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WHAT REALLY IS "NORMAL"?

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Introduction

Webster's Third New International Dictionary defines normal as being an "average over many years at a particular place and for a definite time, a certain day, or some other specified period." What is normal and what isn't has become an issue in both the media and in the meteorological community, especially with the occurrence of one of the largest meteorological events of the century, the 1997-98 ENSO event. Composite charts of deviations from normal were created by the Climate Diagnostics Center (CDC) last summer to show how the atmospheric changes related to El Niño have changed the weather in the past over the United States, and hopefully tell us how this current event would change the distribution of temperatures and precipitation. Now that forecasts of an upcoming La Niña event are being made, additional composites are being generated for the same purpose, to see how temperatures and precipitation could differ from normal. However, when we compare these deviations due to El Niño or La Niña to the average, are we really making a valid comparison? It will be shown that the average that we are comparing these deviations to, is itself comprised of more El Niño and La Niña years than nonevent years. This Technical Attachment (TA) will examine this issue and also demonstrate that additional information may be gained by looking at what is "normal" and what is not.

Methodology

Composite plots of temperature and precipitation departures were created over the Internet using information which is freely available on the CDC homepage at *http://www.cdc.noaa.gov/USclimate/USclimdivs.html*. The period of record for these data is 1895 through May 1998. The monthly values for the latest one to two years are based on preliminary data and are subject to some change when the final data is analyzed. These data are broken up by climatological division, with most states represented by numerous divisions based on climate differences. CDC has corrected the data as much as they can, to remove station biases, time of observation biases, and changes in climatic divisions.

As was demonstrated throughout this recent winter season, these types of plots show regions in the continental United States where there could be a greater likelihood of an extreme cold or warm season (or wet and dry) than one would expect by chance during an El Niño or La Niña event. These inferences are drawn by where similar occurrences have happened in the past, based on a number of previous El Niño or La Niña events. Because of the way the Internet site is designed, 'normal' or average conditions are derived from 1950-1995 data. Another design limitation of the site is that only up to ten years can be composited for each plot. Even with these limitations, it seems that some useful information can be gained from examining plots generated at this site.

The author decided to use 1950 as the cutoff for how far back in the historical record to go in constructing the plots. Plots were created for El Niño years (years with a significantly warmer Eastern Pacific), La Niña years (years with a significantly cooler Eastern Pacific), and years which had neither El Niño or La Niña occurring (nonevent years). Table 1 shows the years that were used for the creation of the plots. These years were divided into four periods of time: Winter (Jan - Mar), Spring (Apr - Jun), Summer (Jul - Sep), and Fall (Oct - Dec). Summer represents the period during which the ocean begins to warm/cool, with winter representing its peak and spring representing its demise.

Results

<u>El Niño</u>

The composite charts for El Niño show the main pattern which was forecasted by the National Centers, mainly for wet conditions along the southern tier of states and drier conditions to the north, especially in the Pacific Northwest and the Mid-Atlantic states. Of note are the composites depiction that Florida would see above normal precipitation developing in the late fall and lasting through March (Fig. 1), before below normal conditions would develop, especially through the central portion of the state (Fig. 2). However, it also shows the Pacific Northwest remaining dry through this spring (April - June), which did not occur.

Temperatures show the same distribution with the northern tier of states above normal and the southern tier below normal (Fig. 3). Many stations in the upper Midwest had their warmest or close to their warmest winter since records began, while stations in the South had continuous months of below normal temperatures. However, for the spring period, the composites show below normal temperatures continuing for New Mexico and Texas, which clearly was not the case this year. Warmer than normal conditions were seen in the composites in the Pacific Northwest and Great Basin, which again, clearly did not occur (not shown).

La Niña

The composite plots for July through September show slightly wetter conditions over the southeastern portion of the United States, with no clear signal elsewhere (Fig. 4). Temperatures show a bias toward being above normal over the upper Midwest extending into the Northeastern states, with slightly cooler than normal temperatures in the Pacific Northwest (Fig. 5).

For the fall period of October through December, the signals become a bit clearer with a bias for above normal precipitation from northern California northward along the West Coast (Fig. 6). Temperatures show a reversed bias from the El Niño signal, with below normal temperatures in the upper Midwest from Montana to Minnesota, and slightly above normal temperatures across the Southwest and Great Basin (Fig. 7).

During the winter period of January through March (Fig. 8), these same signals noted above become stronger with the entire northern tier of states biased toward below normal temperatures, with slightly above normal temperatures shifting to the southeast United States. Two areas of above normal precipitation are shown, one in the Pacific Northwest, and the other in the Mid-Atlantic states from northern Alabama to Pennsylvania (Fig. 9). A bias toward drier than normal conditions is located along the southern tier of states especially southern California, the Gulf Coast, and Florida.

By spring (April - June), the signal becomes noisy although there seems to be a tendency for slightly above normal precipitation to shift to the eastern third of the United States with slightly drier than normal conditions in the Midwest (Fig. 10). No large signal is evident within the temperature distribution except a slight bias toward below normal temperatures in the eastern third of the United States and a slight bias toward above normal in New Mexico and Texas (not shown).

Nonevent Years

Ten nonevent years were also composited. Why look at nonevent years? When we look at composites for El Niño or La Niña years, we compare them with a climatology which includes those years in them. Thus, our "normal" temperatures and precipitation are skewed by the years with warmer/colder sea surface temperatures off of South America. Trenberth (1997) found that El Niños have occurred 31% of the time since 1950, with La Niñas occurring 23% of the time. *Thus, nonevents have only occurred 46% of the time since 1950!* Therefore, "normal" is made up of El Niño, La Niña, and nonevent years, with nonevents making up less than half of the sample size. So far, we have only looked at two thirds of the available signal which makes up our "normal" values. Another signal should be apparent in the composites, mainly what biases from the 1950-1995 averages are due to nonevents in the Pacific Ocean.

In examining the composites for the July - September period, no clear signal could be seen in the temperature data, however precipitation showed a bias toward being below normal in the central United States in nonevent years with a slight bias towards above normal surrounding it (Fig. 11).

For the October - December period (Fig. 12), temperatures showed a slight bias toward below normal in the northern tier of states. A bias toward above normal precipitation could be seen in northern California and southwestern Oregon, along with a broad swath from Oklahoma into the Ohio River Valley (Fig. 13). The southeastern United States showed a bias towards below normal precipitation during this period.

Clearer signals became evident in the winter period (January - March). Temperatures showed a significant bias toward below normal in the eastern half of the United States, especially in the Ohio River Valley (Fig. 14). No clear signal was evident in the West, however. Two areas seem to stand out as having a bias toward below normal precipitation in the composite, namely the Pacific Northwest and an area from eastern Texas northeastward into Kentucky (Fig. 15). A small area of above normal precipitation bias can be seen in central California.

By spring, the signal again becomes much more noisy, with only a small area in the central Atlantic Coast region showing a bias toward below normal precipitation (Fig. 16). The Central Plains show a slight bias toward above normal precipitation, although no one area stands out. A slight bias exists in the western United States for below normal temperatures (not shown).

Discussion and Conclusion

So what does this all mean? Essentially, since what we consider to be "normal" is actually comprised of El Niño, La Niña, and nonevent years, we need to also examine the signal that arises when there is no significant departure in sea surface temperatures in the Pacific Ocean. In examining these nonevent years, equally relevant signals emerge as those that the composites for El Niño and La Niña years showed. Thus, to expect normal conditions to be likely because the sea surface temperatures show no clear deviation from climatology is clearly wrong in some areas of the United States. In areas where the effects of El Niño are balanced by the effects of La Niña, a "normal" forecast is more valid. However, in locations where the effects from El Niño are much stronger than those from La Niña, there is a higher tendency to deviate from what we consider as normal in nonevent years and vice versa. Based on the research of Trenberth, nonevent years make up less than half of the sample for our climatological normals, underscoring that these normals really don't represent any normal at all, but rather the average of three signals, El Niño, La Niña, and nonevents. Each of these three signals create different "normals" in different locations of the United States.

The signals seem strongest during the winter season, with summer being the season with the least amount of consistency. Some things to remember when looking at any composite chart is that the methods used rely upon statistics of past events with no guarantee that the same relationships will exist in the future. Since they show averages, it is possible that the composites are dominated by a few years with high or low values. It is also possible that the average never represents what any actual year will look like. However, these composites are our best indication of what *could* happen based on past experiences, and what was found out this past winter, can be of tremendous use for the public.

This TA examined the three main forcings on the atmosphere, based on El Niño, La Niña, and nonevent years. So far, composites for the first two forcings have been publicized widely, while composites for the nonevent years have gone largely unpublicized. It is clear from this brief examination of the nonevent years that there are some clear departures from what we consider "normal" when there isn't any significant ocean phenomena such as El Niño occurring. Hopefully this TA has shown that more care needs to be taken when comparing composite charts with the 1961-1990 averages, why it may be better to separate out all three signals for your local area, and how the Internet is allowing us to be able to create composites for any type of phenomena in an easy and efficient manner, without having to request large volumes of data, and go through it manually. Any efforts to improve on these Internet sites would allow even more compositing methods to be supported.

Acknowledgments

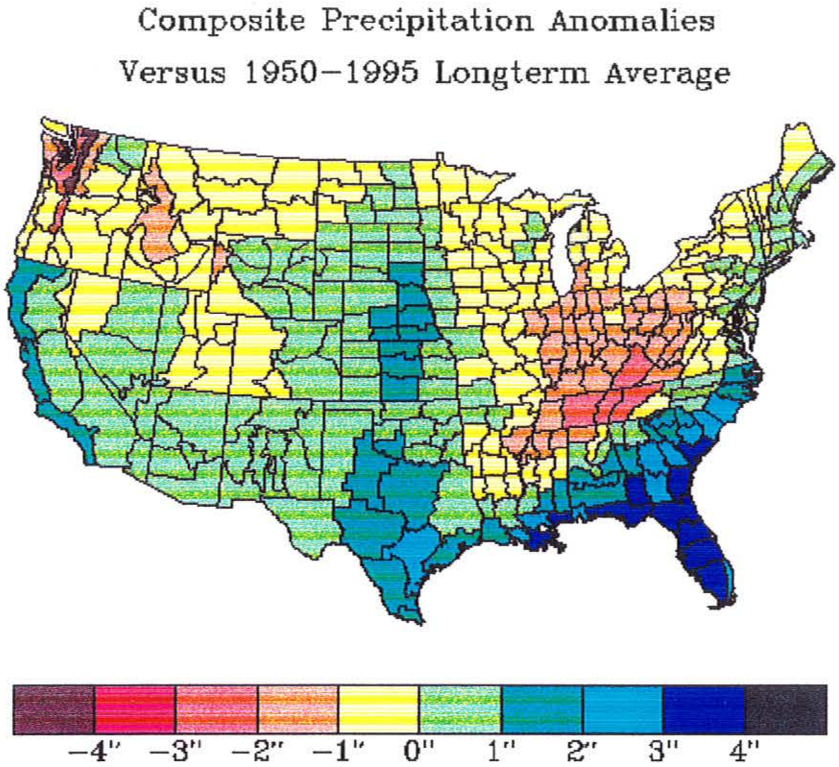
The author wishes to acknowledge the Climate Diagnostic Center for providing the data freely on the Internet. This allows research such as this to be done at the local level.

References

Trenberth, K.E., 1997: The Definition of El Niño. *Bull. Amer. Meteor. Soc.*, **78**, 2771-2777.

Table 1 - Years used in the composite study

El Niño	La Niña	Nonevents
1991-92	1995-96	1985-86
1986-87	1988-89	1984-85
1982-83	1975-76	1983-84
1976-77	1973-74	1981-82
1972-73	1970-71	1980-81
1969-70	1964-65	1979-80
1965-66	1955-56	1978-79
1963-64		1974-75
1957-58		1966-67
1951-52		1962-63



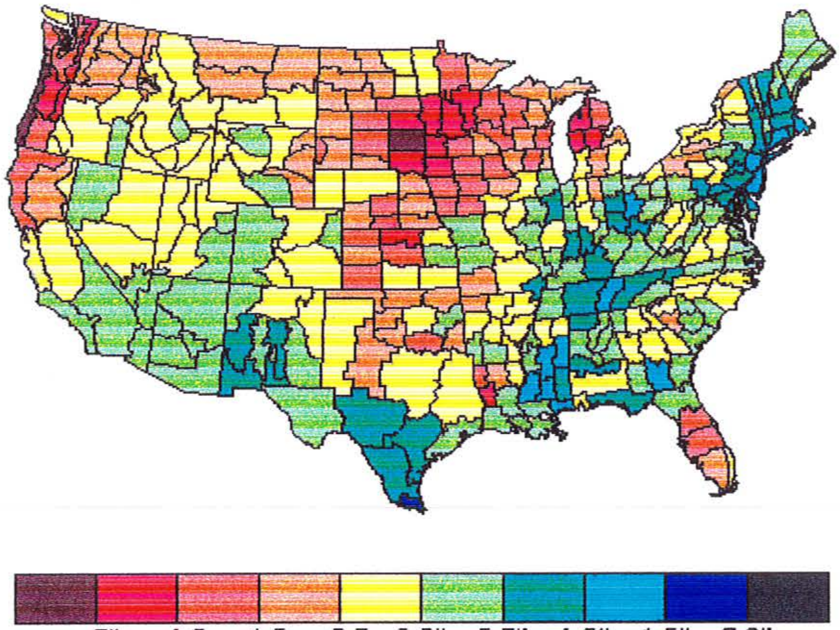
FTP a copy of the data used in the plot

Options Selected for plot

Variable: **Precipitation**
Type: **Average Anomaly**
Season: **Jan** to **Mar**
Number years in composite: **10**
First year in composite: **1992**
Date submitted: **6/28/1998 at 17:46** 1

Figure 1: Composite precipitation anomalies for Jan through Mar for El Niño years.

Composite Precipitation Anomalies
Versus 1950–1995 Longterm Average



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Options Selected for plot

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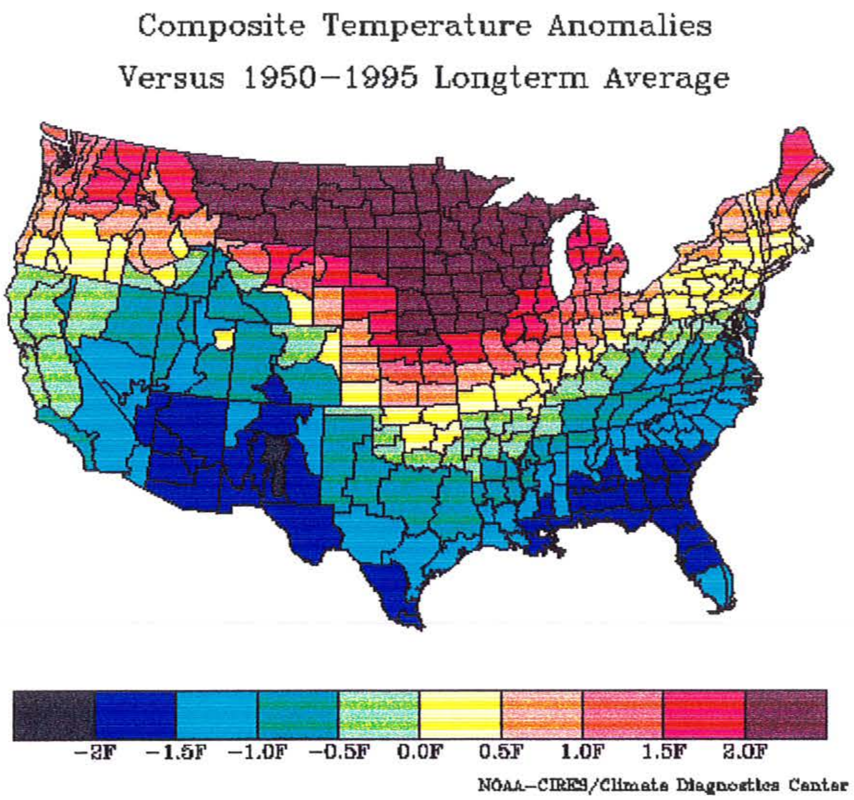
Type: **Average Anomaly**
Season: **Apr** to **Jun**
Number years in composite: **10**
First year in composite: **1992**
Date submitted: **6/28/1998 at 17:50** 1

Figure 2: Composite precipitation anomalies for Apr through Jun for El Niño years.



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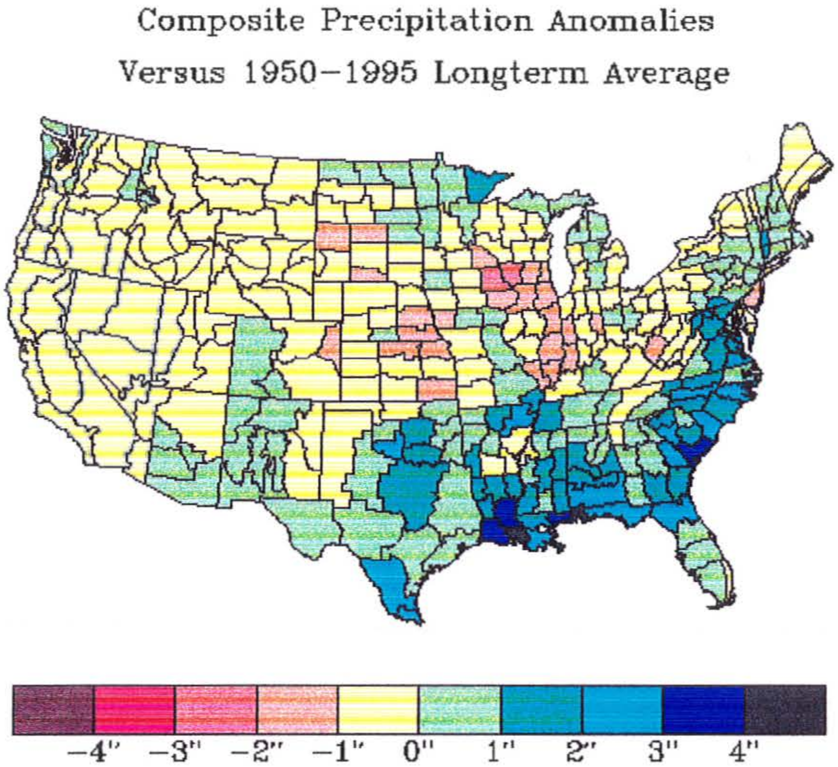
Type: **Average Anomaly**
Season: **Jan** to **Mar**
Number years in composite: **10**
First year in composite: **1992**
Date submitted: **6/28/1998 at 17:48** 1

Figure 3: Composite temperature anomalies for Jan through Mar for El Niño years.



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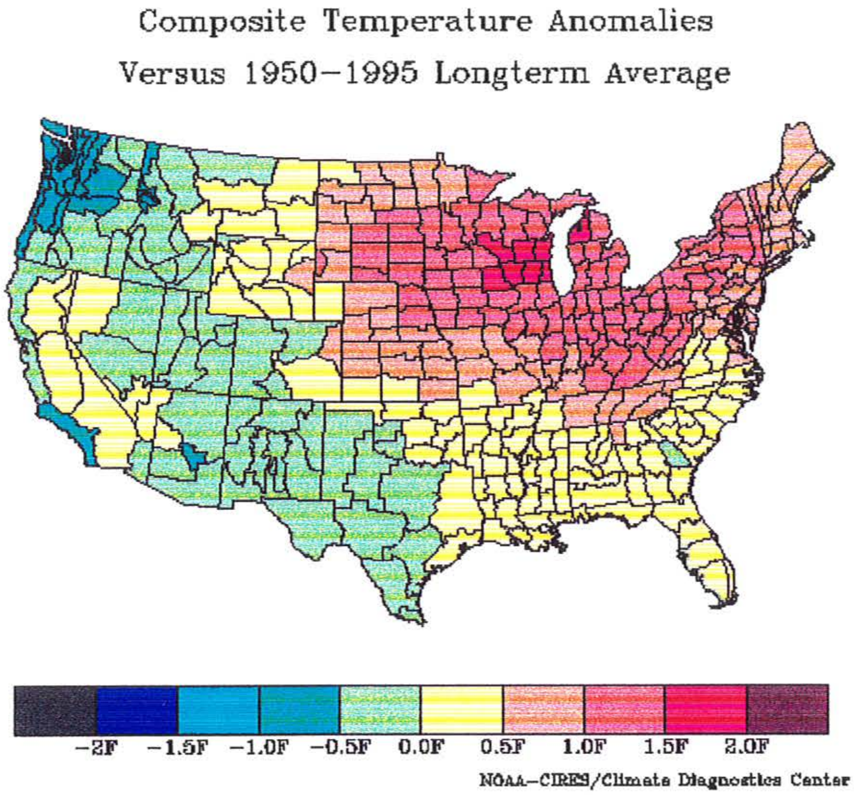
Options Selected for plot

Variable: **Precipitation**
Type: **Average Anomaly**
Season: **Jul** to **Sep**
Number years in composite: **7**
First year in composite: **1995**
Date submitted: **6/28/1998 at 17:23** 1

Figure 4: Composite precipitation anomalies for Jul through Sep for La Niña years.

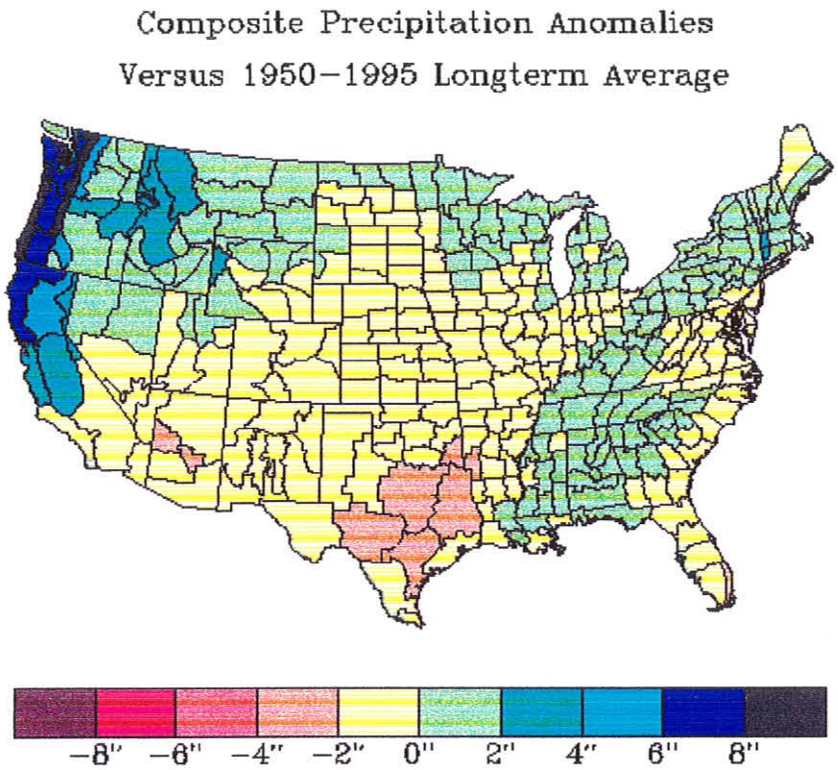


FTP a copy of the data used in the plot

Options Selected for plot

Variable: **Temperature**
Type: **Average Anomaly**
Season: **Jul** to **Sep**
Number years in composite: **7**
First year in composite: **1995**
Date submitted: **6/28/1998 at 17:24** 1

Figure 5: Composite temperature anomalies for Jul through Sep for La Niña years.

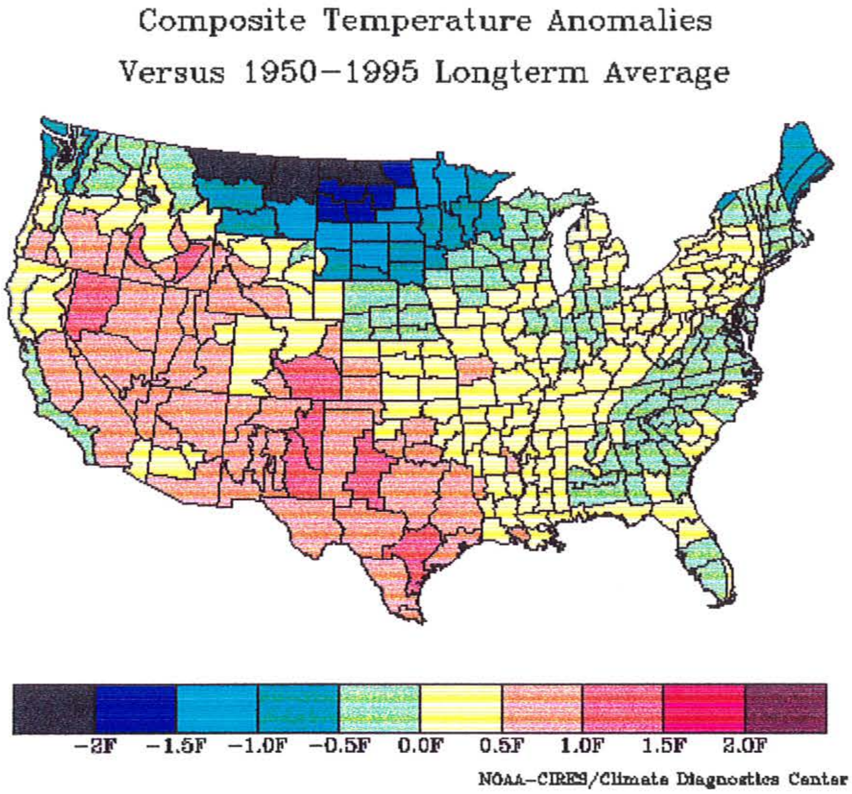


FTP a copy of the data used in the plot

Options Selected for plot

Variable: **Precipitation**
Type: **Average Anomaly**
Season: **Oct** to **Dec**
Number years in composite: **7**
First year in composite: **1995**
Date submitted: **6/28/1998 at 17:26** 1

Figure 6: Composite precipitation anomalies for Oct through Dec for La Niña years.



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Options Selected for plot

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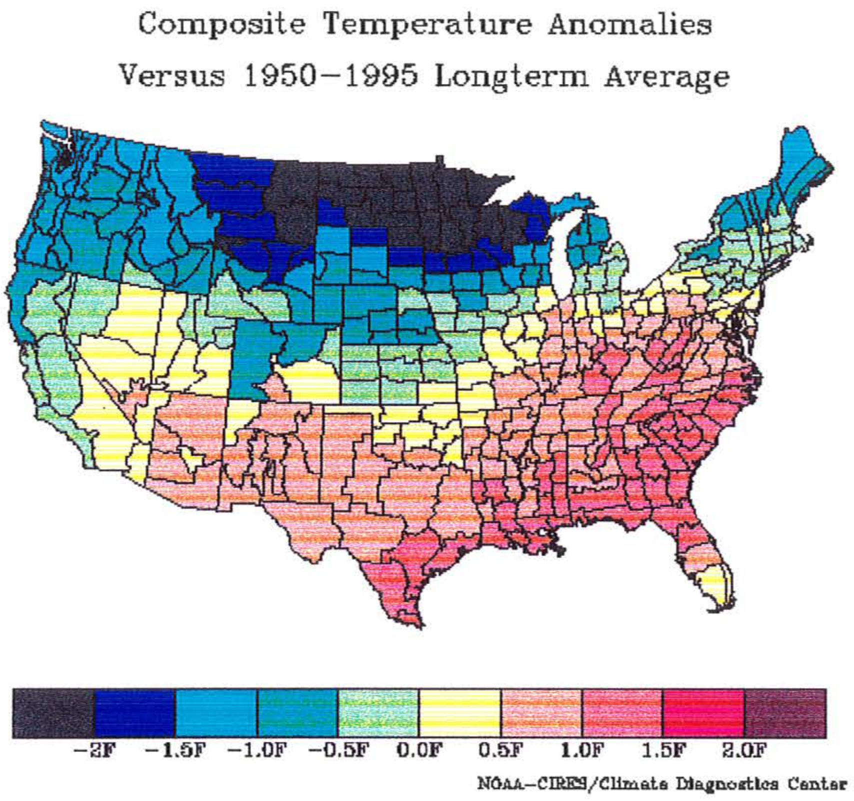
Type: **Average Anomaly**
Season: **Oct** to **Dec**
Number years in composite: **7**
First year in composite: **1995**
Date submitted: **6/28/1998 at 17:25** 1

Figure 7: Composite temperature anomalies for Oct through Dec for La Niña years.

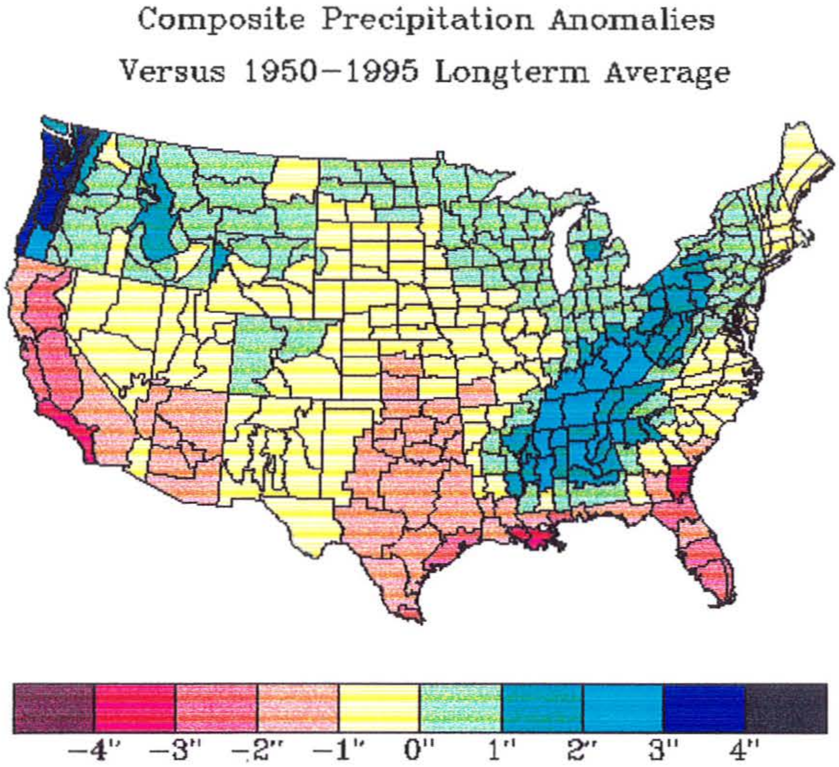


FTP a copy of the data used in the plot

Options Selected for plot

Variable: **Temperature**
Type: **Average Anomaly**
Season: **Jan** to **Mar**
Number years in composite: **7**
First year in composite: **1996**
Date submitted: **6/28/1998 at 17:29** 1

Figure 8: Composite temperature anomalies for Jan through Mar for La Niña years.

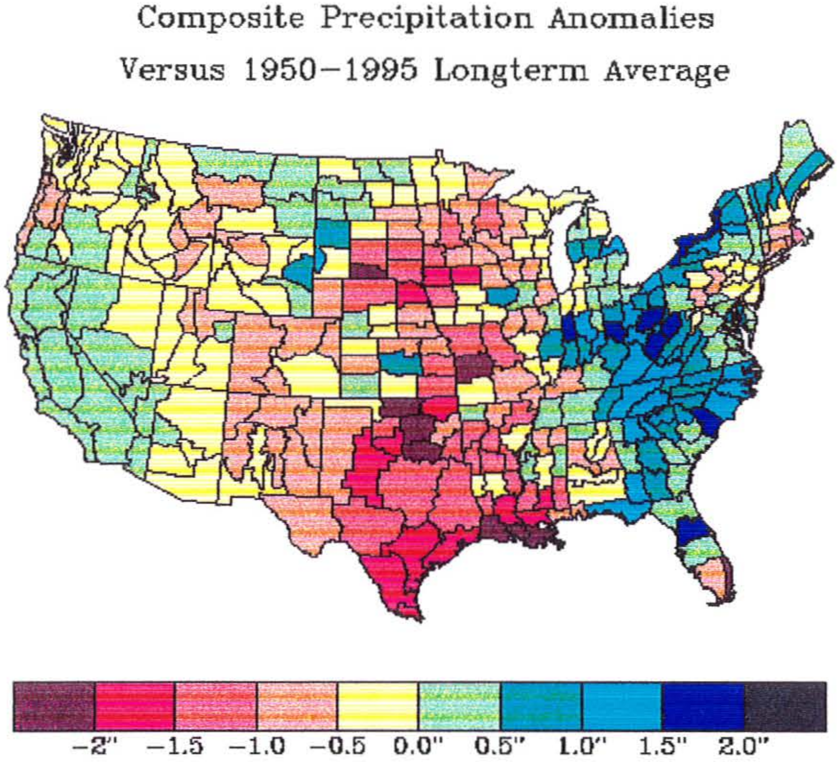


FTP a copy of the data used in the plot

Options Selected for plot

Variable: **Precipitation**
Type: **Average Anomaly**
Season: **Jan** to **Mar**
Number years in composite: **7**
First year in composite: **1996**
Date submitted: **6/28/1998 at 17:28** 1

Figure 9: Composite precipitation anomalies for Jan through Mar for La Niña years.

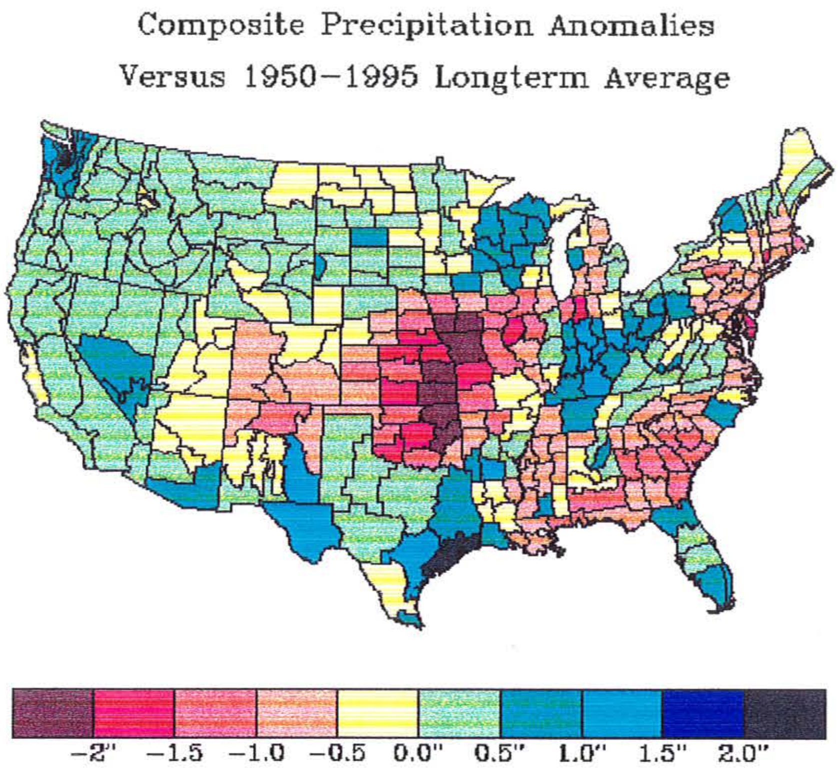


FTP a copy of the data used in the plot

Options Selected for plot

Variable: **Precipitation**
Type: **Average Anomaly**
Season: **Apr** to **Jun**
Number years in composite: **7**
First year in composite: **1996**
Date submitted: **6/28/1998 at 17:32** 1

Figure 10: Composite precipitation anomalies for Apr through Jun for La Niña years.



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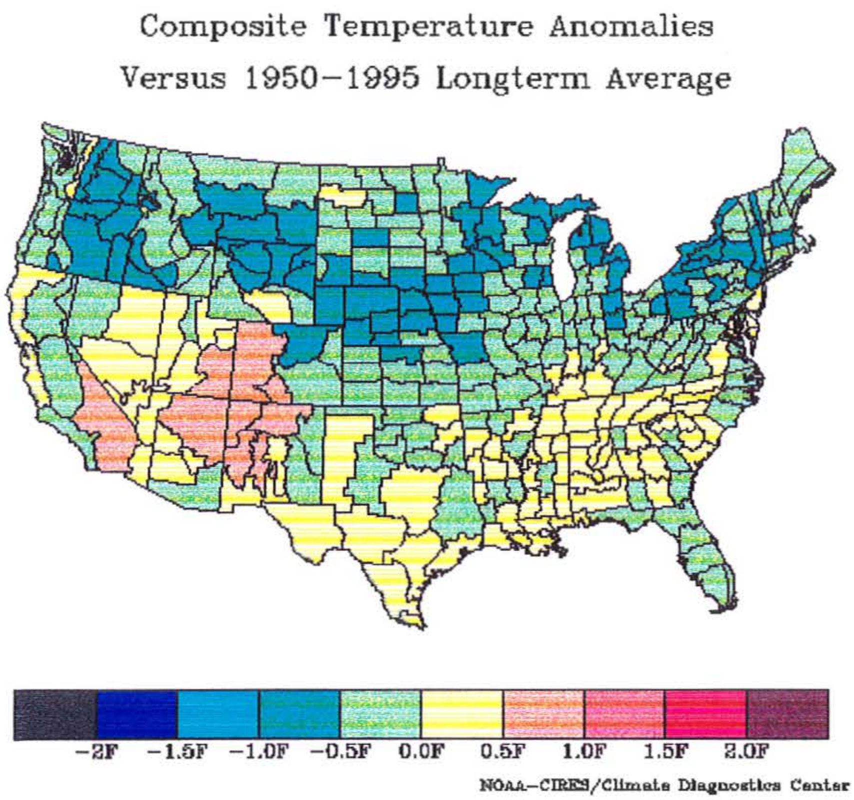
Options Selected for plot

Variable: **Precipitation**
Type: **Average Anomaly**
Season: **Jul** to **Sep**
Number years in composite: **10**
First year in composite: **1985**
Date submitted: **6/28/1998 at 17:03** 1

Figure 11: Composite precipitation anomalies for Jul through Sep for nonevent years.



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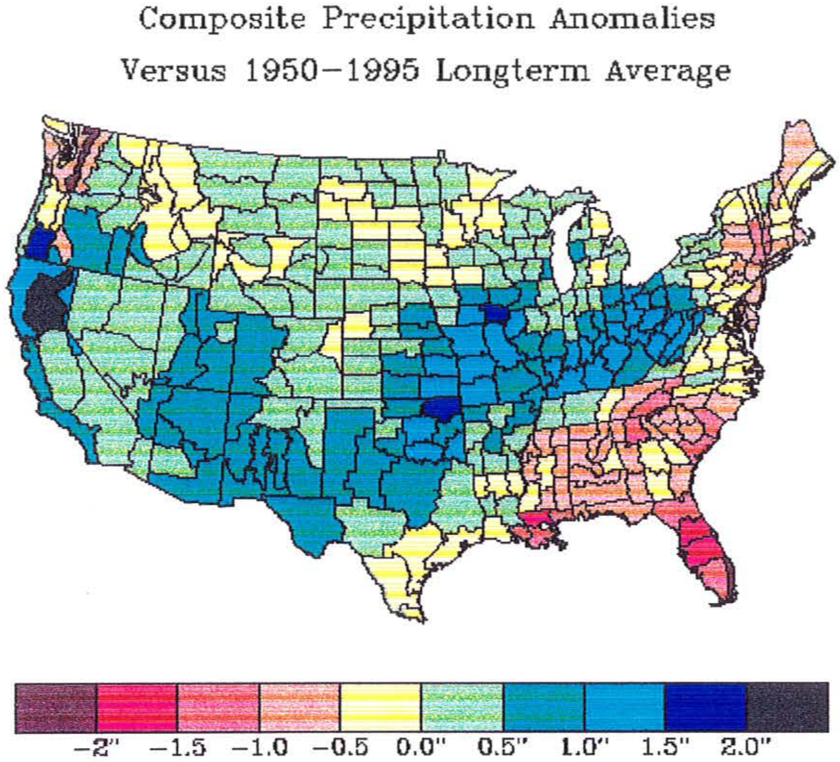
Options Selected for plot

Variable: **Temperature**
Type: **Average Anomaly**
Season: **Oct** to **Dec**
Number years in composite: **10**
First year in composite: **1985**
Date submitted: **6/28/1998 at 17:06** 1

Figure 12: Composite temperature anomalies for Oct through Dec for nonevent years.



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Options Selected for plot

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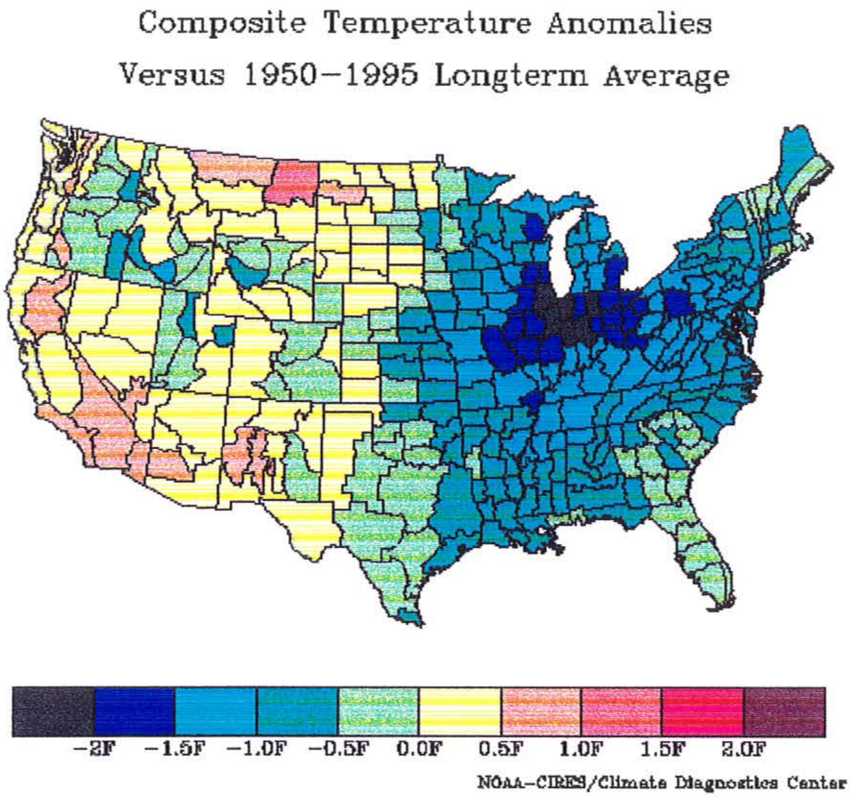
Season: **Oct** to **Dec**
Number years in composite: **10**
First year in composite: **1985**
Date submitted: **6/28/1998 at 17:08** 1

Figure 13: Composite precipitation anomalies for Oct through Dec for nonevent years.



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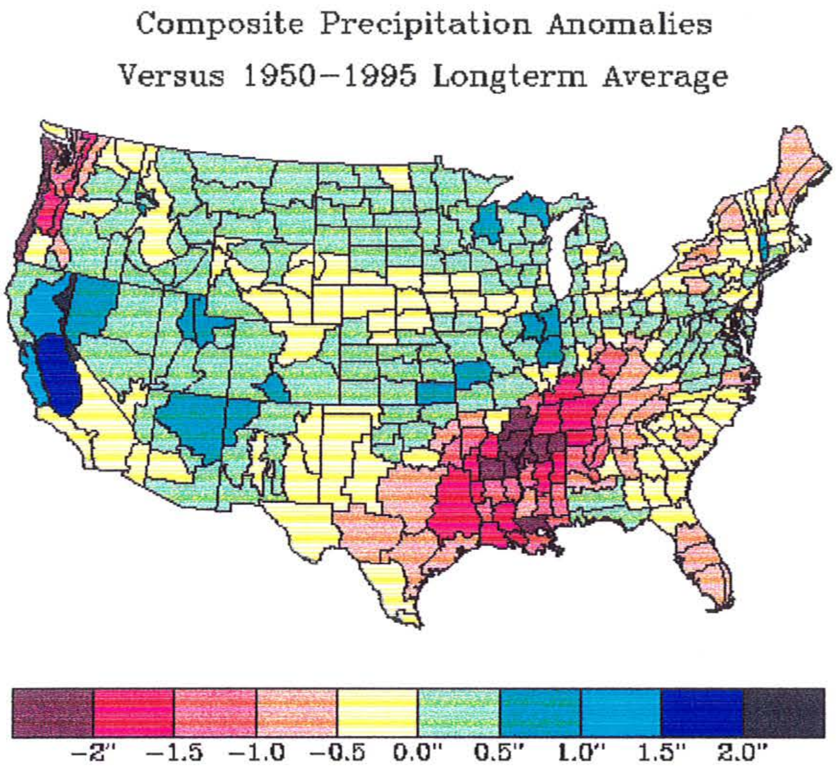
Variable: **Temperature**
Type: **Average Anomaly**
Season: **Jan** to **Mar**
Number years in composite: **10**
First year in composite: **1986**
Date submitted: **6/28/1998 at 17:17** 1

Figure 14: Composite temperature anomalies for Jan through Mar for nonevent years.



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Options Selected for plot

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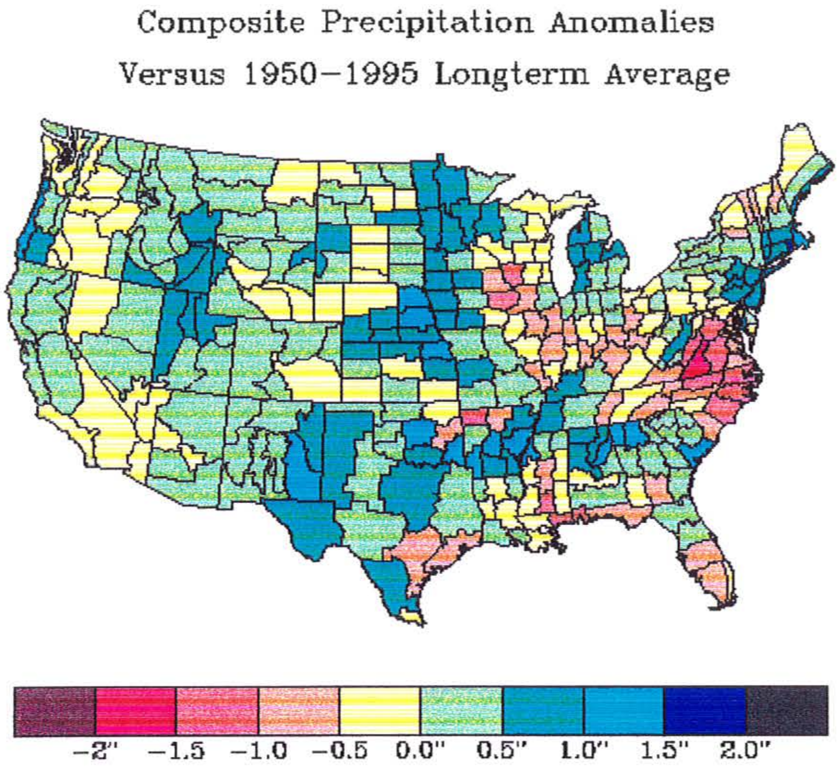
Season: **Jan** to **Mar**
Number years in composite: **10**
First year in composite: **1986**
Date submitted: **6/28/1998 at 17:16** 1

Figure 15: Composite precipitation anomalies for Jan through Mar for nonevent years.



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Options Selected for plot

Variable: **Precipitation**
Type: **Average Anomaly**
Season: **Apr** to **Jun**
Number years in composite: **10**
First year in composite: **1986**
Date submitted: **6/28/1998 at 17:19** 1

Figure 16: Composite precipitation anomalies for Apr through Jun for nonevent years.