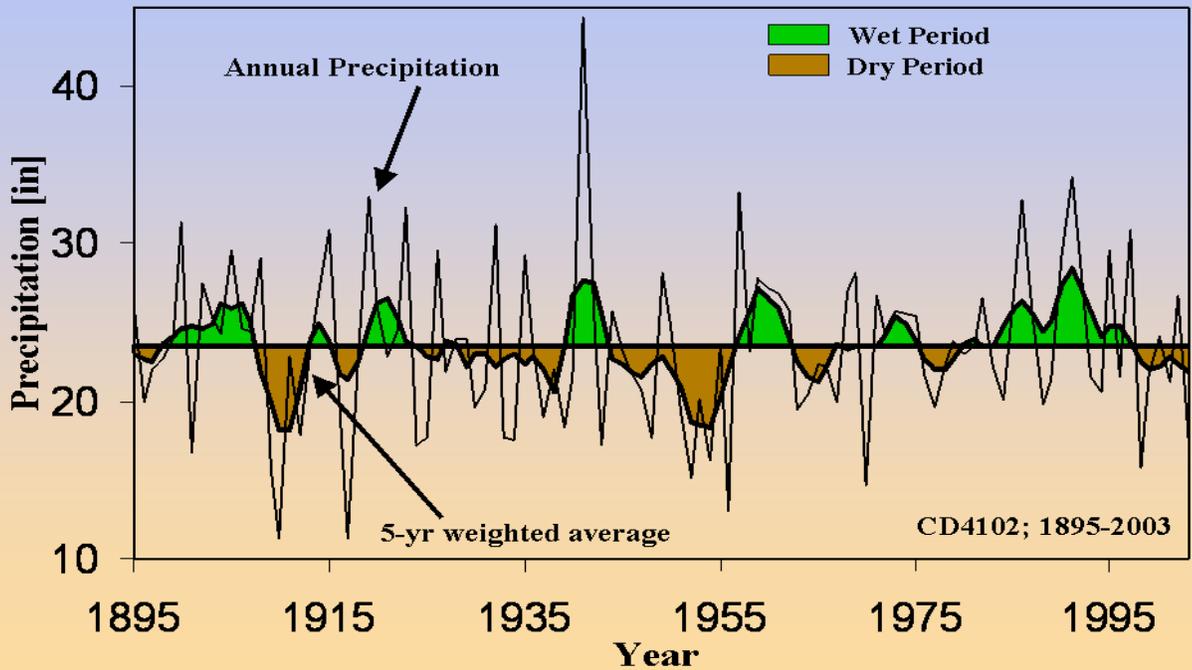
3409: Southern

3410: Lower Valley

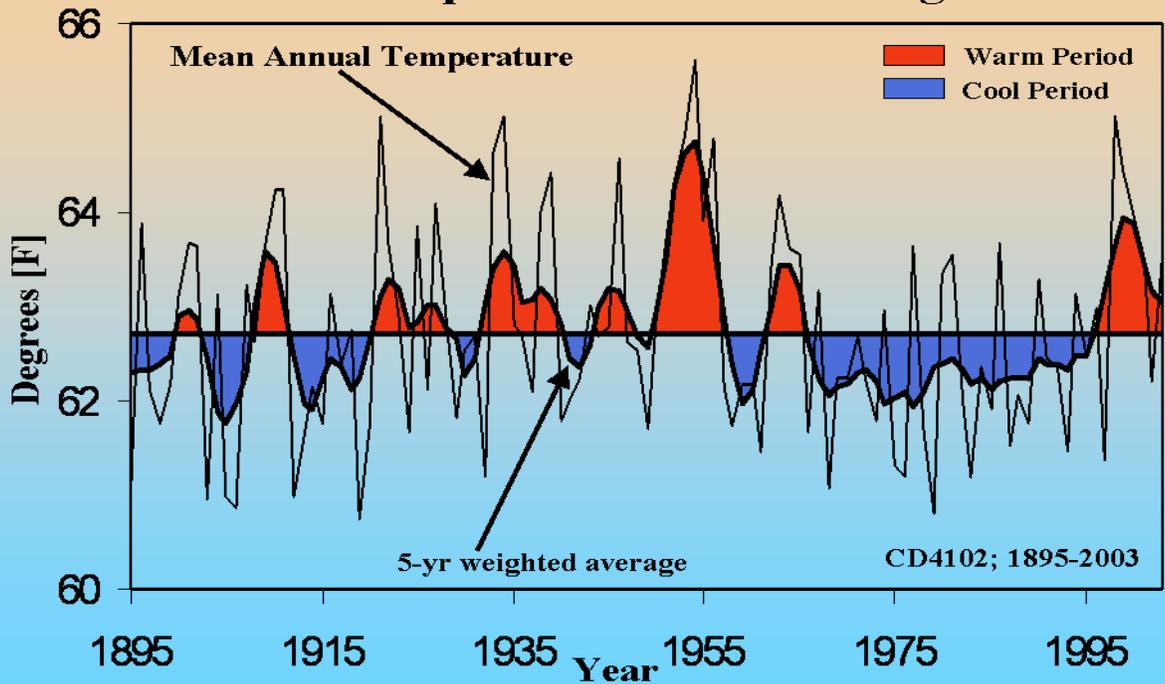


Annual precipitation (top) and mean air temperature (bottom)  
High Plains Texas, Climate Division 4101

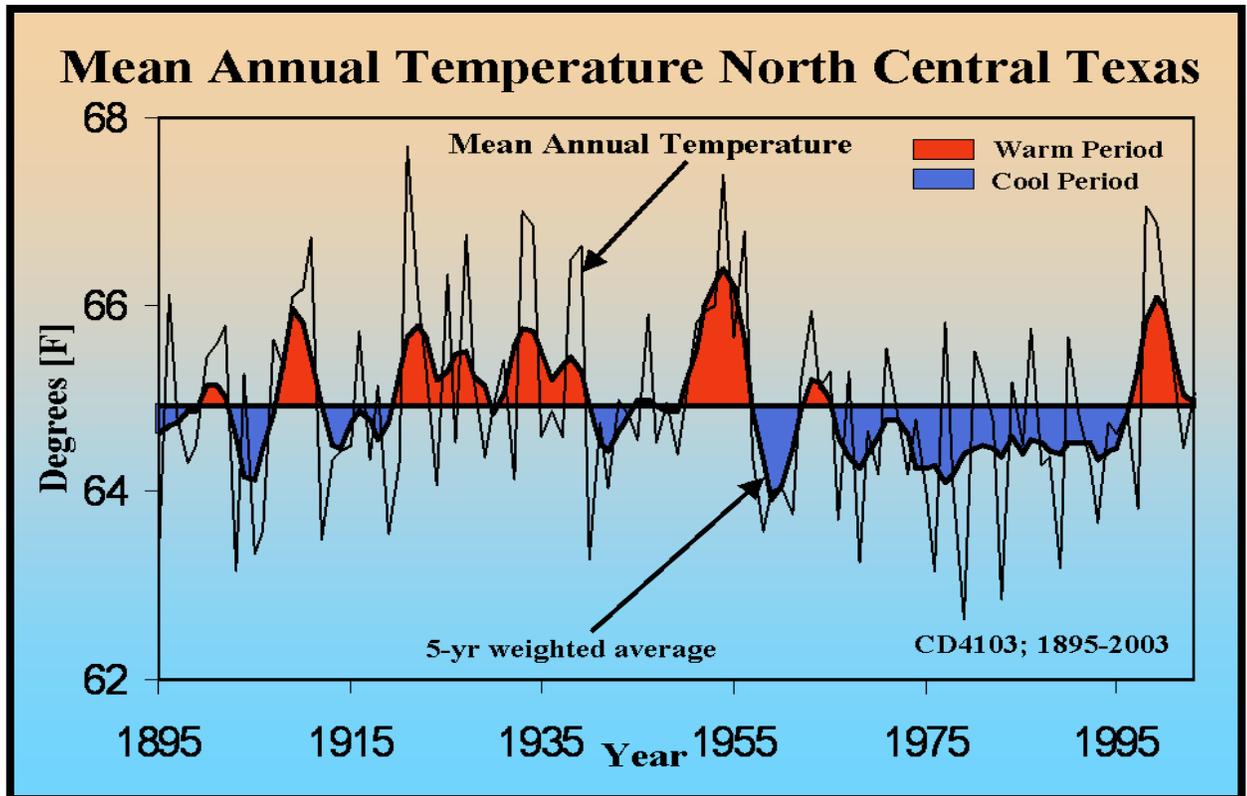
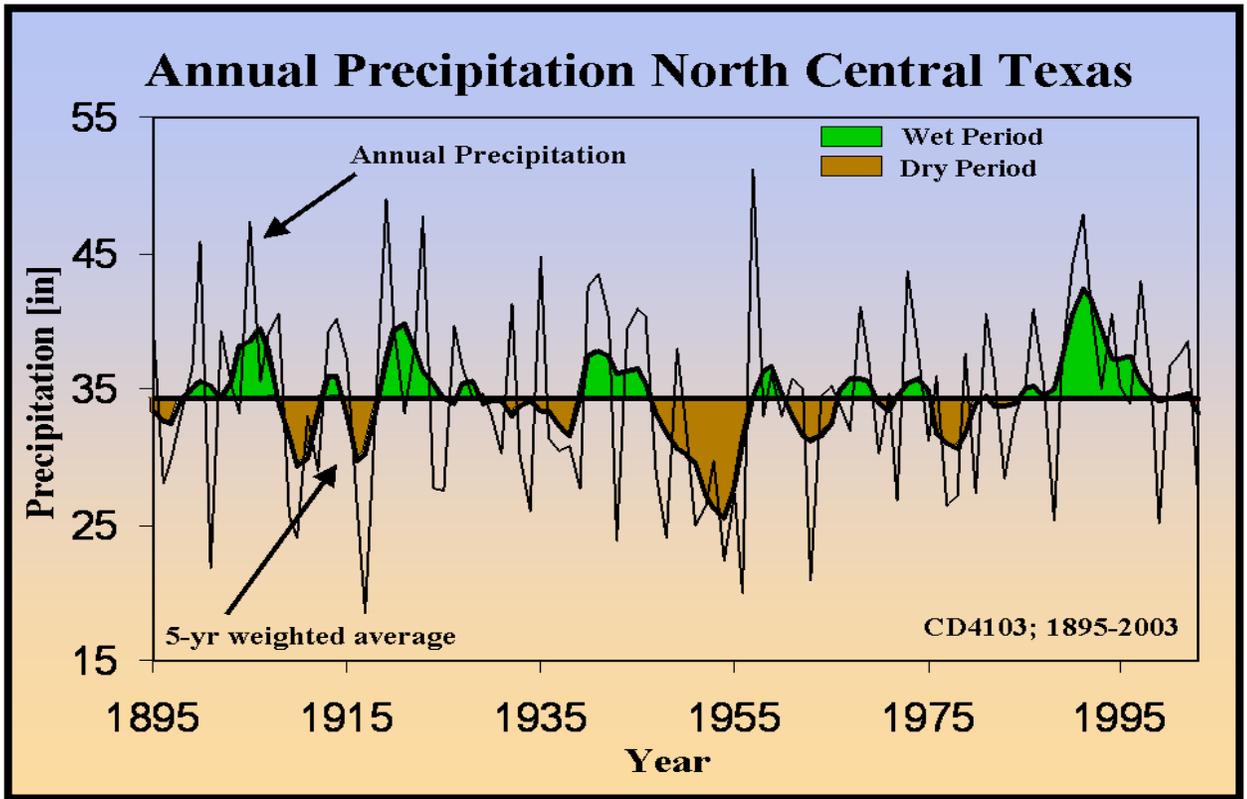
## Annual Precipitation Low Rolling Plains Texas



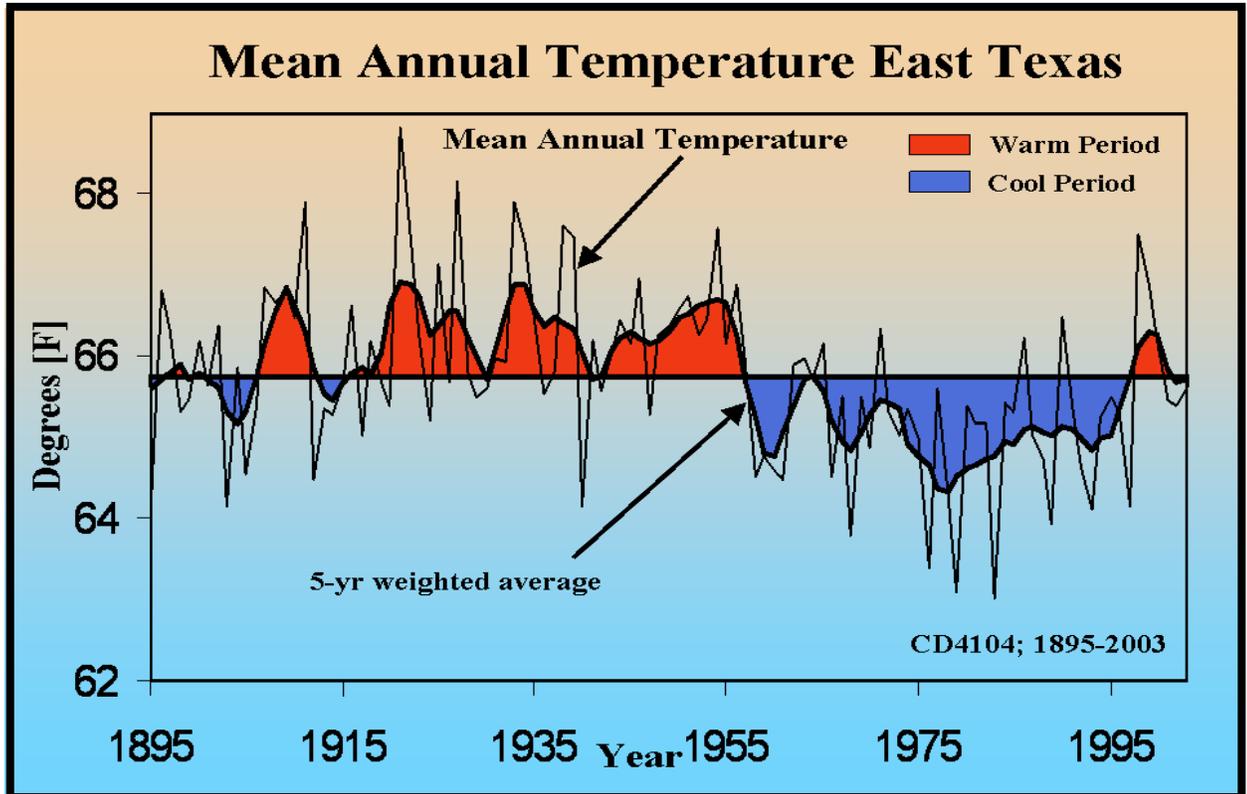
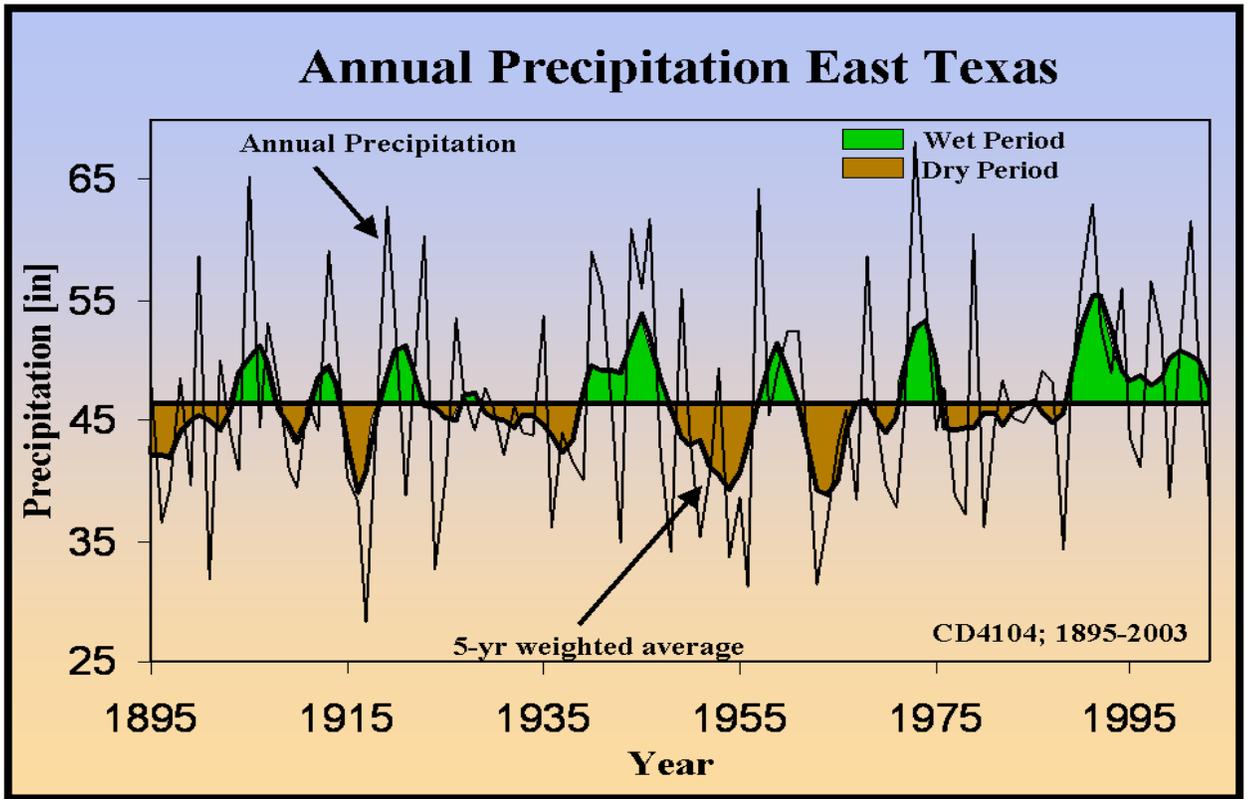
## Mean Annual Temperature Low Rolling Plains Tx.



Annual precipitation (top) and mean air temperature (bottom)  
Low Rolling Plains Texas, Climate Division 4102

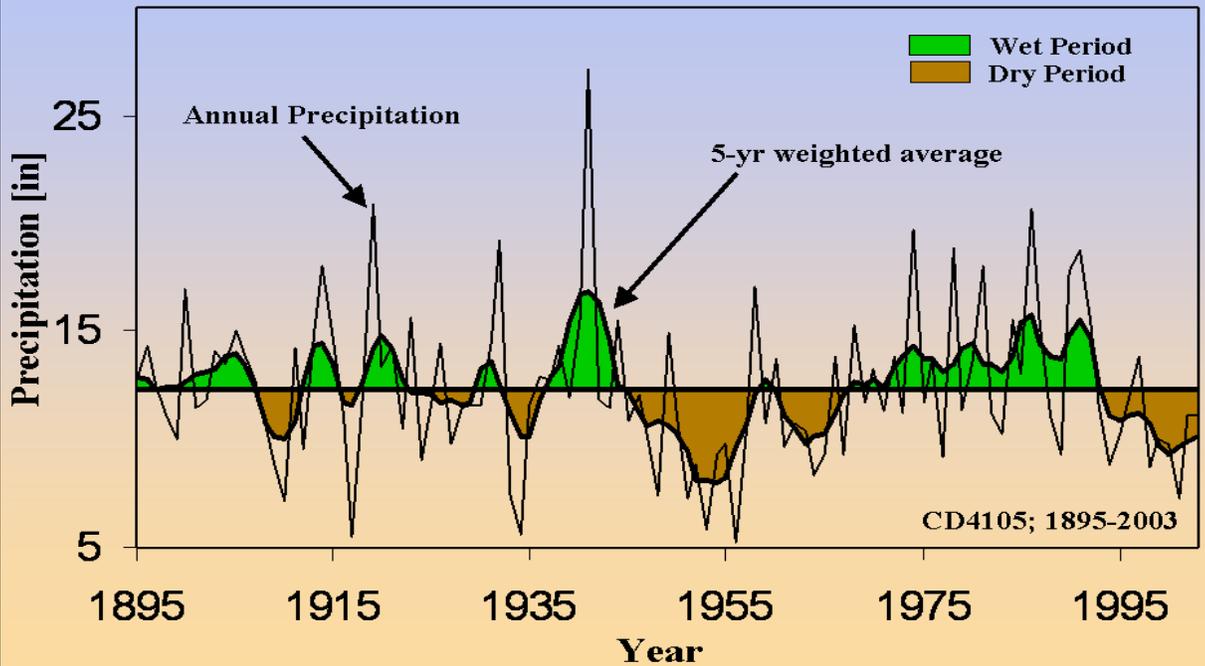


Annual precipitation (top) and mean air temperature (bottom)  
North Central Texas, Climate Division 4103

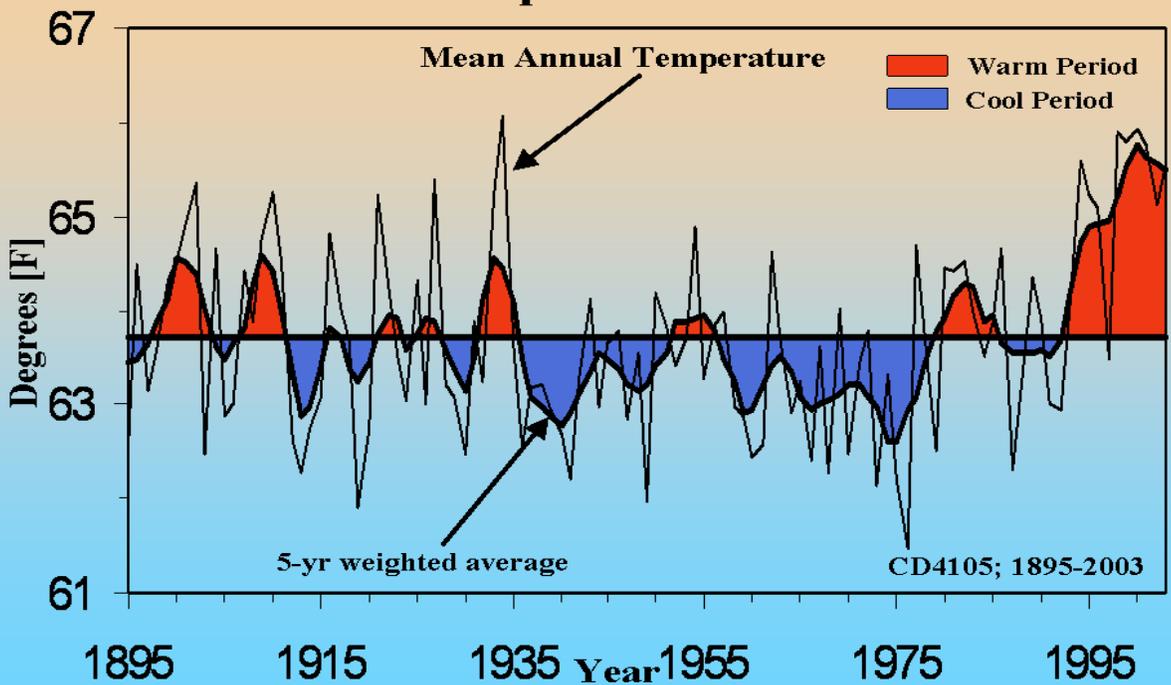


Annual precipitation (top) and mean air temperature (bottom)  
East Texas, Climate Division 4104

## Annual Precipitation Trans Pecos Texas

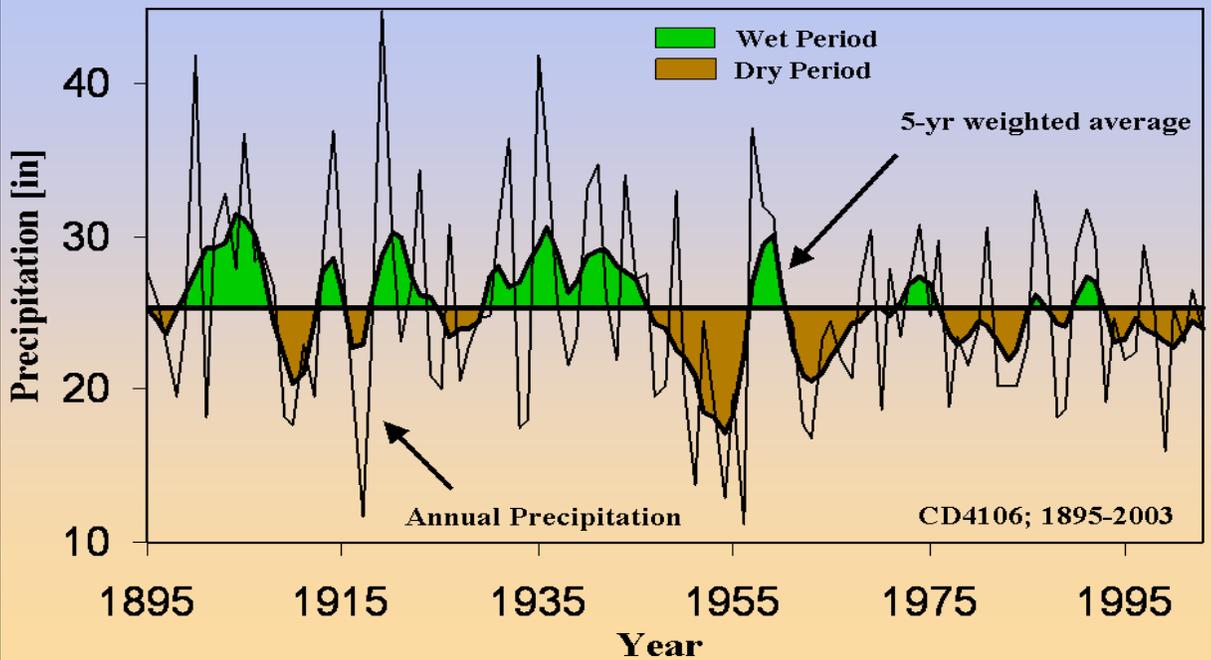


## Mean Annual Temperature Trans Pecos Texas

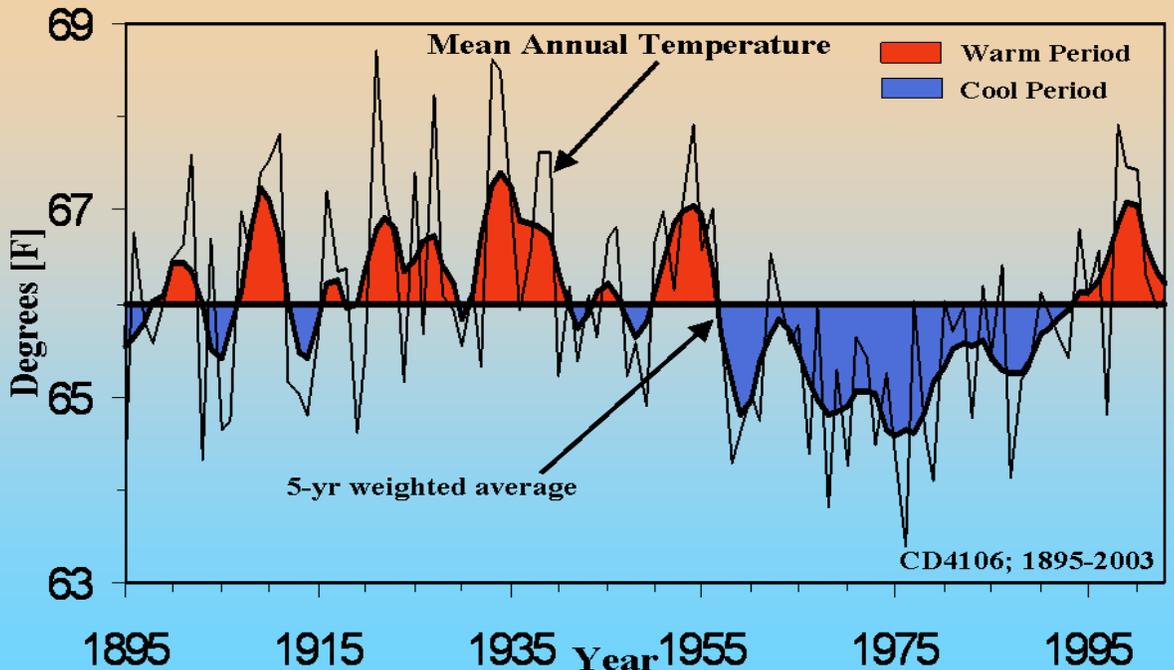


Annual precipitation (top) and mean air temperature (bottom)  
Trans Pecos Texas, Climate Division 4105

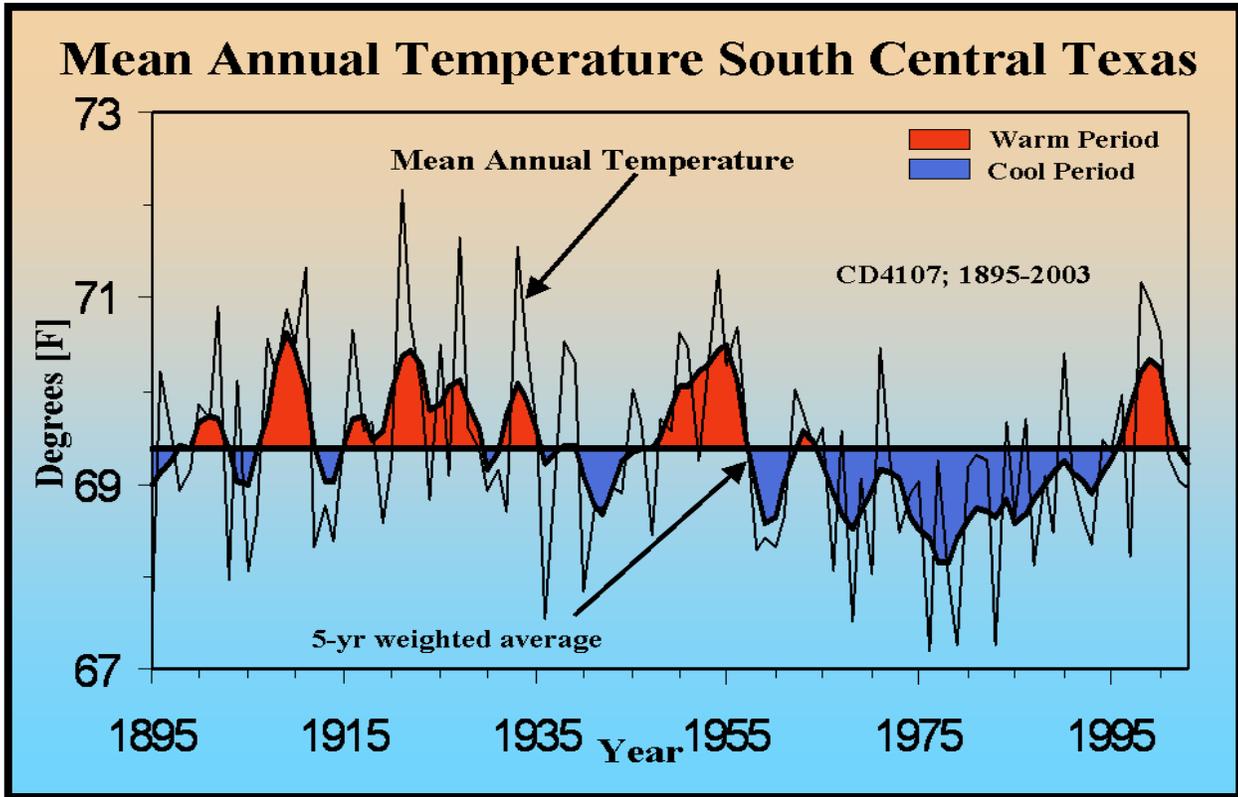
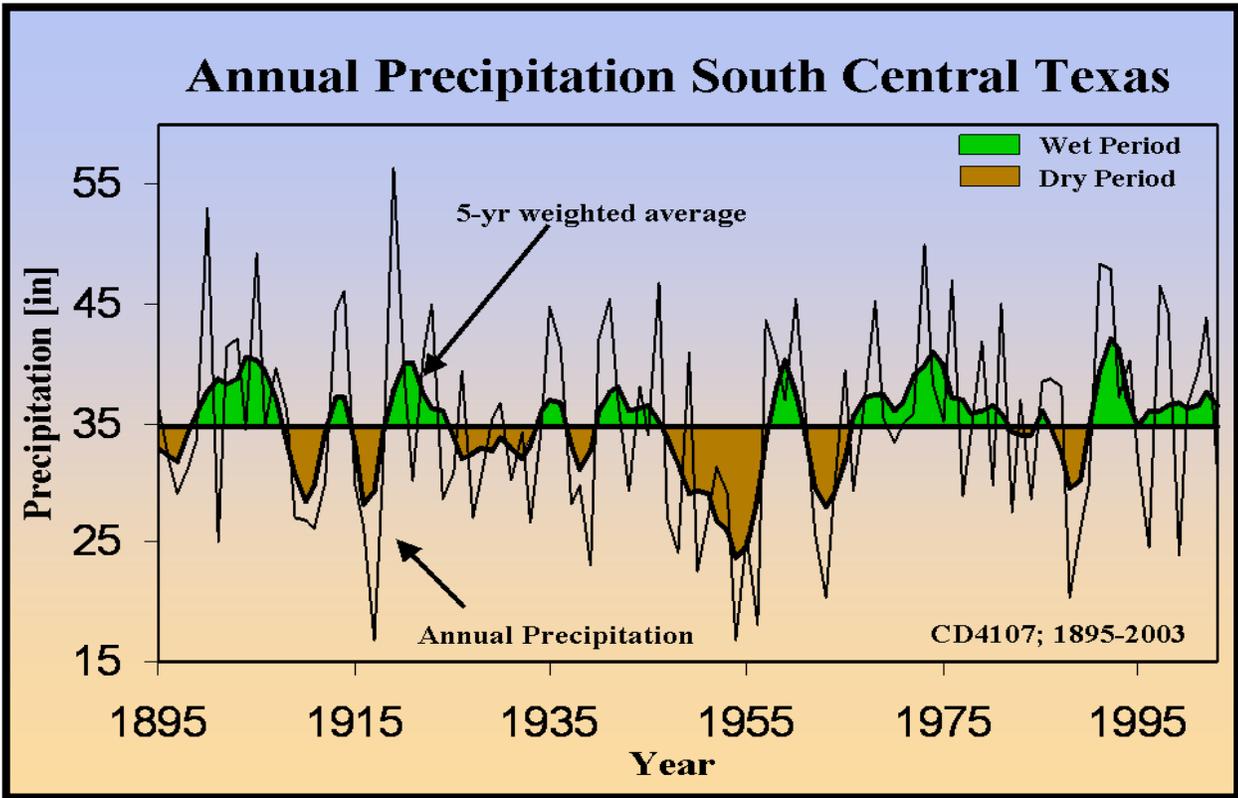
## Annual Precipitation Edwards Plateau Texas



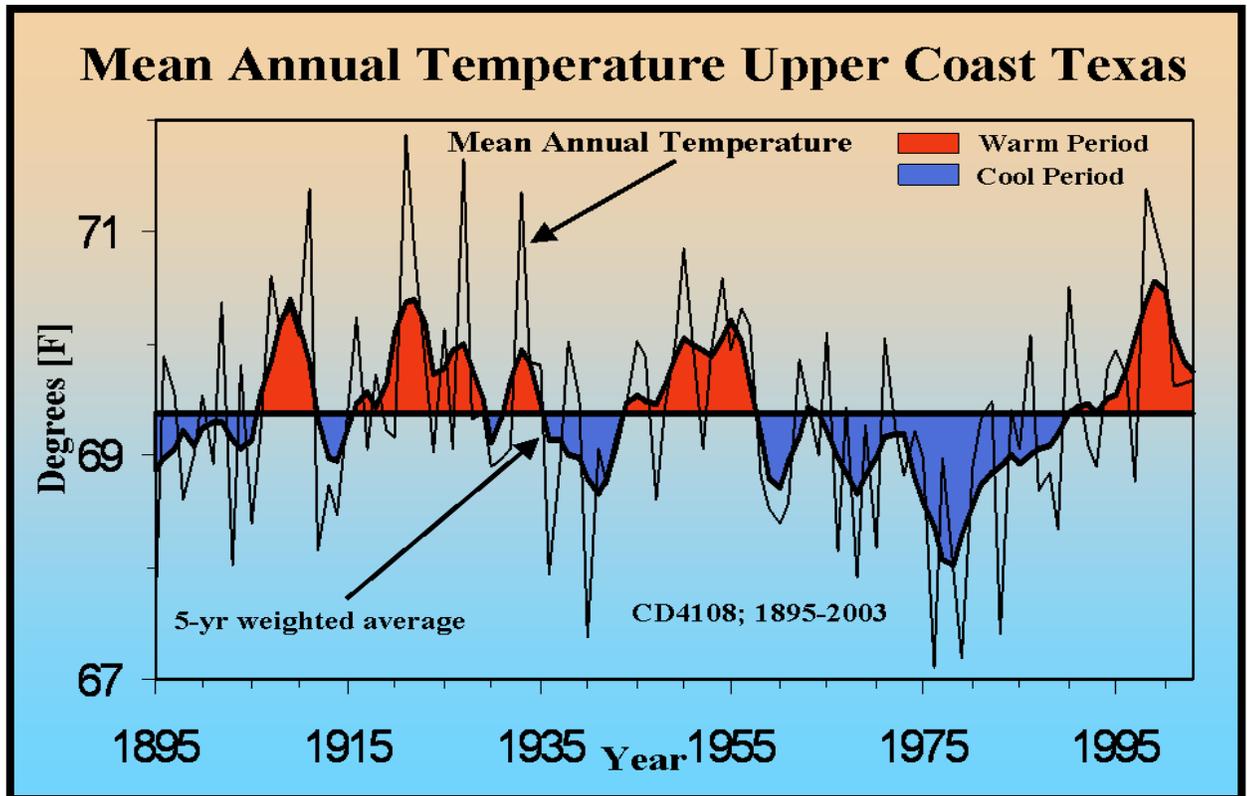
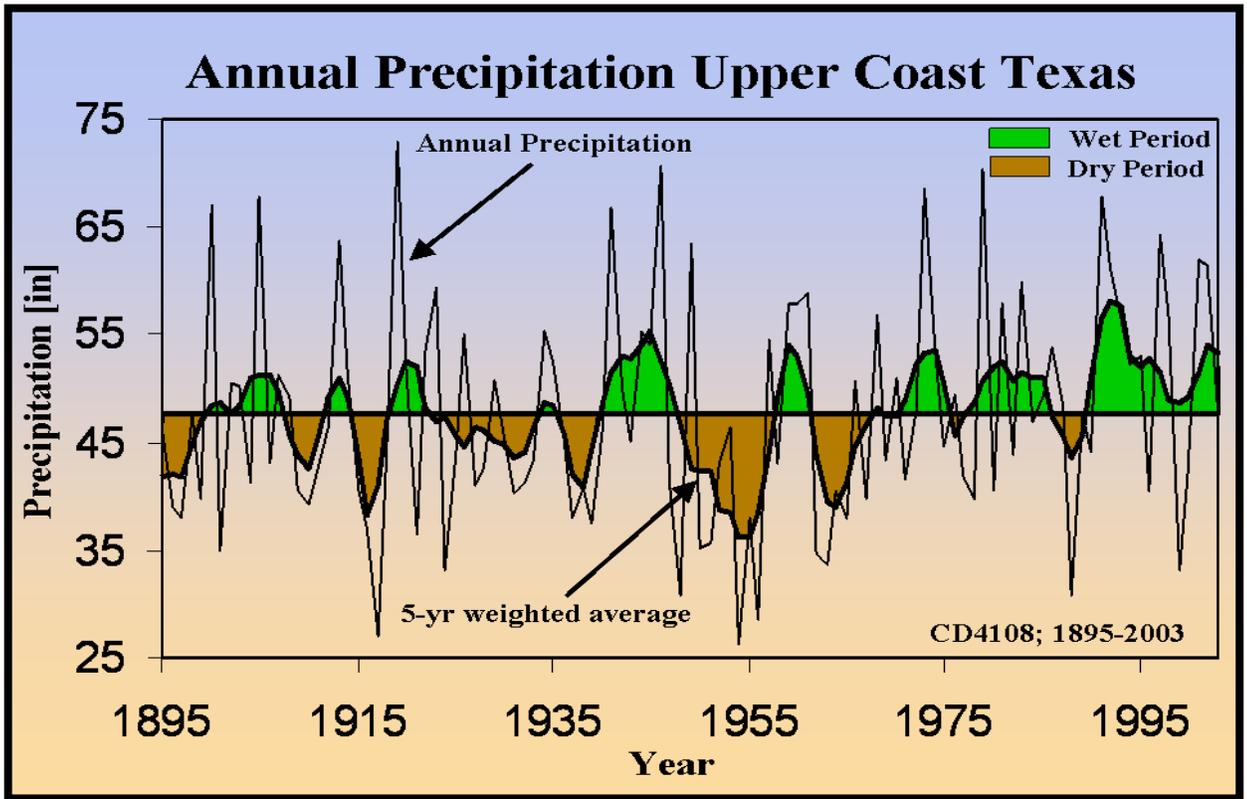
## Mean Annual Temperature Edwards Plateau Texas



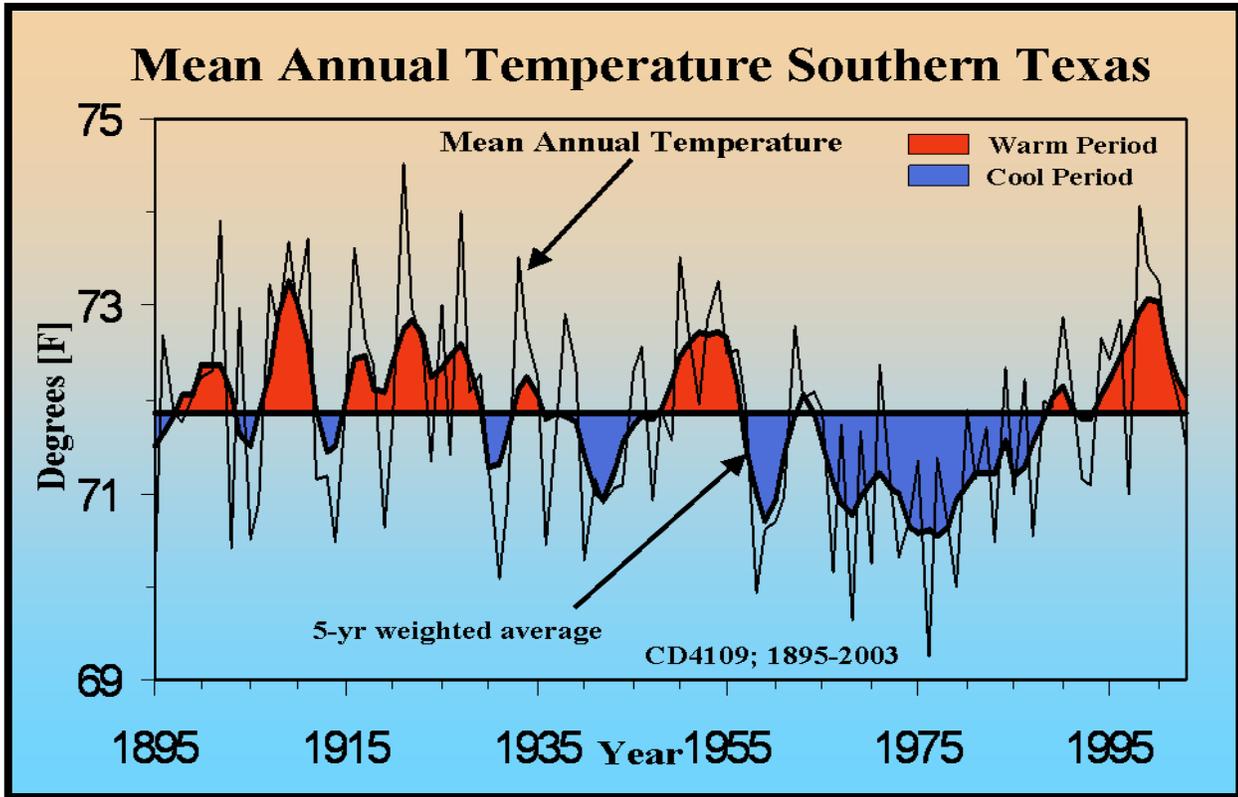
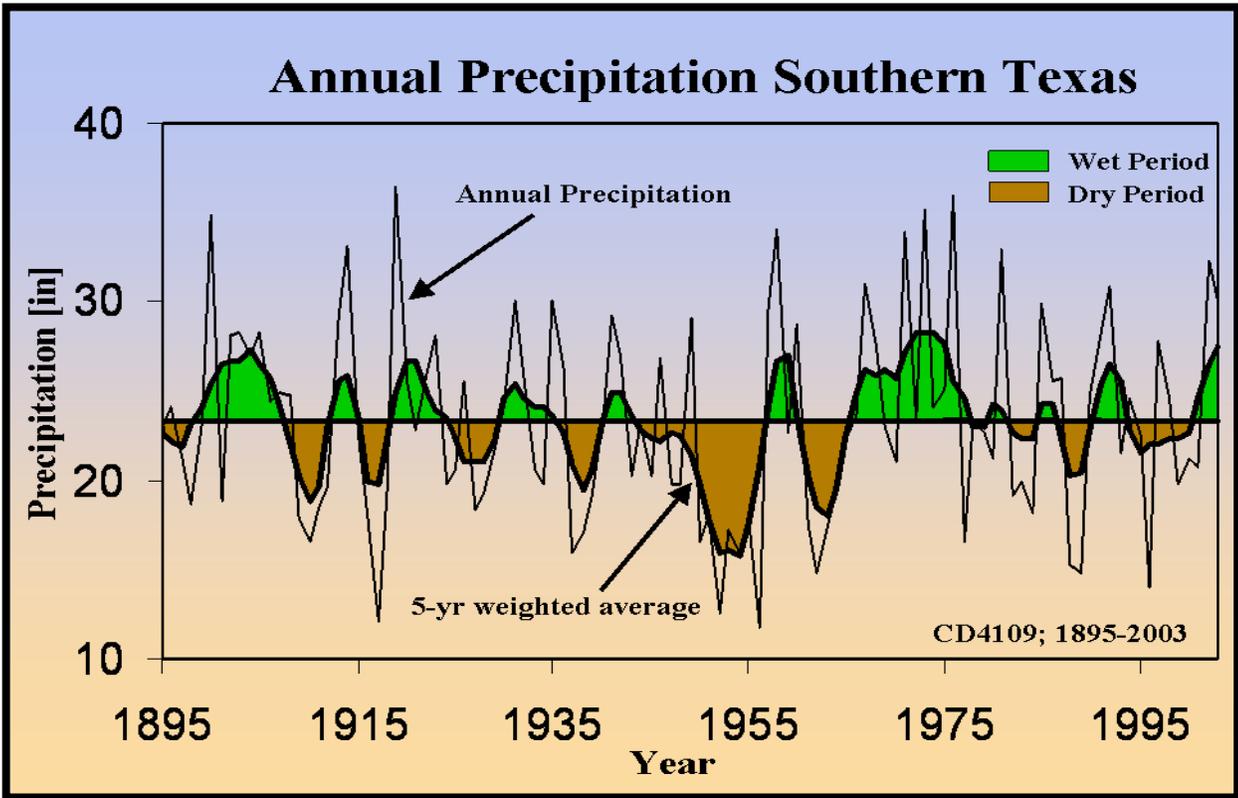
Annual precipitation (top) and mean air temperature (bottom)  
Edwards Plateau Texas, Climate Division 4106



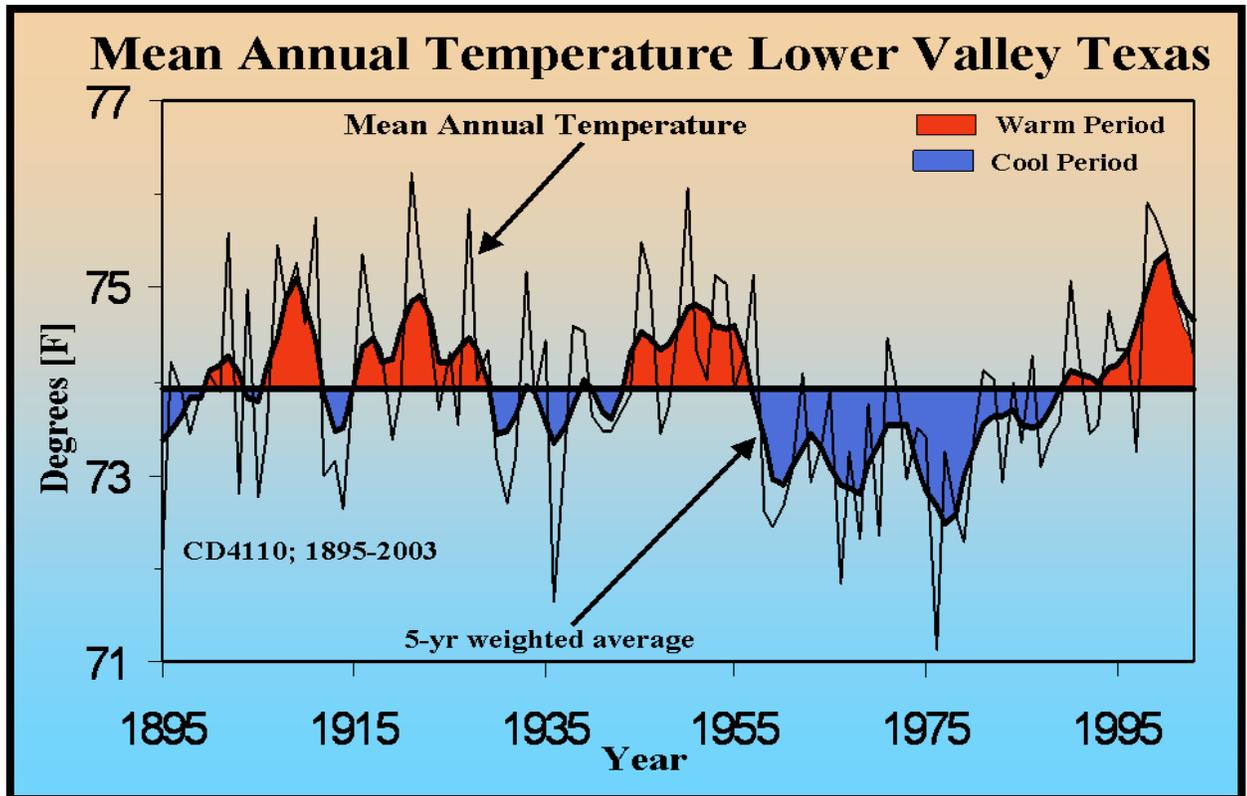
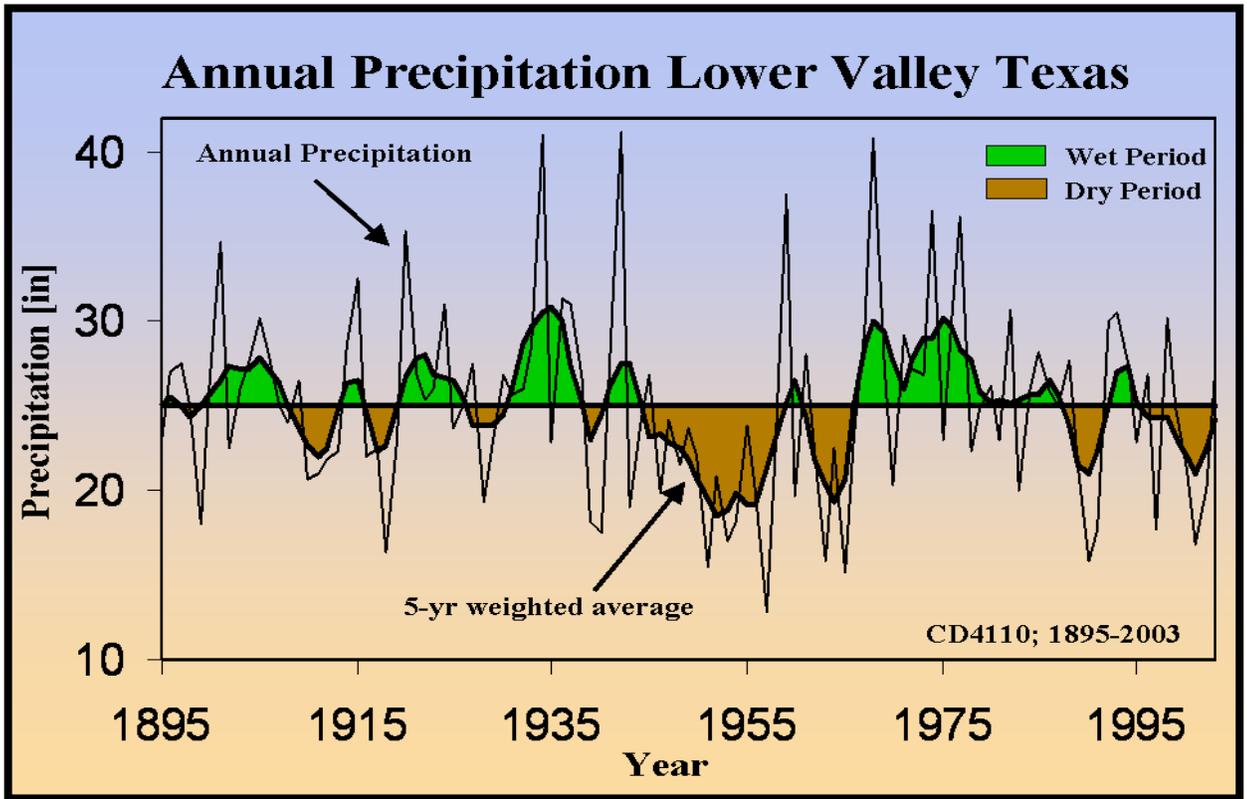
Annual precipitation (top) and mean air temperature (bottom)  
 South Central Texas, Climate Division 4107



Annual precipitation (top) and mean air temperature (bottom)  
Upper Coast Texas, Climate Division 4108



Annual precipitation (top) and mean air temperature (bottom)  
Southern Texas, Climate Division 4109



Annual precipitation (top) and mean air temperature (bottom)  
Lower Valley Texas, Climate Division 4110