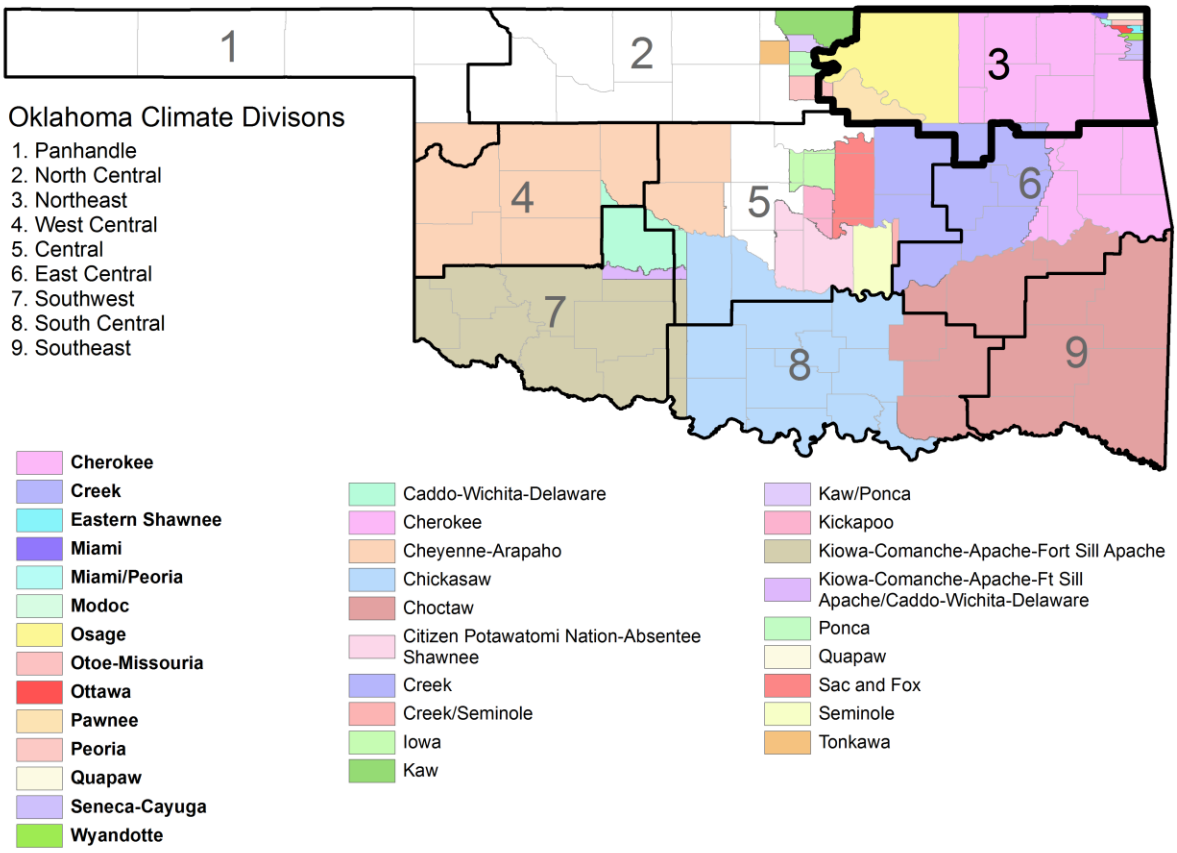
Historical Drought Analysis for:

Northeast Oklahoma, Climate Division 3



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Introduction

The National Drought Policy Commission Report in 2000 defined drought as a persistent and abnormal moisture deficiency having adverse impacts on vegetation, animals, or people. This study aims at providing drought information to tribal, local, or regional officials by examining the patterns and characteristics of droughts that have occurred in Oklahoma climate division 3 (CD3), also known as the Northeast division. **CD3 covers northern Cherokee, northern Creek, Eastern Shawnee, Miami, Miami/Peoria, Modoc, Osage, eastern Otoe-Missouria, Ottawa, Pawnee, Peoria, Quapaw, Seneca-Cayuga, and Wyandotte tribal jurisdictions and Craig, Delaware, Mayes, Nowata, Osage, Ottawa, Pawnee, Rogers, Tulsa, and Washington counties.** Oklahoma is comprised of nine climate divisions (CDs). CD boundaries are based on temperature and precipitation averages of reporting stations in the state[1]. The following historical drought characteristics for CD3 are described in this document:

- Average and maximum duration of past drought events, in months
- Average and maximum intensity of past drought events
- Average month of drought onset and termination
- Characteristics of the 10 longest drought events
- Climatology of drought events
- Wet periods (i.e. drought breaks)

Drought Indices

The data used in this analysis were the drought indices extracted from the National Centers for Environmental Information (NCEI) Center for Weather and Climate (formerly the National Climatic Data Center, NCDC). The drought data are publicly available and the description of the variables is available on the NCEI-CWC website[2]. A by-product database was produced containing the following indices and variables for all Oklahoma climate divisions. The purpose of this by-product database was to compare indices and determine the most useful information for this document.

- Palmer Drought Severity Index (PDSI)
- Palmer Hydrological Drought Index (PHDI)
- Modified Palmer Drought Severity Index (PMDI)
- Palmer Z-Index (ZNDX)
- Standardized Precipitation Index (SPI) in 1-, 2-, 3-, 6-, 9-, 12-, and 24-month time period
- Temperature Data
- Precipitation Data

To quantify drought events, several drought indices have been previously developed by various agencies and organizations based on specific criteria. Planners and managers look

[1] Guttmann and Quayle (1995)
[2] http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp, ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv/divisional-readme.txt

at the indices to help them decide when to start implementing measures to mitigate drought impacts. The strengths and weaknesses of PDSI, and the explanation for the development of the modified PDSI are presented on the website of the National Drought Mitigation Center[3]. PDSI uses observations or estimates of precipitation, temperature and soil water content. The NCEI's explanation for modifying the PDSI is as follows:

> The Modified Palmer Drought Severity Index (PMDI) was instituted by the National Weather Service Analysis Center, who modified the PDSI for operational meteorological purposes. The PMDI and PDSI have the same value during an established drought or wet spell but they have different values during transition periods. The PMDI incorporates a weighted average of the wet and dry index terms, using probability as the weighting factor.

An index that can be employed to illustrate short- and long-term droughts is the Standardized Precipitation Index (SPI). SPI is based only on precipitation but has the advantage of showing multiple time scales, from 1-month to 24-month time period. The 24-month SPI time scale shows the longer duration droughts whereas the 1-3 month time scale shows the shorter duration droughts. The aforementioned indices were plotted for the years 1895-2014. All of the drought events were captured by each index.

After considering the pros and cons of both indices, the PMDI was chosen for this analysis over PDSI. The PMDI is represented by a single value that can serve as a tool in real time monitoring and assessment of drought conditions. The U.S. Drought Monitor also provides way to understand historical and current droughts but the dataset only goes back to the year 2000.

Analyzing a drought index provides a way to compare drought length and magnitude over time. For PMDI, a value of 0 indicates normal conditions, positive values indicate wet conditions, and negative values indicate dry conditions. The negative PMDI is divided into five categories, some of which indicate drought. For this study, the Palmer Classification[4] was adopted to categorize the drought intensity or severity. Table 1 lists the drought intensity categories used in this study.

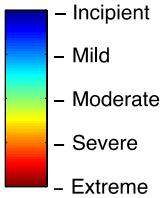
PMDI Value	Drought Category	Color Designation
0 to -0.49	Normal	
-0.5 to -0.99	Incipient Drought	
-1.0 to -1.99	Mild Drought	
-2.0 to -2.99	Moderate Drought	
-3.0 to -3.99	Severe Drought	
-4.0 or less	Extreme Drought	

Table 1. Drought index values and respective categories and colors.

Drought Analysis

The drought characteristics derived from the analysis reflect the various aspects of individual drought events. The drought metrics that were used in this study included

[3] http://drought.unl.edu/Planning/Monitoring/ComparisonofIndicesIntro/PDSI.aspx
[4] http://drought.unl.edu/Planning/Monitoring/ComparisonofIndicesIntro/PDSI.aspx

frequency of drought events in each climate division, onset and termination date, duration, peak intensity, date of peak intensity, duration of breaks, total precipitation, and percent of normal precipitation. Please note that most recent 1981-2010 monthly precipitation normals were used for the relevant calculations, which means that the precipitation statistics for each drought event were compared to the corresponding average precipitation statistics for the 30 year period between 1981 and 2010. The impacts of drought are manifested in severity and duration. Droughts have occurred in all Oklahoma climate divisions but each drought event possesses unique characteristics. Droughts differ in intensity, duration, and other attributes.

General Characteristics of Drought in CD3

Table 2 shows the average, maximum, and minimum of drought variables in CD3, implying the characteristics of historical drought conditions in this division.

Climate Division 3 Drought Characteristics			
Averages			
Drought Onset (day-month)	23-Jul	Drought End (day-month)	22-Jul
Drought Event Duration (months)	5.15	Incipient Dry Spell Duration (months)	1.23
Mild Drought Duration (months)	1.65	Moderate Drought Duration (months)	1.14
Severe Drought Duration (months)	0.76	Extreme Drought Duration (months)	0.38
Peak Intensity (0 to -4 scale)	-1.77	Peak Intensity Occurrence(day-months)	23-Jul
Break Between Drought Events (months)	8.8	Average Percent of Normal Precip.	57.52
Maximum			
Drought Event Duration (months)	46	Incipient Dry Spell Duration (months)	6
Mild Drought Duration (months)	8	Moderate Drought Duration (months)	11
Severe Drought Duration (months)	17	Extreme Drought Duration (months)	20
Peak Intensity (0 to -4 scale)	-6.03	Date of Maximum Peak Intensity (mm/yyyy)	06/1911
Break Between Drought Events (months)	46	Maximum Percent of Normal Precip.	95.22
Minimum			
Break Between Drought Events (months)	2	Minimum Percent of Normal Precip.	2.86

Table 2. List of the averages, maximums, and minimums of drought variables for the period 1895-2014.

Major Drought Events in CD3

Droughts that lasted for more than 12 months were classified as major drought events in this study. Prolonged droughts have more consequences and adverse impacts on the society. Table 3 lists the ten longest drought events in CD3. The duration (in months) under a specific drought intensity category is also given. The peak intensity (the lowest PMDI value) during each drought's occurrence, year/month when the peak intensity has occurred, total precipitation, departure from normal precipitation, and percent of normal precipitation are also included in the table.

Climate Division 3												
Start Date (Year/Month)	End Date (Year/Month)	Duration (# Months)	Incipient Duration (# Months)	Mild Duration (# Months)	Moderate Duration (# Months)	Severe Duration (# Months)	Extreme Duration (# Months)	Peak Intensity	Peak Date (Year/Month)	Total Precip. (in.)	Departure from Normal (in.)	% of Normal Precip.
1953/05	1957/03	47	0	1	8	17	20	-5.95	1956/09	110.09	-56.52	66.08
1916/08	1918/10	27	2	4	11	8	2	-4.28	1918/08	65.63	-31.23	67.76
1910/03	1912/02	24	0	2	9	5	8	-6.03	1911/06	59.65	-25.69	69.90
1965/10	1967/06	21	2	8	7	4	0	-3.83	1967/03	50.06	-24.16	67.45
1924/11	1926/06	20	4	4	10	2	0	-3.18	1925/08	51.54	-18.90	73.17
2005/09	2007/04	20	3	4	3	8	2	-4.09	2006/03	49.22	-18.58	72.60
1900/12	1902/05	18	4	3	3	8	0	-3.96	1902/02	42.73	-19.33	68.85
1963/02	1964/07	18	2	1	3	6	6	-4.85	1964/01	41.95	-24.65	62.99
1933/12	1935/02	15	6	4	2	1	2	-4.47	1934/08	37.04	-11.75	75.92
1980/07	1981/09	15	1	4	6	4	0	-3.51	1981/04	37.98	-15.81	70.61

Table 3. Ten longest drought events in climate division 3. Departure from normal and percent of normal calculations were based on the 1981-2010 monthly precipitation normals (i.e. averages).

Climatology of Drought Events in CD3

The chronology and evolution of drought events for the entire period of record is plotted and shown on a decadal interval in figures 1a-1d. Major droughts were classified as lasting for more than 12 months and listed on top of each graph in red. The magnitude of drought progressing on a monthly time scale is represented by negative index values that also indicate the onset and termination of the event. The major drought events are indicated by more negative index values and red colors.

As seen in the graphs of drought indices, the 1953/05-1957/03 drought was the most prolonged and lasted for 47 months. It was also the second most severe drought with -5.95 PMDI and ran uninterrupted as no break or wet period is seen in the graph. The drought of 1916/08-1918/10 had the second longest duration and lasted for 27 months with lowest PMDI of -4.28. The 1910/03-1912/02 drought that lasted for 24 months was the most severe drought with record low of -6.03 PMDI over the historical period 1895-2014. The droughts in 1930s, though short durations, were associated with Dust Bowl of the Great Plains. The drought during that period was much worse in western Oklahoma.

Some droughts were also severe but relatively short in duration. These were the droughts in 1936/02-1936/12 (-5.5 PMDI), 1963/02-1964/07 (-4.85 PMDI), and 1933/12-1935/02 (-4.47 PMDI). The long-duration wet periods in CD3were observed in the second half of the 1920s, mid 1970s, most of the 1980s and 1990s, and late 2000s. CD3had a total of 111 drought events during the period of record.

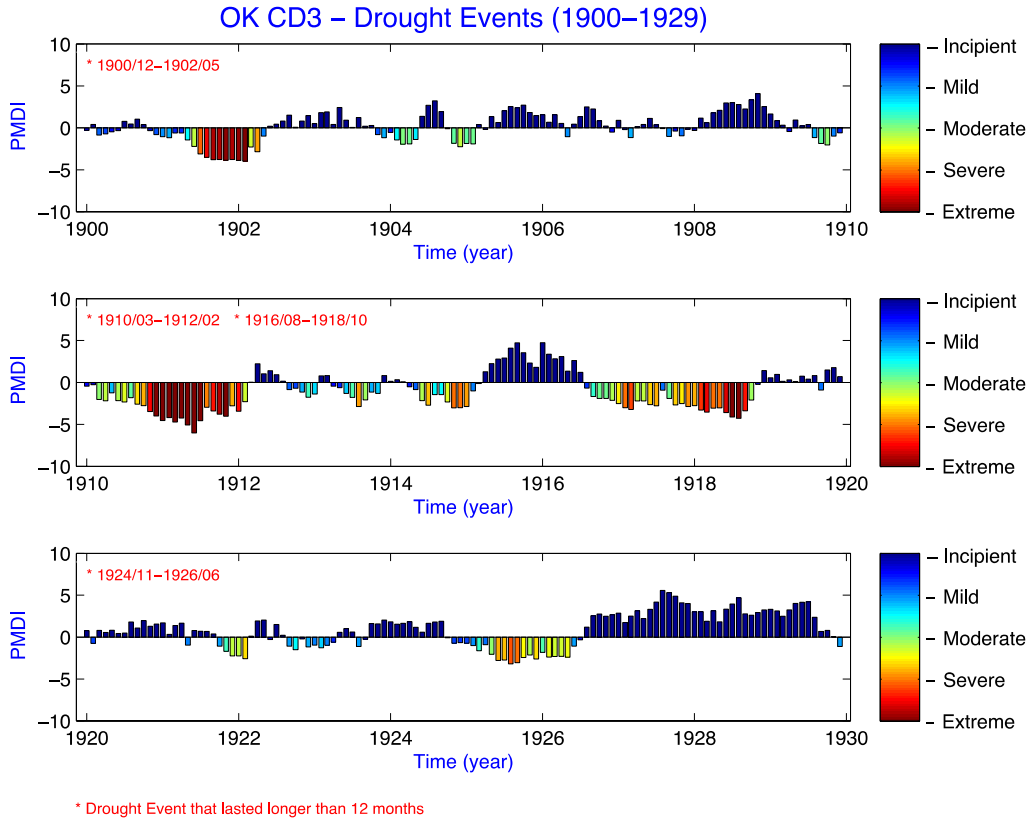


Fig. 1a. Drought events chronology and evolution from 1900-1929 for Climate Division 3.

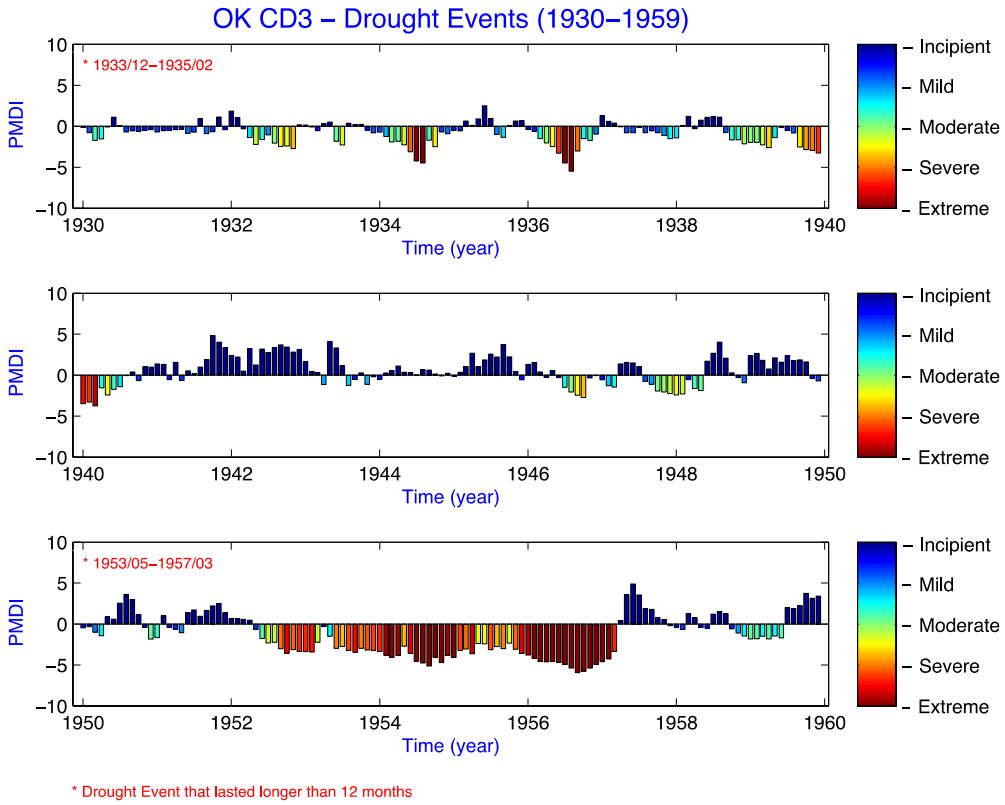


Fig. 1b. Same as Fig. 1a, but for 1930-1959 drought events.

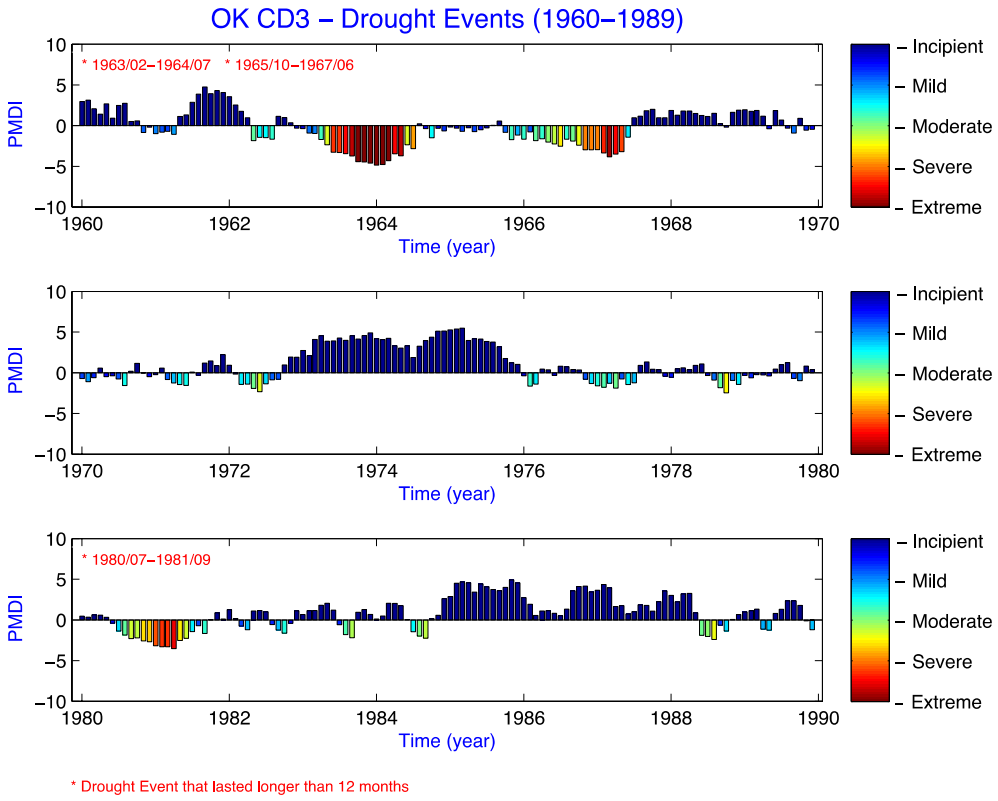


Fig. 1c. Same as Fig. 1a, but for 1960-1989 drought events.

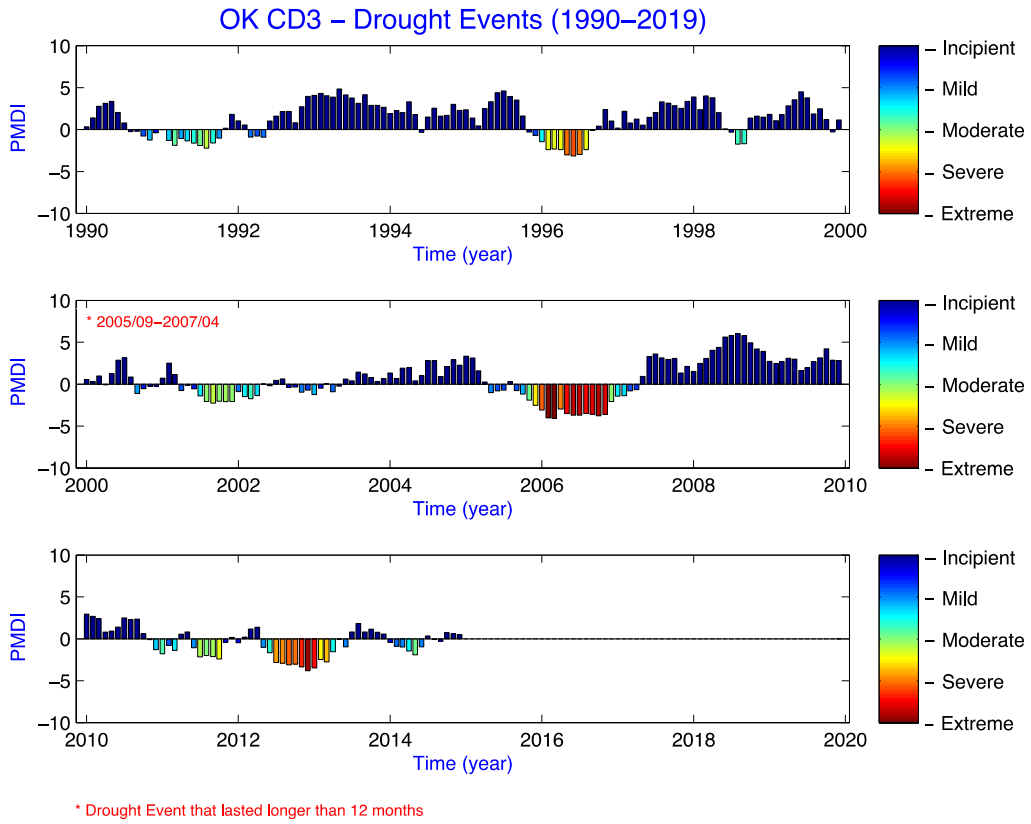


Fig. 1d. Same as Fig. 1a, but for 1990-2014 drought events.

Wet Period Duration

A wet period indicates the time (in months) between drought events. There are years when only 1 break or wet period is observed whereas other years have 2 or more breaks. These breaks are shown in figures 2a and 2b. The number of bars per year indicates the number of breaks that a particular year had. The longest wet period for CD3was 45 months, shortest wet period was 2 months and the average wet period was 9 months. A very short wet period between some drought events indicates a short or very little recovery before the next drought occurred.

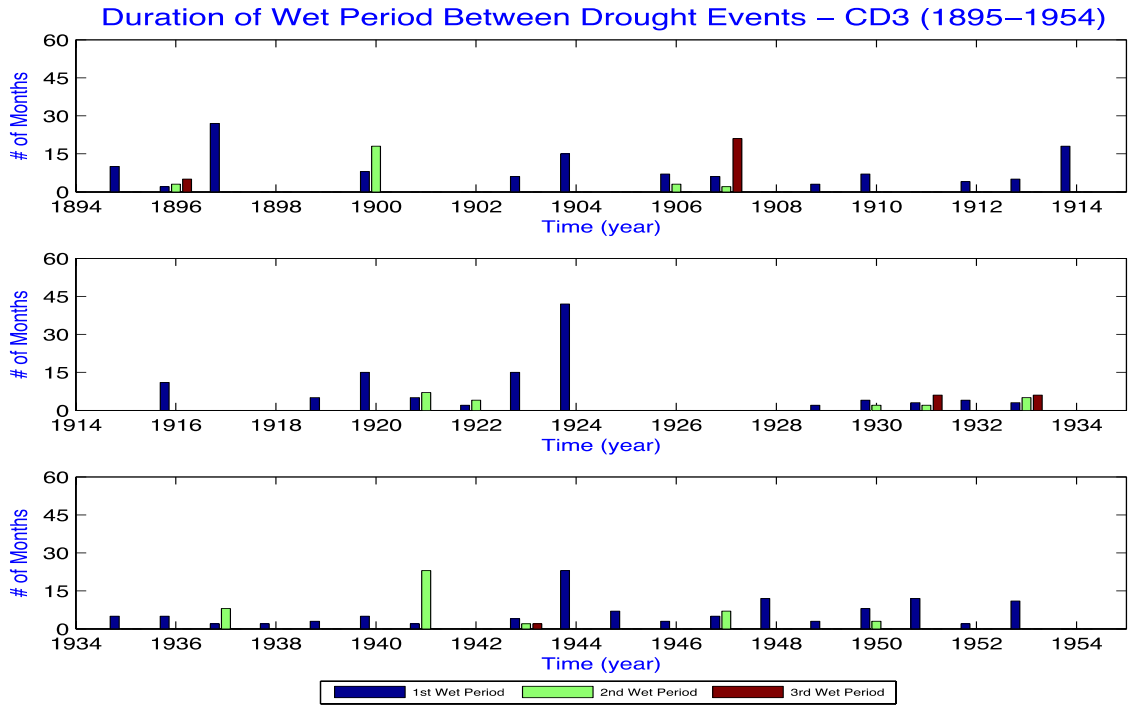


Fig. 2a. Breaks or wet periods per year.

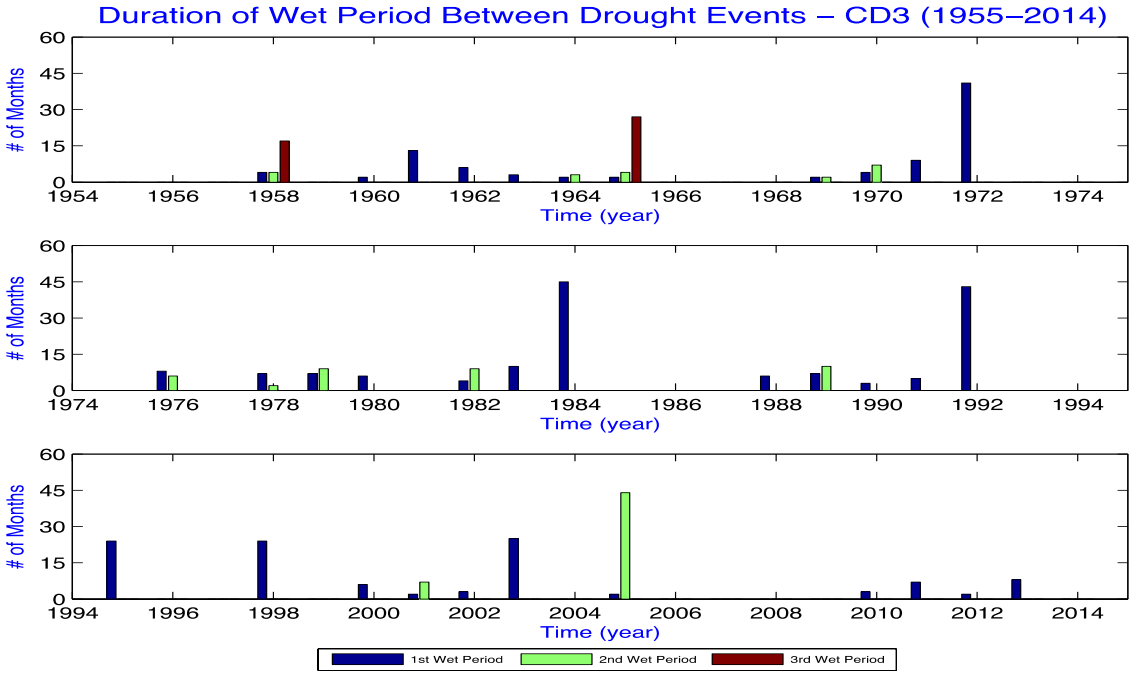


Fig. 2b. Same as Fig. 6a, but for 1955-2014.

Additional Data

Raw data are available from SCIPP as a Microsoft Excel file. If you would like to access this data, contact SCIPP at scipp@southernclimate.org or 405-325-7809.