10B.6 THE EFFECTS OF TEMPERATURE AND PRECIPITATION TRENDS ON U.S. DROUGHT

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1. BACKGROUND

Since 1900 the contiguous United States has experienced statistically significant increases in both annual temperature and annual precipitation.

Over the same period the contiguous United States shows no long-term change in the percent area of the country in drought.

We examine the influence of increasing temperatures on drought coverage and the possibility that the increase in precipitation has masked a tendency for more drought in the United States since 1950.

2. DATA

Monthly temperature and precipitation for 4000 stations from U.S. Cooperative Observer Network. Homogeneity adjusted using the methods developed by Menne and Williams (2005, 2007).

Monthly time series calculated for each of the 344 Climate Divisions.

Three scenarios:

1. Observed temperature and Precipitation
2. Observed temperature and detrended precipitation
3. Detrended temperature and observed precipitation

3. METHODS

Palmer Drought Severity Index.

Hydrologic Accounting System with:

- Antecedent precipitation
- Moisture supply
- Moisture demand (ET)

- Input: Monthly temperature and monthly total precipitation
- Output: scaled to approximately:
  - -5 is exceptional drought
  - +5 is exceptional wetness

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Each scenario was used to calculate PDSI values from 1950-2006 for each Climate Division.

Percent area in severe to exceptional drought (PDSI < -3) for the contiguous United States and each of the nine NCDC Climate Regions was calculated for each month from each scenario.

4. RESULTS

Figure 2 shows the percent area of the contiguous U.S. and each of the nine regions in severe or extreme drought for the 1950–2006 period.

- The contiguous U.S. shows a slight decrease in the area in severe or extreme drought driven mainly by the large drought of the 1950s when the area of the country in severe-extreme drought approached 50% at its peak.

- By contrast the most recent period which includes the ongoing drought in the western U.S., shows a peak of about 35% of the U.S. in drought.

- Regional results are mixed with some areas (such as the Central and South regions) showing a decline, while others (such as the Northwest and West North Central regions) showing a tendency to more drought.

- Interestingly, the West and Southwest show little change but have consistently been in drought, with only short intervals of wetter conditions throughout the entire period.

Figure 3 depicts the difference plots between the observed drought (scenario 1) shown in Figure 2 and the results using observed precipitation and detrended temperature (scenario 3 in blue), and observed temperature and detrended precipitation (scenario 2 in red).

- For the contiguous U.S. (Figure 3a) the percent of the U.S. in drought likely would have been less if there had been no increase in mean temperature.

- This analysis suggests that the increase in temperature has increased by 15% the area in severe or extreme drought in the more recent period.

- Similarly, (Figure 3a, red line) drought coverage likely would have expanded if there had been no

increase in precipitation and temperatures had increased as observed.
An increase in the area of the U.S. of close to 30% is seen for some months in the most recent drought period (1999–2006).

Regional results are also shown in Figure 3.

- In some regions, including the West North Central (3f), and regions in the western U.S. (3h, 3i, 3j), detrending temperature (scenario 3) reduces drought coverage, indicating the observed warming is increasing evapotranspiration and general water demand.

- Similarly, detrending precipitation results in much greater drought coverage and shows that the increase in precipitation has been critical to reducing drought.

5. SUMMARY

In summary, it is clear that the observed increase in precipitation for the contiguous U.S. has masked a tendency for increasing drought due to increasing temperatures. Also, on a regional basis, areas that have experienced persistent drought since the late 1990s, especially the West and Southwest, severe to extreme drought coverage would likely be even more widespread without the observed increase in precipitation. Lastly, given the fact we have more confidence that temperatures will continue to increase due to increasing greenhouse gases than we do in continued increases in precipitation, it is likely we will see more persistent and stronger droughts in the future.

6. REFERENCES

Easterling, D.R., T. Wallis, J. Lawrimore, R. Heim, 2007: Effects of temperature and precipitation trends on U.S. drought, ***Geophys. Res. Letts.***, 34, L20709, doi: 10.1029/2007GL031541, 2007

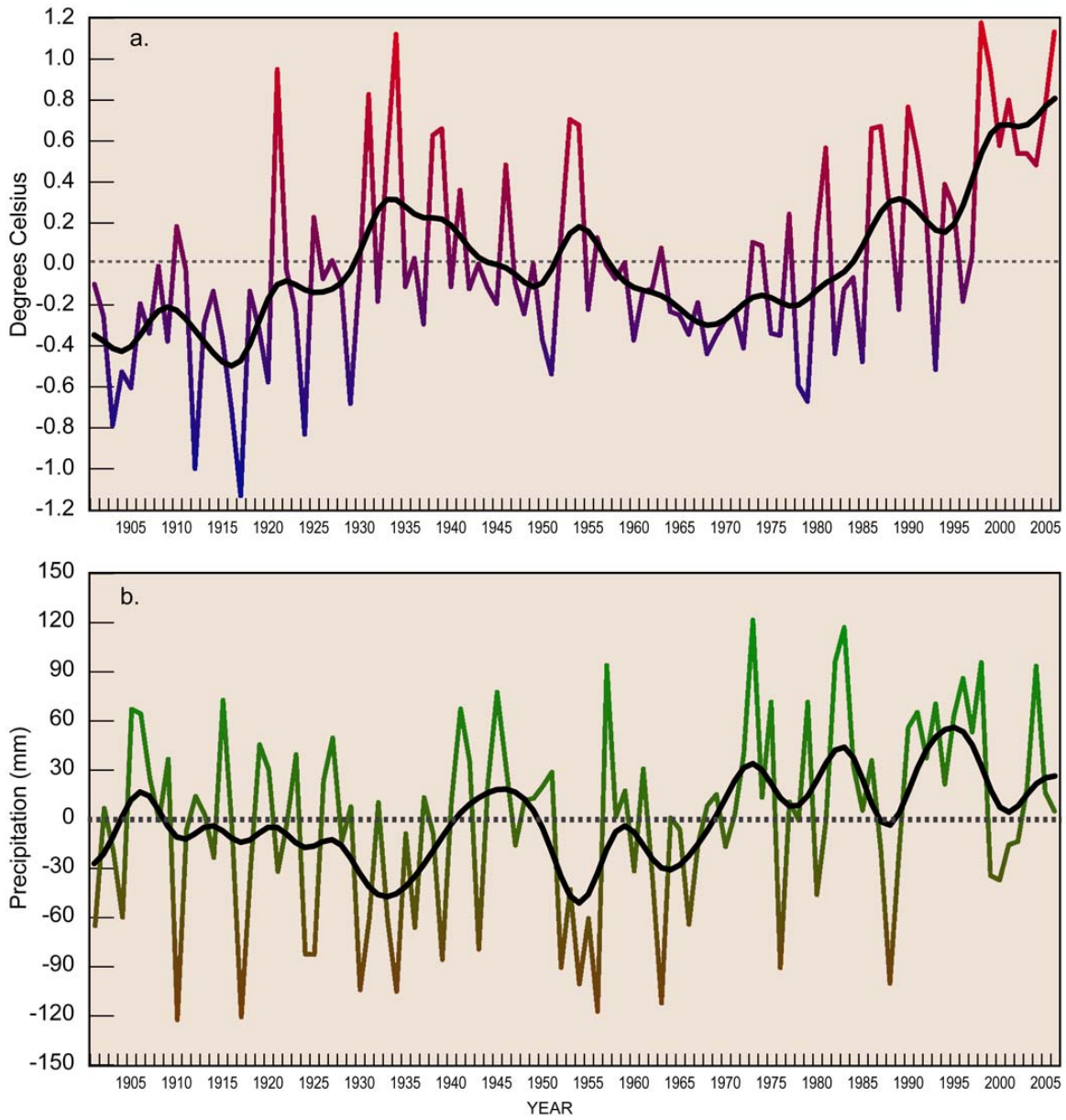

Figure 1. (a) Annually averaged temperature for the continental United States. The linear trend for the entire period is 0.06_C/decade. The linear trend for the 1950–2006 period is 0.15_C/decade and for the 1970–2006 period is 0.31_C/ decade. (b) Annual total precipitation for the continental U.S., 1901–2006. The linear trend during the 1901–2006 period is 4.5mm/decade and is 12.1mm/decade for the 1950–2006 period. The smoothed black lines were generated with a 13 point binomial filter.

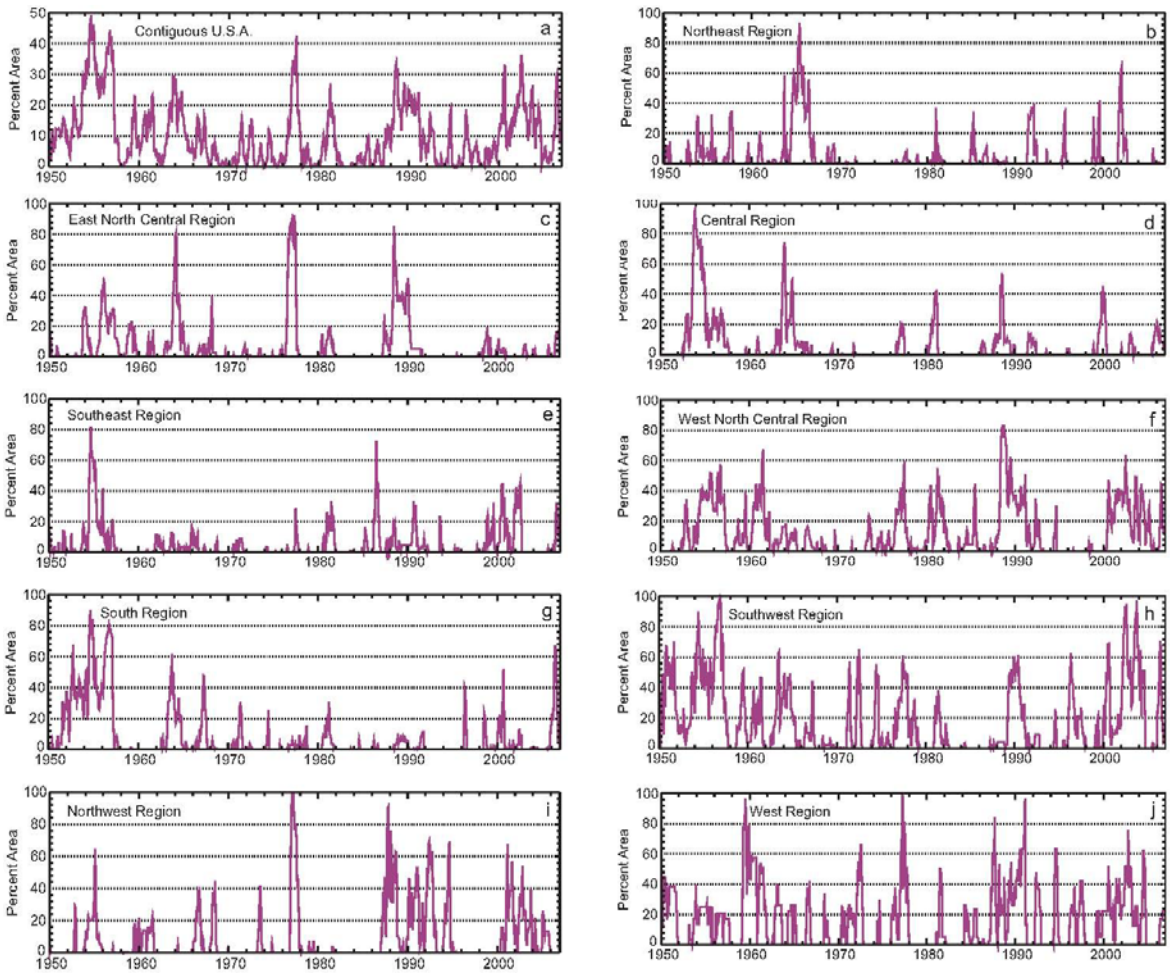

Figure 2. Actual percent area in severe or extreme drought for the contiguous United States and for each of the nine NCDC climate regions. Note the differences in scale of the ordinate for the contiguous U.S. and the regions.

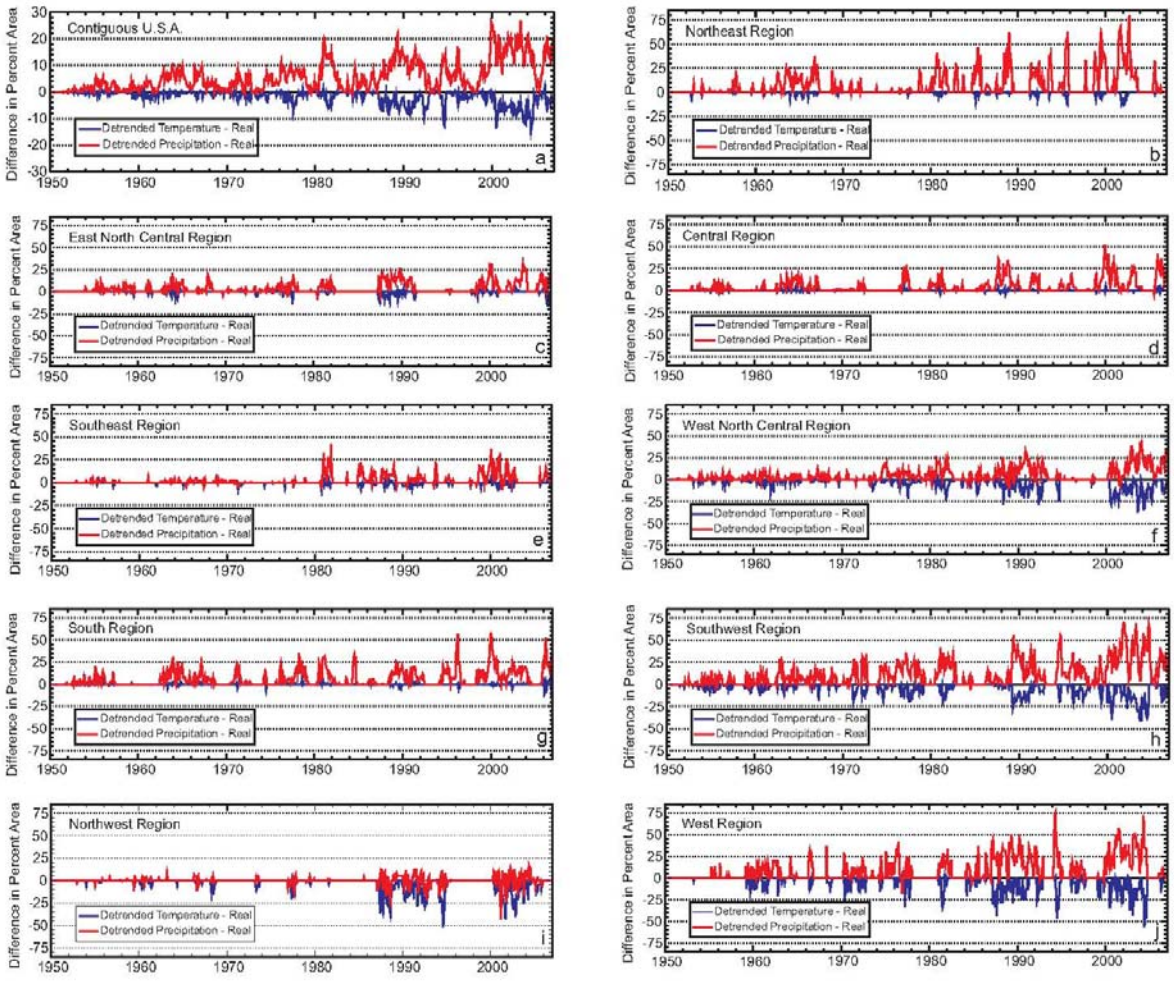

Figure 3. Difference plots between the percent area in drought using the observed temperature and precipitation and the detrended temperature and precipitation for the contiguous United States and each of the nine NCDC climate regions. The red line shows the difference between the observed percent area in severe or extreme drought and the percent area that would have been observed without a trend in precipitation but with the observed trend in temperature. The blue line shows the difference between the observed percent area and what would have been observed without a trend in temperature, but with the observed trend in precipitation. Note the differences in scale of the ordinate for the contiguous U.S. and the regions.