6.5 THE REGIONAL U.S. CLIMATE EXTREMES INDEX

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1. INTRODUCTION

The U.S. Climate Extremes Index (USCEI) was introduced in early 1996 (Karl et al. 1996) with the goal of summarizing and presenting a complex set of multivariate and multidimensional climate change indicators so that the results could be easily understood and used in policy decisions. In 2004, the USCEI was made operational and calculated for nine standard periods (annual, winter, spring, summer, autumn, warm season, cold season, hurricane season and year-to-date) on a monthly basis. These results are made available on the National Climatic Data Center (NCDC) website.

The USCEI provides insight into the average extremes experienced across the contiguous United States (CONUS), but does not allow a user to see how extremes vary from one part of the country to another. The Regional U.S. Climate Extremes Index (RCEI) was developed as a way of depicting observed extremes in the same set of indicators, using identical methodology, but on a regional scale.

2. BACKGROUND

The USCEI is based on a set of climate extremes components on the monthly time scale. Each of these components measures the fraction of the area of the CONUS experiencing extremes in specific variables. They are: monthly mean maximum surface temperature, monthly mean minimum surface temperature, daily precipitation magnitude, days with/without measurable precipitation, drought (or moisture surplus) as measured by the Palmer Drought Severity Index (PDSI), and the number and intensity of landfalling tropical cyclones occurring in the CONUS. Extremes for each are defined as occurrences which are much above/below normal (outside of the $90^{th}/10^{th}$ percentile value) over the period of record (1910-present). The actual USCEI value of the indicator for each variable is the fraction of the area of the region experiencing extreme conditions in that variable. For specific information on how the USCEI is computed, please see Gleason et al. 2008.

Although useful, the national index provides an overview of extremes experienced across the country rather than identifying which regions of the country experienced a large/small proportion of extremes in any given period or season. The RCEI analysis is computed for the same extremes indicators, but across each of the nine U.S. Standard Regions, as defined by Karl and Koss (1984, see Fig. 1). In the interest of brevity, only the annual period for the regional analyses will be discussed here. For details on seasonal features at the regional scale, the reader is referred to the online product.

Figure 1. U.S. Standard Regions for Temperature and Precipitation (Karl and Koss, 1984)

3. RCEI ANALYSIS

On the annual timescale, the percent of the CONUS experiencing extreme conditions has generally increased since the early 1970s. The indicators contributing the most to this increase are: a growing footprint of warm maximum and minimum temperatures, more large-scale droughts and wet spells, and extremes in 1-day precipitation events occurring across the CONUS.

Compared to the national index, regional values show considerably higher year-to-year variation in both the component indices and the overall composite index. There is a marked tendency for the distribution of the percentages to approach 0% and 100% more closely and more often than for the national indices. This is attributable to the scale of analysis and the increased likelihood that an extremes-producing weather or climate pattern to occupy a much higher percentage of a region. There is a good deal of spatial consistency among several of the indicators and similar extremes may span across or be absent from a region in any given season. For example, a persistent heatwave occurs on spatial scales similar to the U.S. climate regions and can therefore approach 100% coverage for its duration.

Regions experiencing an overall increasing trend in extremes over the last several decades are: the Northeast, East North Central, West North Central and Southwest climate regions. The Central, Southeast, West and South regions do not show any appreciable trend in these extremes over the last several decades.

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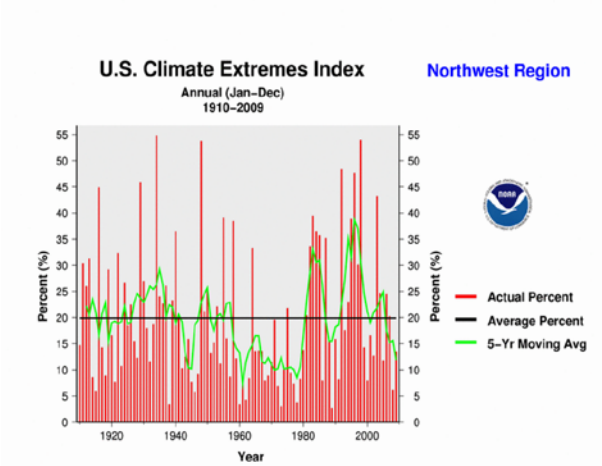


Figure 2. The Regional Climate Extremes Index for the Northwest region during the annual season (Jan-Dec) from 1910 to 2010.

The Northwest region experienced two recent surges in extremes during the 1980s and 1990s, yet extremes have not been as persistent nor as extensive during the last decade (Fig. 2).

The remainder of this section provides an overview of features for each of the RCEI's major components.

Temperature

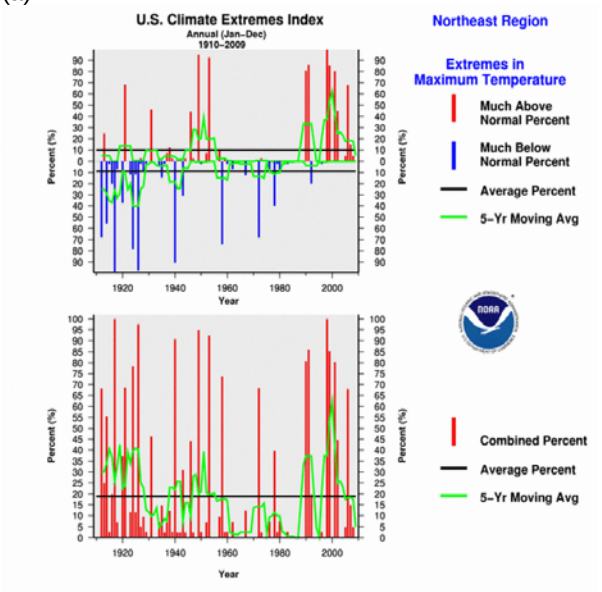
The temperature components of the USCEI, and thus, the RCEI, reflect the fractional areal coverage for both the warm and cool tails of the distribution. Extremes in warm mean maximum and minimum temperature for the USCEI have risen since the 1980s and have impacted a large percentage of the CONUS. As one might expect, these extremes are not uniformly distributed across the country, and RCEI results show differences between regions.

On the annual scale, the greatest increase in the extreme temperature components have occurred across the Southwest, Northeast and East North Central regions during the most recent 30 years. Extremes in warm maximum temperatures across the Northeast cover more than 50% of the region in 7 of the most recent 21 years (Fig. 3a). Prior to this extreme period, the majority of extremes in maximum temperature have been on the cooler side of the extremes spectrum, especially during the early part of the 20th century. Extremes in warm minimum temperatures across the Northeast follow a similar pattern (Figure 3b). These observations are consistent with recently published trend analyses, which show the largest warming trends occurring across these same regions (Menne et al., 2009 and EPA, 2010). On a regional scale, temperatures are increasing at a rate of 1.93°F per century across the Southwest, 1.92°F per century for the Northeast and 1.89°F per century in the East North Central region.

Palmer Drought Severity Index

The PDSI provides information on both the wet and day tails of monthly-to-seasonal conditions. Its results can be used to define the percent area of the region experiencing extremely wet or extremely dry conditions.

(a)



(b)

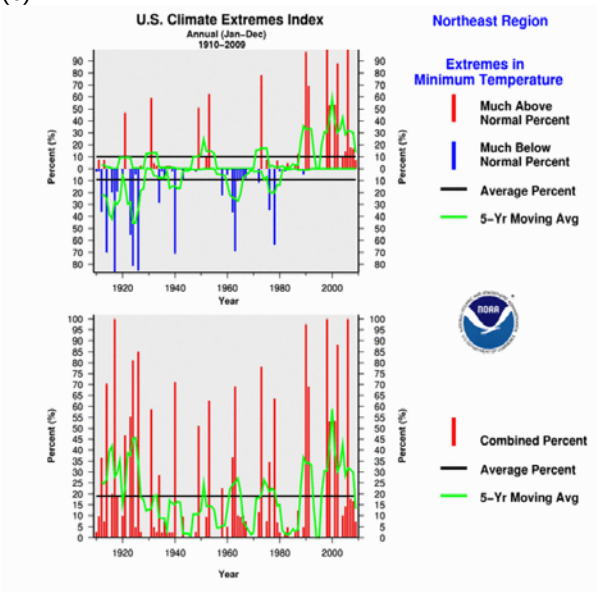


Figure 3. Annual (Jan-Dec) extremes in (a) maximum and (b) minimum temperature for the Northeast region from 1910-2010. For each, the top panel shows the component separated into its warm (red) and cool (blue) constituents, while the bottom panel depicts the combined values of the two.

Extremes in wet and dry PDSI across the CONUS have been elevated and steady since the mid-1980s. Droughts in the late 1980s and early 2000s were followed by wet-spells in the 1990s and during the most recent decade. Regionally, on the annual scale, extreme PDSI drought has affected a large portion of the Northwest, West and Southwest during recent decades. Extreme PDSI wet-spells have dominated the Central, East North Central and the Northeast regions over the last two decades. Since 1980, more than 20% of the East North Central region has been affected by extreme PDSI wet spells on an annual basis 13 times; the mid-range value for any given year is 10 percent. Only twice during this time frame have droughts impacted a large portion of the region (Fig. 4). Prior to the mid-1960s, the majority of PDSI extremes in this region were dry (some extending over more than 50% of the region) and extreme wet spells were virtually absent across the region.

Precipitation

From 1901 to 2010, precipitation across the CONUS has increased at a rate of 6.4% per century (EPA 2010). Much of this increase is attributable to increases in precipitation from single events (GCCI 2009). Some regions have experienced a larger increase than the national average while others have seen much smaller increases. The East North Central, South and Northeast regions have seen precipitation

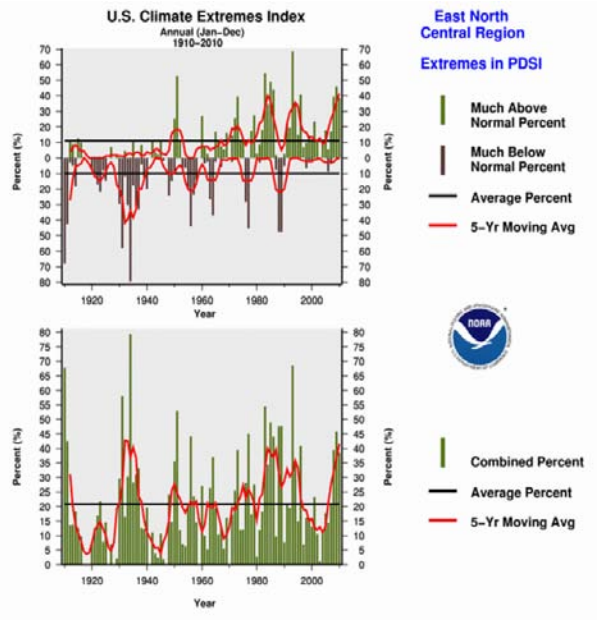


Figure 4. Extremes in Palmer Drought Severity Index (PDSI) for the East North Central region during the annual season (Jan-Dec) from 1910 to 2010. Top panel, PDSI broken into wet (green) and dry (brown) components. Bottom panel: wet and dry combined in a single value.

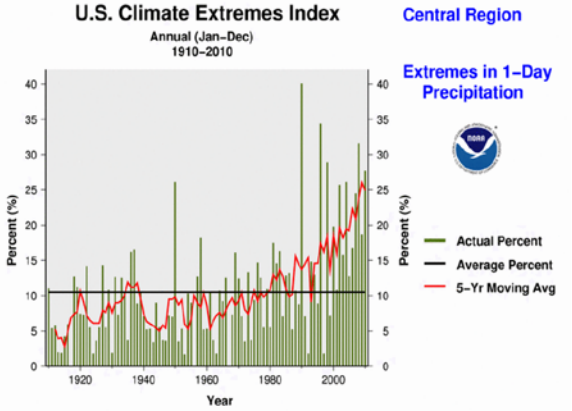


Figure 5. Percent coverage of extremely high single-day precipitation for the Central region during the annual season (Jan-Dec) from 1910 to 2010.

trends increase on the scale of 10% per century. In contrast, the Southwest, Northwest and West regions are only seeing a trend in the range of about 3% per century. The USCEI, and thus the RCEI, track precipitation extremes in two ways: single-day precipitation and the number of days with and without observed precipitation.

The single-day precipitation component displays the distribution of extreme single-day precipitation throughout the period of record. This is the only single-tailed indicator in the CEI suite. Please see Gleason et al. (2008) for more details.

Extremes in 1-day precipitation across the CONUS have generally been increasing since the 1970s. Regions contributing to this upward trend include: the Northeast, Central, Southwest and East North Central. The Central region has seen a steady increase in the extent of 1-day precipitation extremes since the early 1960's (Fig. 5). In the last 20 years, 1-day precipitation extremes have covered more than 20% of the region during seven separate annual periods (again, by definition, 10% is the mid-range long-term value). The only other year in the period of record in which extremes covered as much of the region was 1950. The Northwest and West regions have not seen an appreciable trend in 1-day precipitation over the last several decades.

Positive trends in the number of days with precipitation are evident over the last several decades across the Northeast, East North Central, Central and West North Central regions. During the last decade, extremes in both the number of days with and without precipitation have been on the decline in the Southwest region (Fig. 6). During the 1980s and 1990s, extremes in the number of days with precipitation were more extensive, covering between 20% and 30% of the region in nearly half of these years.

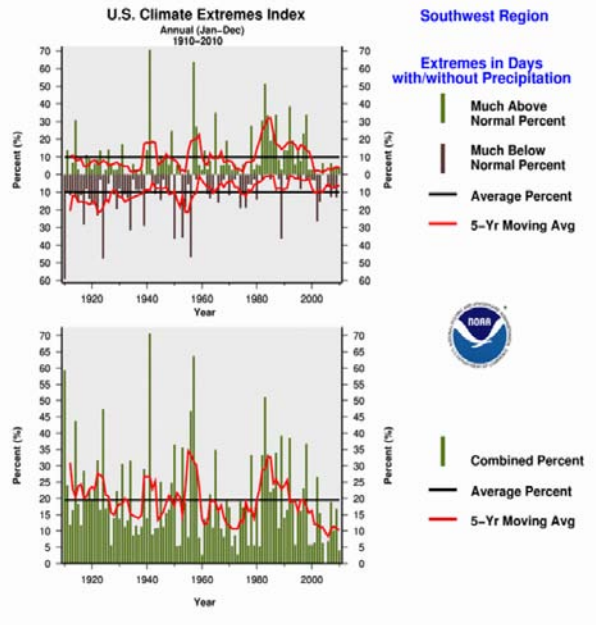


Figure 6. Extremes in the number of days with and without precipitation for the Southwest region during the annual season (Jan-Dec) from 1910 to 2010. Top panel: indicator broken into coverage of extremely high number of days with precipitation (green) and extremely low number of days with precipitation (brown). Bottom panel: both values combined into a single index.

4. SUMMARY

The USCEI is a powerful tool for understanding potential changes in climate extremes averaged across the country. However, its national-scale approach limits insights at the regional level. The RCEI now allows users to see how these extremes are changing from one region of the CONUS to another. Regions which appear to be experiencing the greatest amount of change in extremes extent for the annual period over the last 20-30 years include the Northeast, East North Central and West North Central. Most of the increase in extremes is related to an increase in warm maximum and minimum temperatures, more extensive drought and wet-spells as well as an increase in extreme 1-day precipitation.

For additional information on the RCEI, please visit the National Climatic Data Center's Climate Extremes Index website: http://www.ncdc.noaa.gov/extremes/cei/.

5. REFERENCES

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