11B.2 THE CLIMATE OF 2008 IN HISTORICAL PERSPECTIVE

THE CLIMATE OF 2008 IN HISTORICAL PERSPECTIVE

Richard R. Heim Jr.*, Karin Gleason, Karsten Shein, Ahira Sánchez-Lugo, Michael J. Brewer,
NOAA National Climatic Data Center, Asheville, North Carolina

Chris Fenimore
STG, Inc., Asheville, North Carolina

ABSTRACT

The increase in global temperatures recorded over the past 100+ years has occurred in all seasons and throughout almost all regions of the world. There is also evidence that a more rapid rise in global temperatures that began in the 1970's is continuing and there are indications of increases in climate extremes during the past several decades. In this annual summary of the climate of 2008 (based on preliminary data available as of this writing), the NOAA National Climatic Data Center (NCDC) provides an overview of conditions throughout the U.S. and around the world during the past year. As the scientific community works to better understand our changing climate, continual monitoring provides vital information on climate variability, continuing trends and the incidence of extreme events. Our primary focus places the recent climate record in historical perspective based on more than 125 years of in-situ temperature and precipitation measurements as well as paleoclimate records that extend understanding of the earth's climate to the more distant past. Included is a discussion of century-scale variability and trends in temperature and precipitation as well as extreme events such as droughts, tornadoes and tropical storms. The 2008 annual report can be found online at:
http://www.ncdc.noaa.gov/oa/climate/research/2008/ann/ann08.html

1. GLOBAL CLIMATE ANOMALIES IN 2008

1.1 *Global Temperature*

Data for 2008 were available through only October as of this writing. The global (land and ocean) annual (January-October) average temperature anomaly (compared to the 1901-2000 mean) for 2008 was +0.47°C, which gave 2008 a rank of 9th warmest for January-October, based on data going back to 1880 (Figure 1). The global land temperature rank was 6th warmest and global ocean temperature rank was 10th warmest. The spatial pattern of January-October 2008 temperature anomalies is shown in Figure 2. The warmest anomalies occurred over Eurasia while the coldest anomalies occurred over parts of North America. The global and hemispheric January-October temperature ranks are summarized in Table 1.

Notable monthly temperature anomalies occurred in Australia and parts of East Asia. Australia experienced its warmest January during 2008 in the 1950-2008 period of record, while Uzbekistan had the coldest January temperatures in nearly four decades.

January-October 2008		Anomaly	Rank
Global			
	Land	+0.75°C	6th warmest
	Ocean	+0.37°C	10th warmest
	Land and Ocean	+0.47°C	9th warmest
Northern Hemisphere			
	Land	+0.83°C	5th warmest
	Ocean	+0.40°C	8th warmest
	Land and Ocean	+0.56°C	8th warmest
Southern Hemisphere			
	Land	+0.50°C	8th warmest
	Ocean	+0.34°C	12th warmest
	Land and Ocean	+0.37°C	10th warmest

Table 1. January-October 2008 surface temperature anomaly (°C) and rank (1=warmest, 129=coldest). Source: NOAA/NCDC.

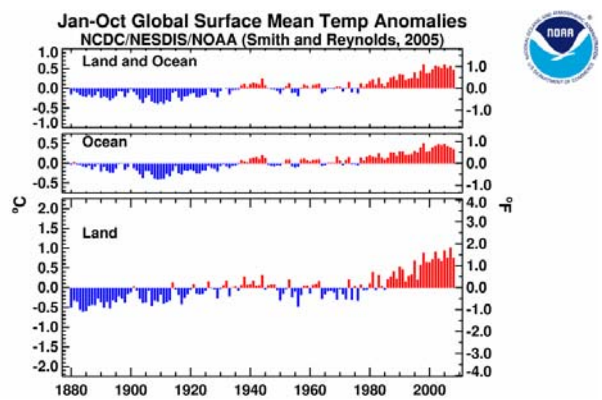

Figure 1. Global surface mean temperature anomalies for January-October, 1880-2008. Source: NOAA/NCDC.

* *Corresponding author address:* Richard Heim, NOAA National Climatic Data Center, 151 Patton Ave., Asheville, NC 28801; e-mail: Richard.Heim@noaa.gov.

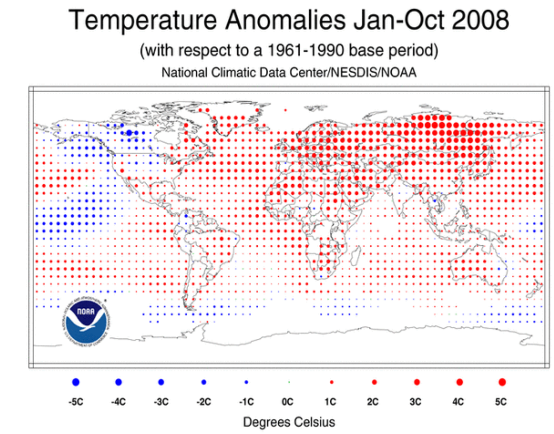

Figure 2. Global surface mean temperature anomalies for January-October 2008. Source: NOAA/NCDC.

1.2 *Tropospheric Temperatures*

Temperatures above the surface of the earth are measured using in-situ balloon-borne instruments (radiosondes) and polar-orbiting satellites (NOAA's TIROS-N). The radiosonde (RATPAC) and satellite records have been adjusted to remove time-dependent biases (artificialities caused by changes in radiosonde instruments and measurement practices as well as changes in satellite instruments and orbital features through time). Several different adjustment algorithms are applied to the satellite data. NCDC's monitoring activities utilize the adjustments by the University of Alabama in Huntsville (UAH), Remote Sensing Systems (RSS), and University of Washington (UW). Global averages from radiosonde data are available from 1958 to present, while satellite measurements began in 1979. The length of record can affect the period of record means, the resulting sign of the anomalies, period of record trends, and, therefore, one's perception of the importance and meaning of the ranks and time series for each analysis.

Radiosonde measurements indicate that for January-October 2008, temperatures in the mid-troposphere were 0.17°C above average, resulting in the 19th warmest January-October period in the 1958-2008 record (Figure 3). Satellite measurements of January-October 2008 mid-tropospheric temperatures, based on the shorter 1979-2008 period, varied from 20th warmest (11th coolest) to 25th warmest (6th coolest) (see Table 2).

1.3 *Global Precipitation and Drought*

The spatial pattern of January-October 2008 precipitation consisted of large areas of wet anomalies over the central and northeast U.S., Southeast Asia, Amazon Basin, and parts of Western Europe and northern Australia. Dry anomalies dominated much of the Mediterranean Sea, Australia, Hawaii, the western U.S., and parts of southern Africa, South America, and East Asia.

As of February 2008, Spain had suffered from the worst drought in more than a decade, while Portugal had the worst winter drought since 1917. Central and southern parts of Chile faced their worst drought in five decades. Parts of Australia have been experiencing drought conditions for over a decade, with January-October 2008 rainfall totals very low and numerous locations expecting record low annual totals.

January-October	Anomaly	Rank
Lower Troposphere		
UAH	+0.02°C	19th warmest
RSS	+0.07°C	16th warmest
Mid-Troposphere		
UAH	-0.13°C	25th warmest
RSS	-0.07°C	22nd warmest
UW-UAH	-0.03°C	21st warmest
UW-RSS	+0.02°C	20th warmest
RATPAC	+0.17°C	19th warmest

Table 2. January-October 2008 global tropospheric temperature anomaly (°C) and rank (out of 30 years for the satellite data, 1=warmest, 30=coldest; out of 51 years for the radiosonde [RATPAC] data, 1=warmest, 51=coldest). Source: NOAA/NCDC, UAH, UW, RSS.

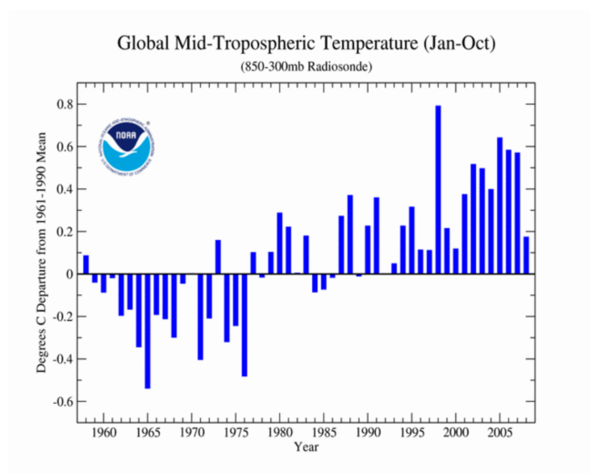

Figure 3. Global mid-tropospheric mean temperature anomalies for January-October, 1959-2008, based on radiosonde (RATPAC) data. Source: NOAA/NCDC.

1.4 *Northern Hemisphere Snow Cover*

Satellite observations of snow cover extent began in late 1966. The January 2008 Northern Hemisphere snow cover extent was the largest January extent in the historical record (Figure 4). It was also the largest January extent in Eurasia, with severe winter weather bringing freezing temperatures and heavy snow across much of China and central Asia. The worst severe winter weather in five decades affected over 78 million people in China, destroyed nearly 107,000 homes, and was responsible for 60 fatalities. Iran experienced its heaviest snowfall in more than a decade, while Baghdad, Iraq saw snowfall for the first time in living memory.

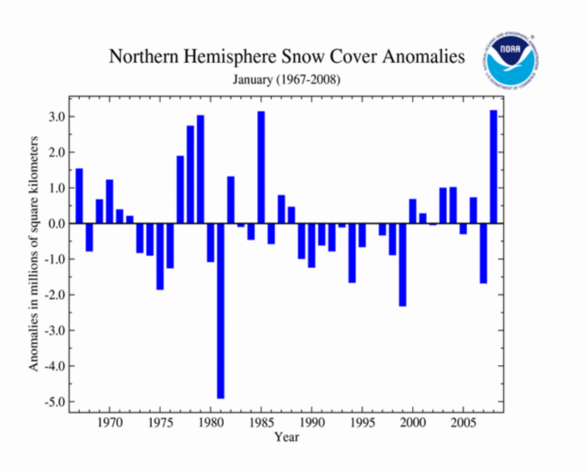

Figure 4. Northern Hemisphere snow cover anomalies, January, 1967-2008. Source: Rutgers University.

Unusually warm temperatures in the subsequent months resulted in the least snow cover extent for Eurasia during March, April, and boreal spring. March 2008 ranked as the 2nd least snow cover extent for the Northern Hemisphere, behind 1990 (Figure 5).

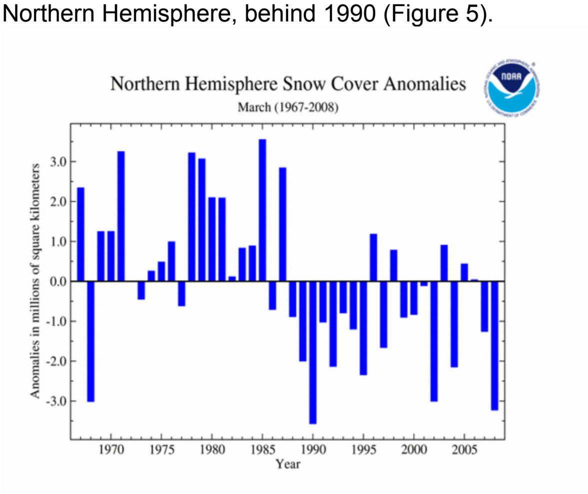

Figure 5. Northern Hemisphere snow cover anomalies, March, 1967-2008. Source: Rutgers University.

1.5 *Arctic Sea Ice Extent*

Northern Hemisphere sea ice extent is measured from passive microwave instruments onboard NOAA satellites and has a record going back to 1979. The seasonal cycle – of expanding ice in the cold season and contracting ice in the warm season (with the seasonal cycle reaching a minimum typically in September) – is based largely on sun-earth orbital considerations and resulting seasonal variations in solar energy received in the northern latitudes. When examining trends in arctic sea ice extent, this normal seasonal cycle needs to be taken into account. The long-term variations in sea ice extent on a month-by-month basis reveal a significant decreasing trend since 1979 in all months. The 2008 monthly sea ice extent was second lowest for August and second lowest for September (Figure 6). In both cases, the lowest extent occurred in 2007. September sea ice extent has decreased at a rate of 11.7 percent per decade.

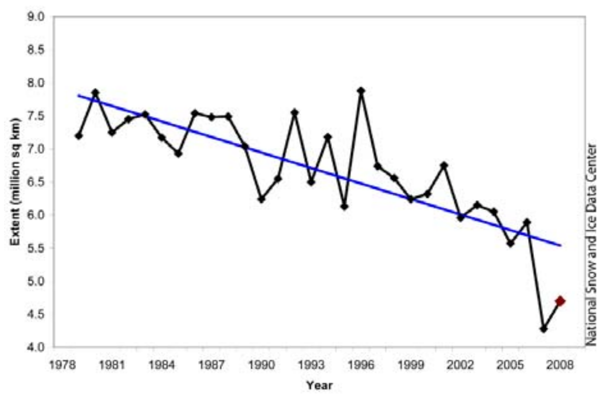

Figure 6. Northern Hemisphere sea ice anomalies, September, 1979-2008. Source: NSIDC.

1.6 *Tropical Cyclones*

Global tropical cyclone activity was below average during 2008, with 42 hurricanes/typhoons/cyclones and 20 "major" hurricanes/typhoons/cyclones (all 2007-2008 data are preliminary). Tropical cyclone activity by ocean basin is summarized in Table 3.

Ocean Basin	Activity	Number of Storms	Number of Cyclones
Atlantic	Above average	16	8
East Pacific	Near average	17	7
NW Pacific	Below average	25	11
South Pacific	Below average	7	3
North Indian	Near average	7	1
South Indian	Above average	12	8
Australian	Near average	9	4

Table 3. Tropical cyclone activity in 2008, by ocean basin. Cyclones are called hurricanes in the Atlantic and East Pacific basins. The values for southern hemisphere oceans are tallied from July 1, 2007 through June 30, 2008 to capture the southern hemisphere seasonal offset. Source: UNISYS, University of Hawaii, NCDC preliminary best track data.

The western Pacific Ocean had, for the first time since 1959, three typhoons form in May. Tropical Cyclone Ivan (South Indian Ocean) was one of the strongest cyclones ever to strike Madagascar. Tropical

Storm Fay (Atlantic basin) was the first storm in recorded history to make four landfalls in Florida (or in any state). In the Atlantic basin, 2008 was the second most destructive season on record, behind 2005, and was the only year in which a major hurricane existed in every month from July through November. In terms of accumulated cyclone energy (based on integrated wind power of all tropical cyclones during the season, both landfalling and those remaining out at sea), 2008 ranked as the 16th most energetic season out of the last 59 (see Figure 7).

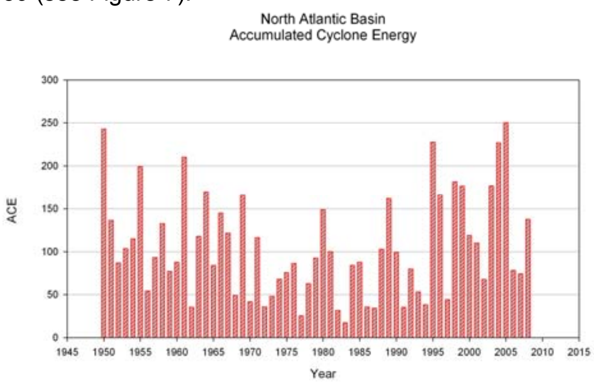

Figure 7. Accumulated Cyclone Energy for the North Atlantic Basin, 1950-2008. Source: NOAA/NCDC.

2. U.S. CLIMATE ANOMALIES IN 2008

2.1 *U.S. Temperatures*

In contrast to the continued unusual warmth on a global scale, 2008 temperatures in the contiguous United States averaged near the 20th century mean (Figure 8). This broke a string of ten consecutively much-warmer-than-average years. The spatial temperature pattern consisted of persistently cool anomalies in the central U.S. with warm anomalies in the Southwest and Northeast (Figure 9). No large-scale heat outbreaks occurred on either a monthly or seasonal time scale during 2008.

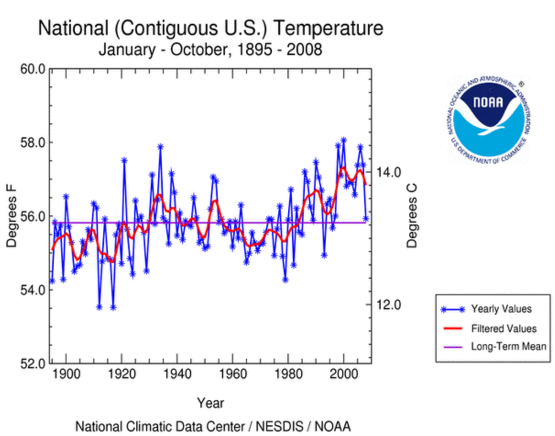

Figure 8. Contiguous U.S. temperatures, January-October, 1895-2008. Source: NOAA/NCDC.

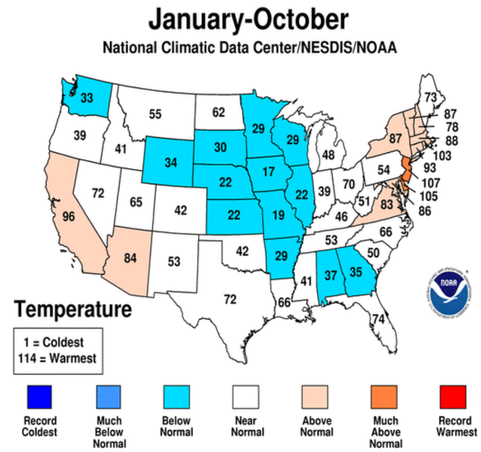

Figure 9. Statewide temperature ranks for January-October 2008. Source: NOAA/NCDC.

2.2 *U.S. Precipitation and Drought*

The below-average temperature anomalies in the central U.S. were associated with above-average precipitation anomalies, with persistent wetness occurring from the Great Plains to the Northeast (Figure 10). It was the wettest year (January-October 2008) in the 114-year record for Missouri and New Hampshire, and second wettest for Illinois and Massachusetts.

A series of strong storm systems dumped heavy rain over the Midwestern U.S. during the first half of June 2008. Widespread flooding occurred along the Mississippi River and its tributaries, with several dams and levees breached in Wisconsin, Iowa, and Indiana. The record June rains combined with persistently wet conditions earlier during the winter and spring to give Iowa, Missouri, and Ohio a rank of wettest January-June on record. Numerous locations in the flood zone experienced as many as 10 extremely wet days (days with more rainfall than 90% of all historical events for that location and time of year) during April 1-June 15 (Figure 11). Approximately one third of NOAA's observing stations in the region experienced a record number of extremely wet days for this period.

In contrast, 2008 was characterized by persistently dry conditions across much of the West, Southeast, northwestern Great Lakes, and south central Texas (Figures 12a-b). California had its driest spring (March-May) and March-August periods on record, and Nevada had its driest March-September period. By year's end, extreme to exceptional drought was occurring across parts of the Southeast, south central Texas, and Hawaii (Figure 12b). Based on the Palmer Drought Index, the 2008 percent area of the contiguous U.S. experiencing moderate-extreme drought peaked at 31% in June-July, while the 2008 percent area in moderate-extreme wet spell conditions peaked at 29% in October (Figure 13).

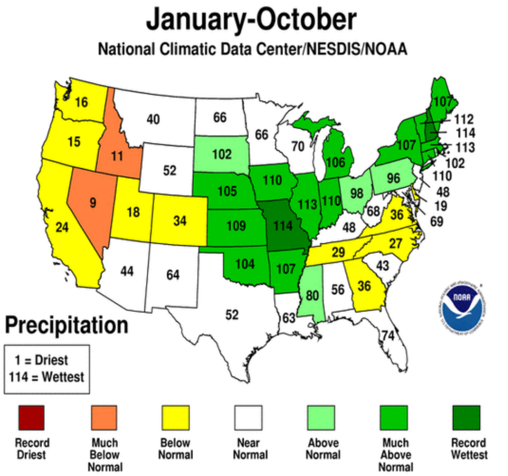

Figure 10. Statewide precipitation ranks for January-October 2008. Source: NOAA/NCDC.

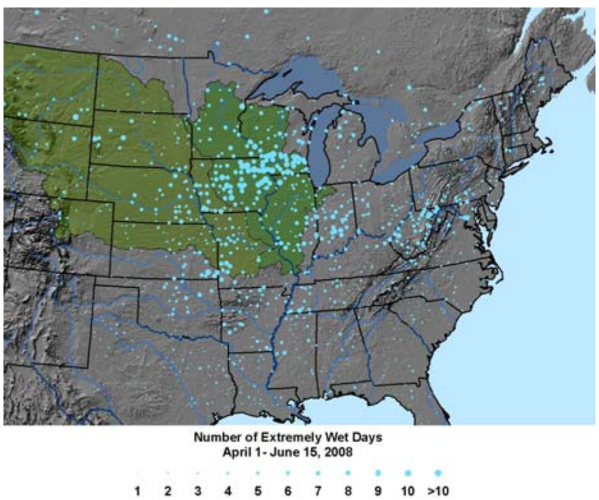

Figure 11. Number of extremely wet days from April 1-June 15, 2008. The Missouri and Upper Mississippi river basins are delineated. Source: NOAA/NCDC.

December 2007-June 2008 ranked as the fourth driest December-June in the 114-year precipitation record for south central Texas. A precipitation index for this region based on tree-ring data covers the period 1652-1995. The correlation between the annual values of the tree-ring record and December-June precipitation is 0.748, indicating a high degree of shared variance. In the approximately 250-years prior to 1896, the tree-ring record shows about a dozen individual years that likely had very low December-June precipitation similar to the lowest values in the past century, such as 2008 (Figure 14). The 1950s drought is the drought of record for the 20th century, with seven consecutive years (1950-1956, orange bar in Figure 14) having below-normal December-June precipitation. Looking at multi-year droughts, the 1950s drought appears to have been matched and possibly exceeded by one that occurred in the early 1700s (red bar), in which the ring-width index was below average for seven years in a row (1711-1717) and the cumulative ring-width anomaly for those seven years was slightly lower than for 1950-1956.

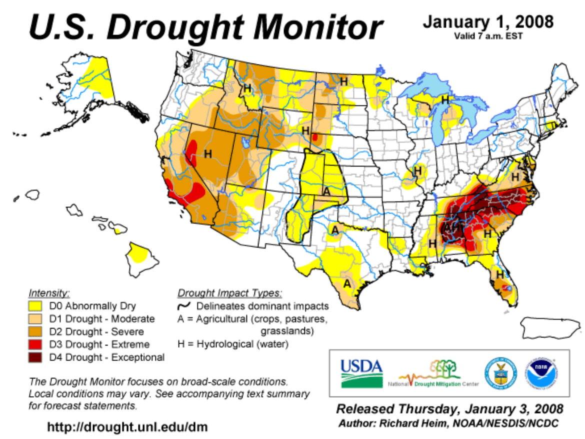

Figure 12a. U.S. Drought Monitor depicting drought conditions at the beginning of the year (January 1, 2008). Source: NDMC.

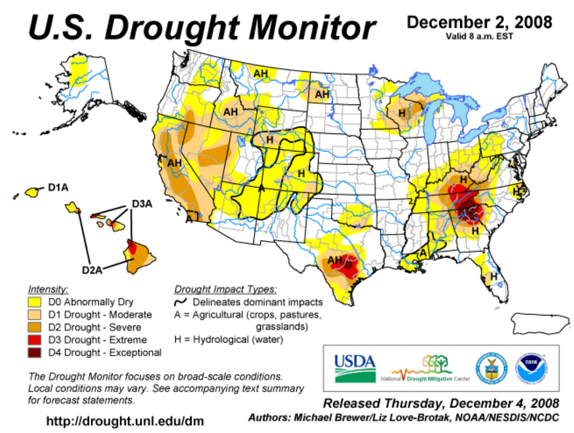

Figure 12b. U.S. Drought Monitor depicting drought conditions near the end of the year (December 2, 2008). Source: NDMC.

2.3 *U.S. Tornadoes*

The year began with unusual tornado activity in the U.S. The second largest January tornado outbreak on record occurred with 54 confirmed tornado reports on the 7th and 8th. On February 5 – “Super Tuesday Outbreak” – 87 tornadoes occurred while 24 states held primary elections. There were 57 deaths, the highest number of fatalities from a single outbreak since May 31, 1985 (76 deaths occurred then). With 460 tornadoes confirmed, May 2008 was the third most active May on record. June had two additional outbreaks causing 289 confirmed tornadoes. The high number of tornado-related fatalities during the first half of 2008 makes this one of the top ten deadliest January-October periods since reliable records began in 1953 (Figure 15).

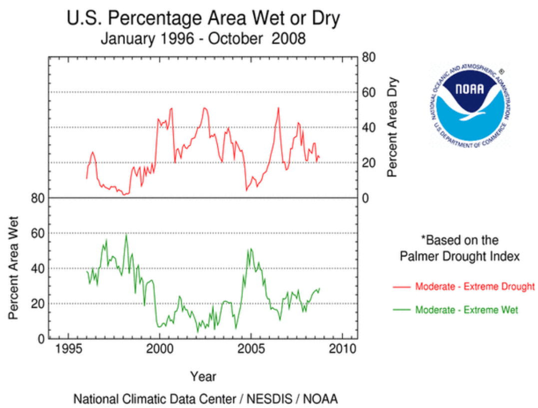

Figure 13. Percent area of the contiguous U.S. experiencing moderate to extreme drought (top, red) and moderate to extreme wet spell conditions (bottom, green) for January 1996-October 2008, based on the Palmer Drought Index. Source: NOAA/NCDC.

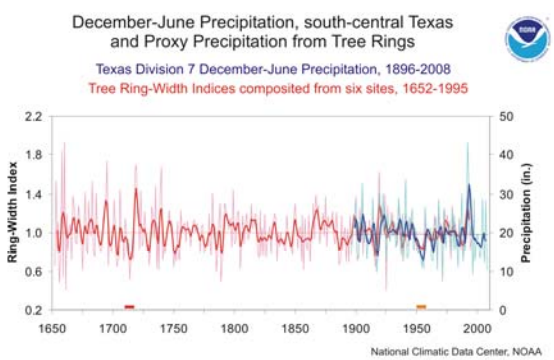

Figure 14. South-central Texas December-June precipitation (1896-2008, blue curves) and proxy precipitation from tree rings (1652-1995, red curves). Annual values are shown as the thin curves, 5-year smoothed values are shown as the thick curves. Source: NOAA/NCDC/Paleoclimatology Branch.

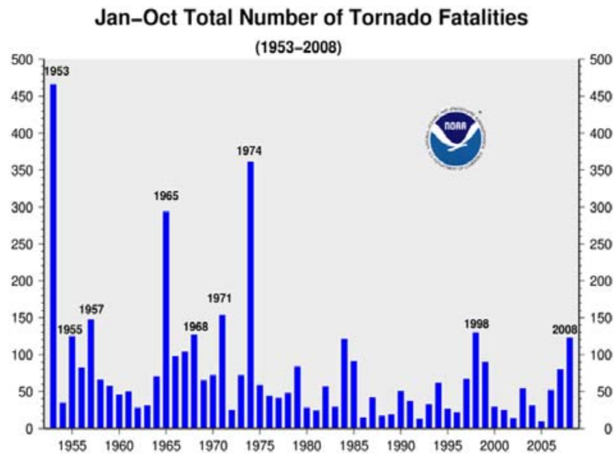

Figure 15. Total number of U.S. tornado fatalities, January-October, 1953-2008. Source: NOAA/SPC.