Science and Technology Infusion Climate Bulletin
NOAA's National Weather Service
37th NOAA Annual Climate Diagnostics and Prediction Workshop
Fort Collins, CO, 22-25 October 2012

US Climate Review of 2012: The Hot and Dry

Melissa Ou

Climate Prediction Center, NCEP/NWS/NOAA, MD

1. Introduction

The climate across the Contiguous U.S. (CONUS) was dominated by above normal temperatures during 2012, even record setting temperatures in many locations. Northern areas of the CONUS experienced anomalously low snow cover this winter and widespread hot and dry conditions across the CONUS during the summer. This report discusses some of these major climatic events, their impacts, and some attribution studies up to the end of October 2012.

2. Discussion

a. A warm winter and spring

The majority of 2012 was above normal for most of the CONUS, until the end of summer (August and September) when anomalous warm focused in the western half of the CONUS. January through August was the warmest first eight months of any year on record for the CONUS. The largest temperature departures for Jan-Mar 2012 occurred across the Midwest and New England. Much of the west coast was below normal.

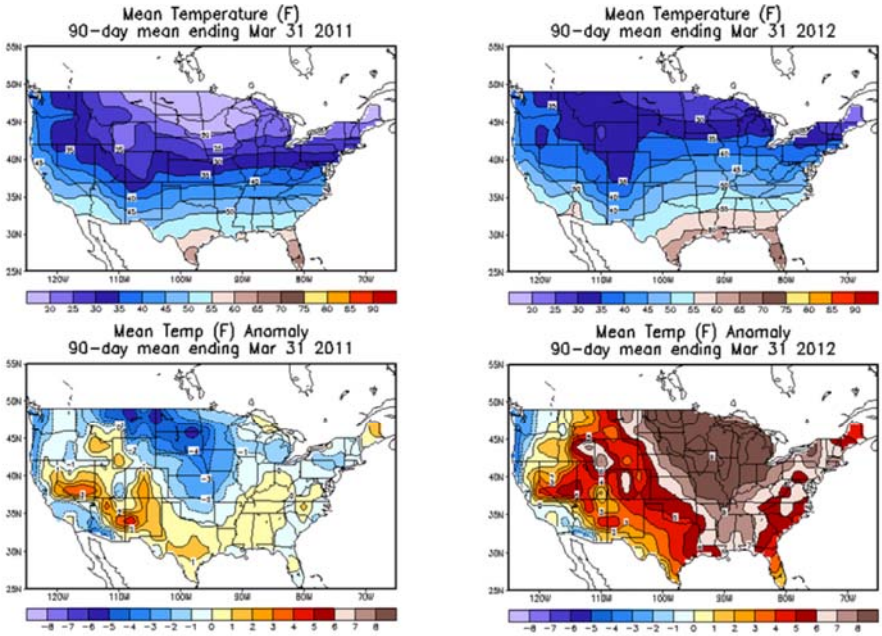

Fig. 1 Jan - Mar averaged temperatures (top row) and anomalies (bottom row) for 2011 (left) and 2012 (right). Units in degrees Fahrenheit. (Source: Climate Prediction Center's temperature analyses web page).

The long-term time series of Jan-March (JFM) averaged temperatures (from 1895-2012) showed that this past Jan-Mar had the highest CONUS temperature in the long-term time series. The value was about 43 degrees Fahrenheit, which is about 6 degrees above the long-term average.

A comparison of last year's Jan-Mar averaged CONUS temperatures and anomalies to this year's (Fig. 1) shows that this year had a very different pattern than 2011. Last year, a large area of CONUS experienced below-average temperatures, whereas this year most of the country saw above-average temperatures. Some areas across the Midwest experienced temperature anomalies of 8 degrees (F) above normal (indicated by the dark brown shaded areas in Fig. 1). The west coast in both years had below-normal temperatures. In 2012, the sea surface temperatures off the west coast were colder than normal, likely keeping temperatures along the west coast cool.

Correspondence to: Melissa Ou, Climate Prediction Center, NCEP/NWS/NOAA, 5830 University Research Court, College Park, MD 20740-3818; E-mail: Melissa.Ou@noaa.gov.

The large-scale winter flow is examined to find some features that could be attributed to the anomalously warm winter temperatures. December-February (DJF) 500mb heights are used to look at the large-scale synoptic pattern of last year's winter compared to this year's winter. The DJF season was used because it is thought to best capture the cold season pattern. According to NCDC's state of the climate, the frequent development of cold upper-level systems over the west, and lack of frequent and persistent cold outbreaks in the east led to above-normal temperatures over much of the country east of the Rockies. Fig. 2 shows plots of 500mb heights and anomalies of 2011 and 2012. Last year's plots show below-normal heights across the eastern US, whereas this year this region had above-normal heights, which may reflect the below average frequency of storm systems in the east. This upper-level pattern of ridging across the eastern US is consistent with a positive Arctic-Oscillation (AO) pattern during the winter season.

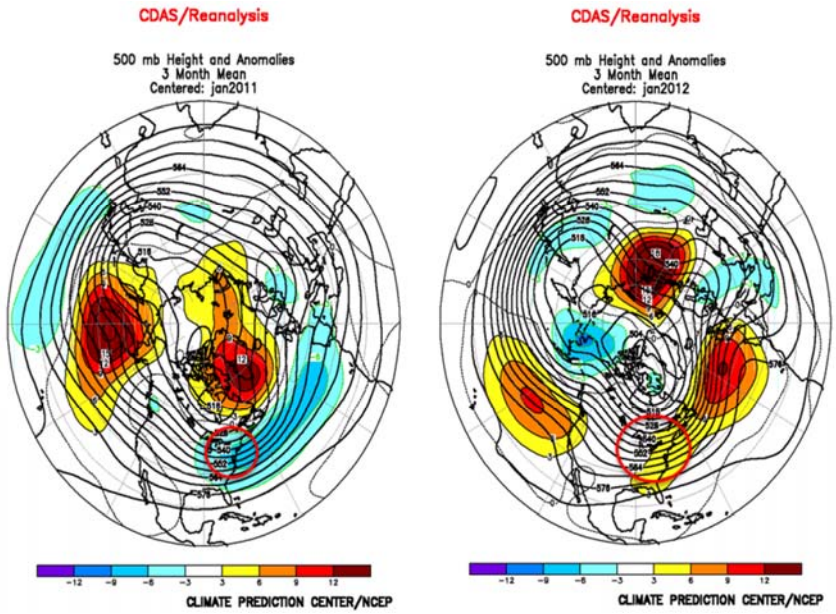

Fig. 2 Dec-Feb averaged 500mb heights (contour) and anomalies (shaded) for last year (left) and this year (right). Circled areas in red are mentioned in the text. (Source: Climate Prediction Center)

One impact from the lack of cold outbreaks was anomalously low snow cover across many parts of the CONUS. There were fewer days than normal that received snow cover during January and February of this year. Large areas across the Northern Plains had 25% fewer days than normal of snow cover than climatology. This was the 3rd smallest winter snow cover in the 46-year satellite period, especially in the west.

b. Impacts from a warm winter and spring

Some impacts from the warm winter and spring include earlier migration of animals and spring flower blooms. Cherry trees in Washington D.C., a popular tourist attraction, bloomed 2 weeks earlier than normal in 2012. Typically the average peak bloom is near April 4, whereas this year it occurred on March 20. There were also large profit losses to ski areas. Many areas did not have enough snow to open, and many of those that did open had to close early due to lack of sufficient snow. These warm conditions also led to an early start to wildfires across the nation.

c. A dry, hot summer

Above-normal temperatures continued across most of the CONUS during the summer, accompanied by persistent dry conditions. Plot of June-August average temperature departure from normal (Fig. 3) shows that the summer season was warmer than average for a large portion of the CONUS, with the exception of the Southeast and parts of the Northwest. It was the 3rd hottest

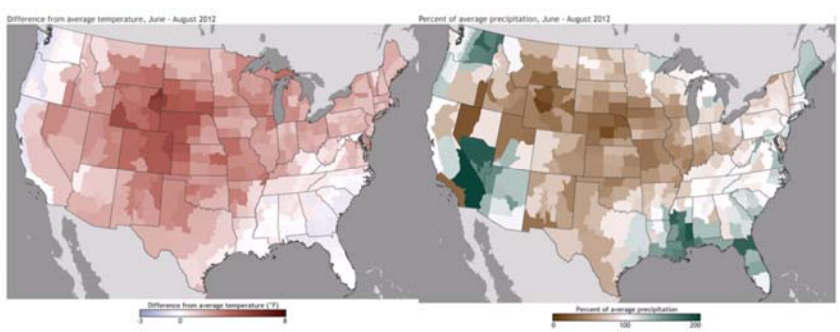

Fig. 3 U.S. Temperature (left) (ºF) and precipitation (right) (percent of average precipitation) departures from normal averaged over June-August 2012. (Source: NCDC)

summer on record according to NCDC. In fact, the average CONUS temperature was more than 2 degrees Fahrenheit above the 20th century average.

Many areas across the US experienced a heat wave in June, with most of them occurring over the CONUS. 645 locations experienced record heat, with 410 records broken, and 235 of them tied with previous records. Several Midwestern locations saw multiple days of extremes, which are reminiscent of the country's legendary "Dust Bowl Days" of the 1930s.

The long-term timeseries of CONUS temperature averaged June-August (JJA) (Fig. 4) shows that this year's JJA was the second highest temperature on record at 74.28 º F, closely beat by 1936 at 74.45 º F. The long-term average is displayed on the plot in Fig. 4 as the solid gray line. This value is at about 72.1, making this year's summer temperature about 2 degrees higher than the long-term average.

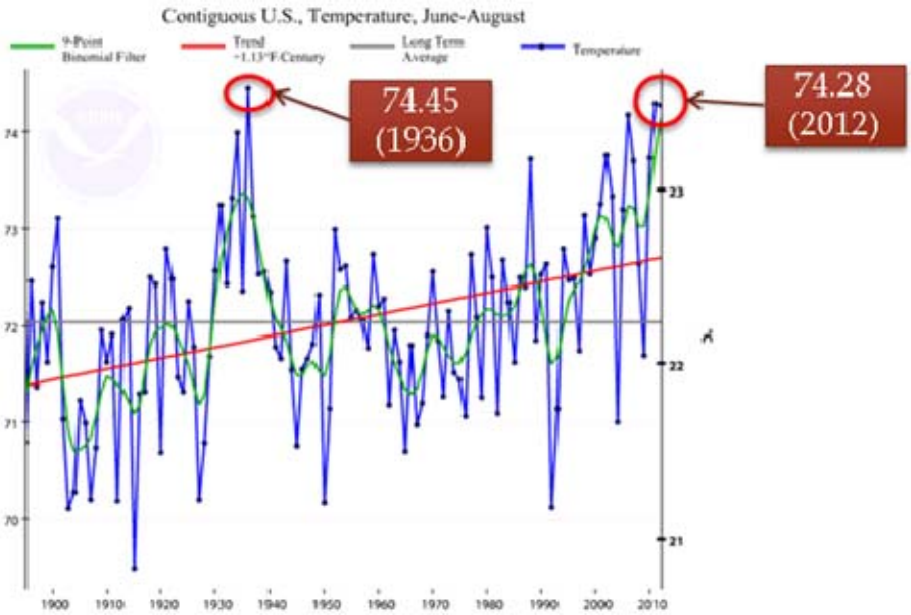

Fig. 4 Long-term timeseries of June-August averaged CONUS temperature from 1895 - 2012. The highest 2 values are circled in red. (Source: National Climatic Data Center)

The average June-August (JJA) CONUS precipitation was below average at 188 mm (average is about 210 mm), although was not as record-breaking as the temperature. This JJA was much drier overall, than the previous year. Last year the CONUS on average during JJA received above-normal precipitation (238 mm).

Even though the overall average CONUS precipitation is not as impressive in terms of the long term records, some of the localized precipitation rankings reached record driest. The central part of the CONUS had many areas of much-below normal to record driest precipitation. Last year, the most arid areas were focused across the south, especially Texas, whereas this year most of the driest areas in JJA were in central US. Most of the record breaking dry conditions this year were seen in Nebraska. In contrast, Florida had its wettest summer on record this year, partially driven by tropical storm Debby in June and Isaac in August.

Many parts of the CONUS received below-normal precipitation, especially central CONUS, which resulted in large spatial coverage of moderate to exceptional drought. According to the North American Drought Monitor (NADM) created July 31, 2012, 62.9% of the nation was in moderate to exceptional drought (D1 to D4 NADM categories). The maximum value of coverage of 63.9% occurred on July 24, 2012, which was a record spatial coverage in the 13-year of the U.S. Drought monitor (USDM) history (according to the NCDC State of the Climate report).

Unfortunately, despite the fact that the 2012 Atlantic hurricane season was relatively active, the tropical storms and hurricanes that made landfall did little to improve drought. A comparison of the drought monitoring maps before and after hurricane Isaac made landfall (Fig. 5) delineates the fact that the areas with the most severe drought in the Central and Southern Plains and the southeast saw little improvement associated with precipitation from Isaac. The track of hurricane Isaac was located too far east to result in significant rain supporting drought improvement in these areas.

Hurricane Isaac had a larger impact to flooding than drought. Above average streamflow observations in the southeast after Isaac made landfall highlight this fact.

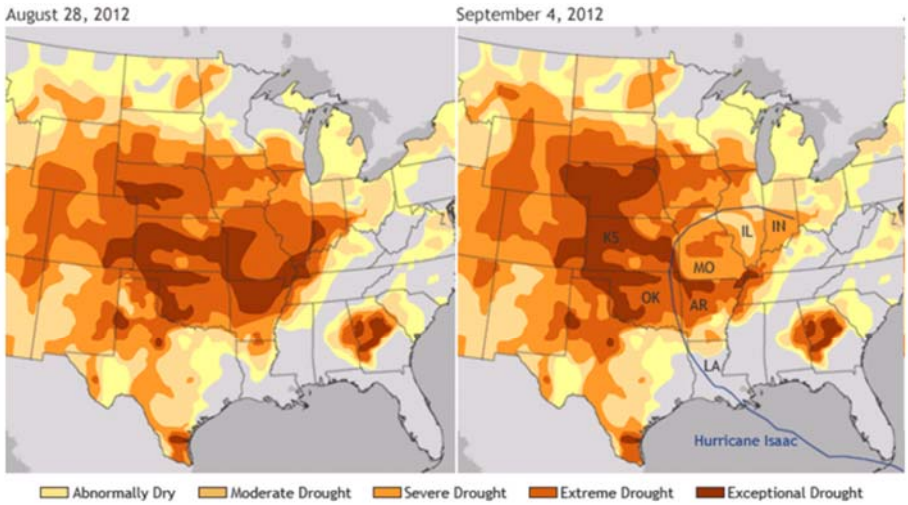

Fig. 5 Drought monitoring maps for the week of August 28, 2012, and September 4, 2012, which was made before and after landfall of Hurricane Isaac, respectively. The track of Isaac is outlined in blue. (Source: National Climatic Data Center, created by Climate Portal at climate.gov)

d. Examination of precipitation and drought analogs for July 2012

I examine some of the atmospheric variables for precipitation and drought analog years to July 2012 to attempt to glean some information about similarities and differences of the synoptic pattern associated with these analogs. July 2012 was selected for investigation because July 24, 2012 broke the 13-year U.S. Drought Monitor (USDM) history for the greatest spatial coverage of areas with moderate to exceptional drought (D1 - D4). Based on numerous characteristics regarding the spatial pattern and intensity of various climate indicators, the National Climatic Data Center identified 1954 as a good analog for July drought, and 1936 as a good July precipitation analog. Drought in July 1936 was worse than 1954, but 1954 was the last time such drought occurred and was identified by NCDC to have more similar characteristics overall to July 2012.

First, I will discuss the July 1954 and 2012 drought analogs by looking at synoptic pattern information such as 500mb heights as well as the surface air temperature anomalies, and drought blends of these years (Fig. 6). The drought blend is a short-term drought indicator, which approximates drought-related impacts that respond to precipitation on time scales ranging from a few days to a few months, such as wildfire danger, non-irrigated agriculture, topsoil moisture, range and pasture conditions, and unregulated streamflows.

The 500 mb flow of both July 1954 and 2012 were dominated by an upper-level ridge covering much of the CONUS. However, more of the CONUS was impacted by higher heights in 1954 than 2012. The shaded red area, indicating high 500 mb heights in Fig. 6, stretches further west into California during 1954, compared to 2012. There were more areas in California in 1954 that experienced above normal temperatures than 2012 likely associated with this impact from the upper-level ridging, although it did not seem to lead to more areas of drought in California.

Maps of temperature anomalies (Fig. 6) indicate that the values across central US had similar amplitudes between 2012 and 1954, but that there was a wider area of greater temperature anomalies across this area during 2012 than 1954. This feature may have supported a more condensed area of severe drought compared to 1954 which had more scattered areas with the most severe drought.

Another synoptic feature difference is that in 1954 the upper-level trough axis was negatively tilted and along the east coast, whereas in 2012 it was positively tilted and situated further inland across the east coast states (trough axis highlighted in dashed white lines on Fig. 6). This means that in 1954, there were more states in eastern CONUS impacted by the persistent upper-level ridge pattern which may have resulted in less precipitation from storms in eastern states than in 2012. This can be indicated by more areas of severe drought extending further eastward in 1954 than in 2012.

It should also be noted that even though July 1954 had greater spatial coverage of severe to exceptional drought (D1-D4) of 53.34% compared to 40.28% in 2012, July 2012 had slightly greater spatial coverage of exceptional drought (D4) (10.86% in 2012 compared to 9.69% in 1954).

In terms of precipitation analogs to July 2012, 1936 was identified as a good analog by NCDC. July 1936 was the most anomalous, historically, in terms of extreme drought coverage and dry conditions. Fig. 7 shows 500mb heights, surface air temperature anomalies, and statewide precipitation for July 1936 and 2012.

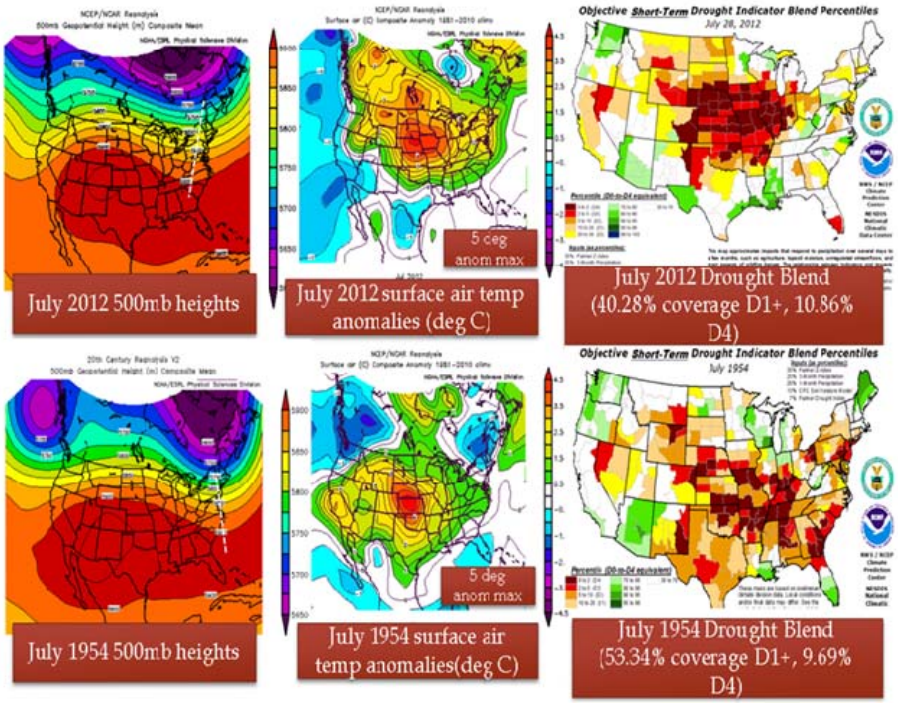

Fig. 6 500mb heights (left), surface air temperature anomalies in deg Celsius (center), and the objective short-term drought blend (right) for 1954 (bottom) and top (2012). 1954 was an identified drought analog for July 2012. (Sources: 500mb heights and surface air temperature anomalies created using composite web application by Earth System Research Laboratory, objective short-term drought blends from Climate Prediction Center)

A comparison of the 500 mb height pattern for July 1936 and 2012 reveals that in 1936 the upper-level ridge had a larger spatial extent than in 2012. This likely supported the larger magnitude and more widespread coverage of positive temperature anomalies over central CONUS. Maps of surface air temperature anomalies (center, Fig. 7) indicate greater maximum temperature anomalies of 9 degrees Kelvin during 1936 than 2012, which had values of 5 degrees Celsius (2012) (Fahrenheit and Kelvin are identical if comparing degree differences). This more widespread anomalous heat and ridging in 1936 was likely the main cause of the worst dry conditions in the Midwest historically. The statewide precipitation maps reflect the more widespread and severe dry conditions in 1936 than in 2012. Many of the Midwest states had record driest categories in 1936, whereas 2012 had no states categorized as record driest.

It is interesting to note that when applied to the temperature pattern for July 2012, several Julys from the 1930s (1934, 1935, 1936) are a close match in many regions.

Record-setting hot, dry, and windy conditions during the last week of June supported widespread fire activity, especially in the west. Colorado had multiple days at or above 100 º F (NCDC State of the Climate). Many of the fires were caused by lightning, with the hot, dry conditions providing an environment conducive for fire initiation and spread. The Waldo Canyon Fire, which started on June 23, 2012, is considered the most destructive fire in Colorado state history.

Increased fire activity burned thousands of acres, leading to hundreds of destroyed homes and thousands of people evacuated. Impacts negatively affected tourism, water resources, and energy interests. The primary corn and soybean agricultural belt was severely impacted. According to NYTimes.com, this year's U.S. corn yield is projected to be the lowest since 1995. Widespread burning also led to devastated crops and livestock from the Great Plains to the Midwest, which elevated prices for domestic and international food and animal feed. There was a significant stress on water resources and increased fish kills due to dried up rivers and increased water temperatures.

e. Southwest monsoon report

This summer's onset of the North American (Southwest) monsoon was considered normal. Typically the monsoon season runs from early July to end of September. The noticeable spike in Tucson's daily dewpoint tracker during early July most likely indicates the onset of the monsoon.

Overall, precipitation was slightly above normal in the southwest during the monsoon season. The accumulated precipitation plots (Fig. 8) indicates that the precipitation observations (black curve) were greater than the climatology (green dashed curves) for most of the time in most of the zones, excluding zone 3, 4, and 6 (zones 4 and 6 results not shown).

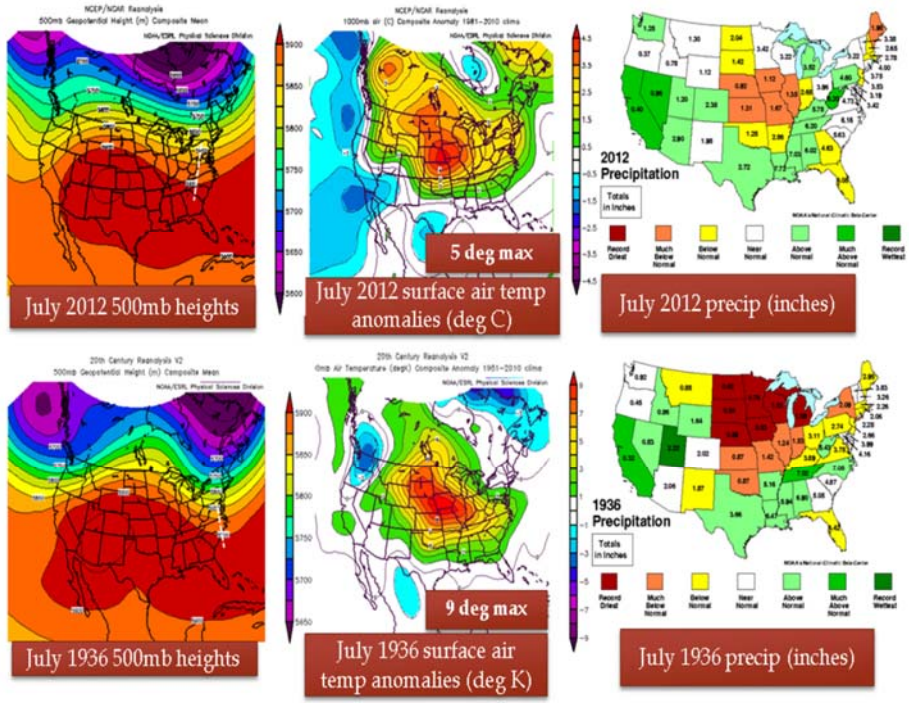

Fig. 7 500mb heights (left), surface air temperature anomalies in deg Celsius (center), and the statewide precipitation in inches (right) for 1936 (bottom) and top (2012). 1936 was an identified precipitation analog for July 2012. (Sources: 500mb heights and surface air temperature anomalies created using composite web application by Earth System Research Laboratory, objective short-term drought blends from Climate Prediction Center)

Verification of models' monsoon related accumulated precipitation forecasts shows that the high resolution CFS with April initial conditions and the GSFC with March initial conditions did the best over most of the U.S. southwest regions, although typically the GSFC over predicted the amount of accumulated precipitation (Fig. 8). The exclusion of this is in zone 8, where the lower resolution CFS with March initial conditions performed the best.

f. Most recent conditions (September/October 2012)

During September 2012, most of the west experienced above-normal temperatures. Parts of the northwest, upper Midwest, California, and the southeast received below normal precipitation. Much of the northwest and the upper Midwest had much below to record driest September precipitation. These warm and dry conditions led to another month of above average wildfire in the northwest. Above-normal temperatures and lack of sufficient precipitation exacerbated severe drought conditions, especially across the Great Plains. Another impact of this warm, dry environment was enhanced likelihood for wildfires. At Rocky Mountain Park, CO - many areas were in very high risk for fires. According to DenverPost.com, the fire started on October 9 and increased by 40 acres more of burning on October 20.

3. Summary

Much of the CONUS was dominated by above-normal temperatures during the winter and spring. This is most likely attributed to more cold upper-level low pressure systems over the west, and less persistent cold outbreaks in the east, which is consistent with a positive Arctic-Oscillation (AO) pattern.

Hot, dry conditions pervaded during the summer over CONUS, which led to widespread severe drought over much of the country. Much of this drought occurred over agriculturally significant areas which severely impacted many of the country's most important crops and livestock, especially corn and soybeans and the

feed and water used to sustain livestock. Dry conditions supported widespread fires, resulting in the destruction of many homes and evacuations. The most recent conditions as of October 2012 were anomalous warm and dry conditions across the northwest, upper Midwest, and southeast, and widespread extreme drought across the Great Plains.

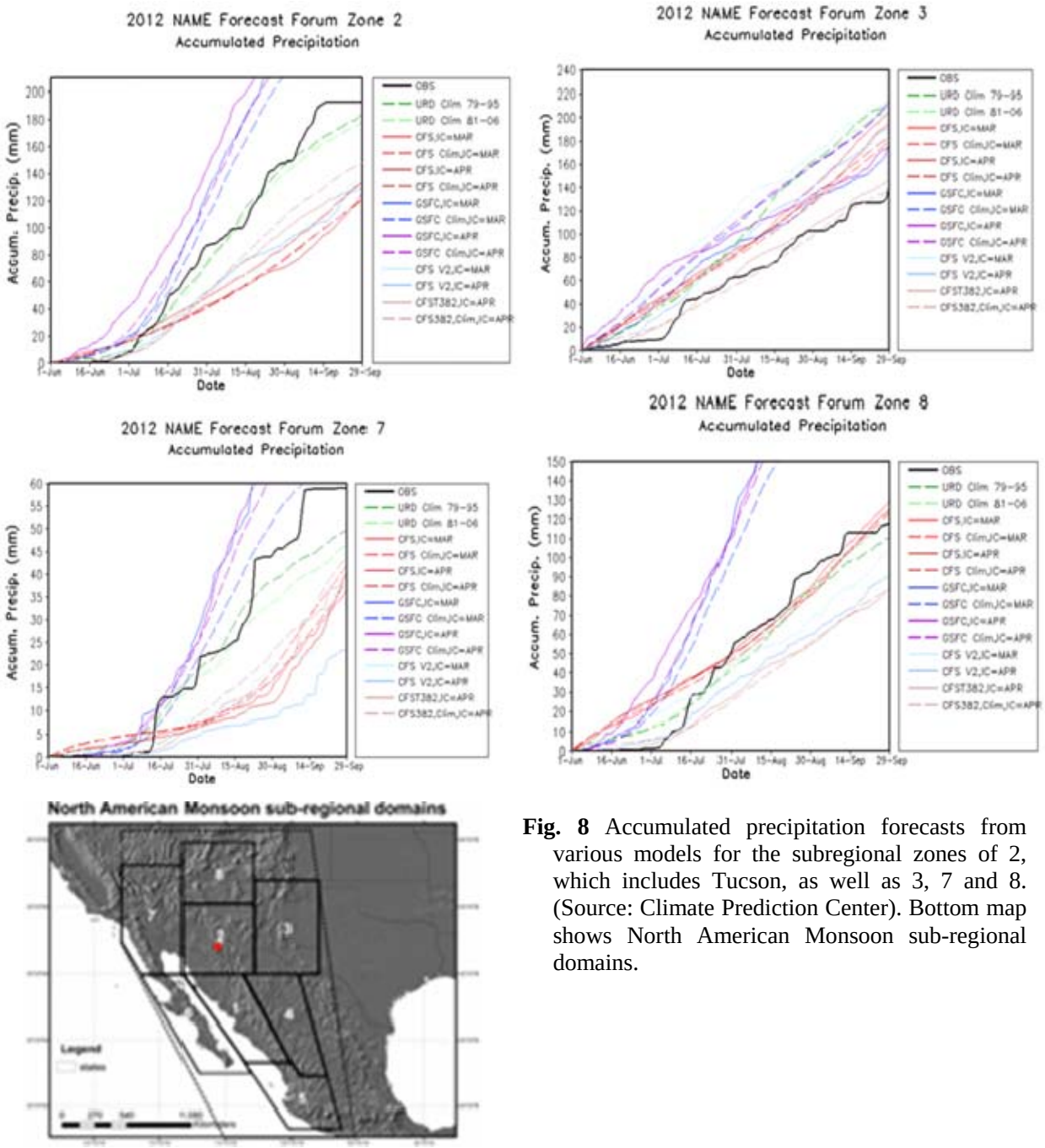

Fig. 8 Accumulated precipitation forecasts from various models for the subregional zones of 2, which includes Tucson, as well as 3, 7 and 8. (Source: Climate Prediction Center). Bottom map shows North American Monsoon sub-regional domains.