6.1 100+ YEARS OF SHORT-DURATION EXTREME CLIMATE EVENTS IN THE U.S.

Kenneth E. Kunkel* and Karen Andsager
Illinois State Water Survey, Champaign, IL
and
David R. Easterling
National Climatic Data Center, Asheville, NC

1. INTRODUCTION

The National Weather Service Cooperative Observer Network (CON) has been in operation since the late 19th century. Consisting mainly of institutional and individual volunteers, this network has collected daily observations of several climatic variables, including precipitation, snowfall, snow depth, and maximum and minimum temperature. Throughout its operation, observers have recorded their measurements on paper forms, which are submitted monthly to the National Climatic Data Center (NCDC). Starting in 1948, the routine digitizing of observations from the paper forms was begun and continues to the present. Although selected observations taken prior to 1948 have also been digitized as a result of various projects to extend the digitally available record, the pre-1948 data in digital form has represented a small fraction of all U.S. pre-1948 observations. This situation has recently changed. The Database Modernization Project (DMP), funded by the U.S. Congress and managed by NCDC, has been putting into digital form data sets formerly available only in hard copy (paper, microfiche, microfilm) form. The pre-1948 daily CON data was one of the first data sets to be chosen for keying, which has recently been completed. The availability of the pre-1948 daily data affords an opportunity to perform studies of unprecedented detail, extending back to the late 1800s, of trends in short duration extreme events. Such studies may provide important insights into natural and anthropogenically-forced variability.

These data are now being quality-controlled. This paper presents preliminary analyses of century-scale trends in extreme temperature and precipitation values. Since quality control is not yet complete, these results are provisional, subject to change once quality control is completed.

2. ANALYSIS

A set of stations with less than 10% missing data for 1895-2000 was identified. The number of stations meeting this criterion was 838 for precipitation and 733 for temperature. The method of trends assessment followed recent studies by Kunkel et al. (1999). Extreme events were defined by duration and return period. The event duration for precipitation was chosen to be 1 day. The event thresholds were chosen to be that for return periods of 1, 5, and 20 years. These thresholds were determined empirically from each station's own climatology. The specific procedure is as follows. The highest ranking event is first determined. The days comprising this event are removed from the data time series. The second-ranked event is then determined by finding the highest ranking event in the remaining data. The procedure continues in an iterative fashion until a sufficient number of events have been identified to determine a threshold. The threshold for a return period R will be the magnitude of the rank N event where $N = M_y/R$, where M_y is the number of years of data. For example, if a station has 100 years of data, the threshold for a 1-yr return period will be the magnitude of the rank 100 event.

Growing season indicators were determined using the threshold of 0°C. Growing season length, the first fall occurrence of frost, and the last spring occurrence of frost were examined. We also examined the frequency of daily temperature records, including high maximums and low minimums.

For each station, the annual number of heavy precipitation events was identified. To assess national trends for the conterminous U.S., station values were arithmetically averaged for climate divisions. The climate division values were then averaged with area weighting to derive national values. This average will be referred to as the extreme precipitation index (EPI). This index is simply the national average frequency (per station) of extreme precipitation events for each year. For a 1-year return period, the average value of this index is 1.

3. RESULTS

Figure 1 shows the time series of the indices for heavy precipitation events, averaged for decadal periods. The most notable feature is the increasing frequency over the past 60 years. This behavior has been described before by other investigators, including Karl and Knight (1998) and Kunkel et al. (1999). However, rather high frequencies of heavy precipitation events also occurred at the end of the 19th Century and in the early part of the 20th Century. This behavior had been noted before by Kunkel et al. (1999) for the Midwest U.S. With the new availability of data for the entire U.S., it now appears that this behavior was a national phenomenon. The high frequencies in the early part of the 20th Century indicate that natural variability may be of similar magnitude to the observed recent upward trends.

Figure 2 shows the results for the growing season. There are three distinct regimes. During the early part of the period (prior to about 1930), the growing season was shorter than the 1895-2000 average by about 5 days with earlier fall frosts and later spring frosts. During the period 1930-1980, there was very little change. Since 1980, the

**Corresponding author address*: Kenneth Kunkel, Illinois State Water Survey, University of Illinois, 2204 Griffith Drive, Champaign, IL 61820; e-mail: k-kunkel@uiuc.edu.

growing season has lengthened by 5-10 days with later fall frosts and earlier spring frosts.

Figure 3 shows the frequency of temperature records averaged by decade. The number of record high maximum temperatures was highest in the 1930s and lowest in the 1960s and 1970s. There was about an average number of such records in the 1980s and 1990s. There does not appear to be any overall trend. By contrast, there does appear to be a downward trend in the number of record low minimum temperatures. The number of record low minimum temperatures was highest prior to 1920 and lowest in the most recent decade of the 1990s. The latter result is not unexpected given recent studies showing an upward trend in nighttime minimum temperatures

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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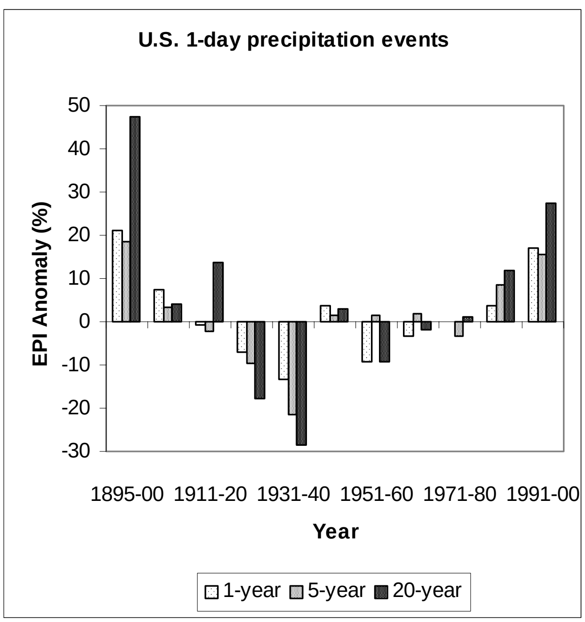

Figure 1. Decadal values of the extreme precipitation index (EPI) averaged for the conterminous U.S. for 1-day duration and 1, 5, and 20-year recurrence events.

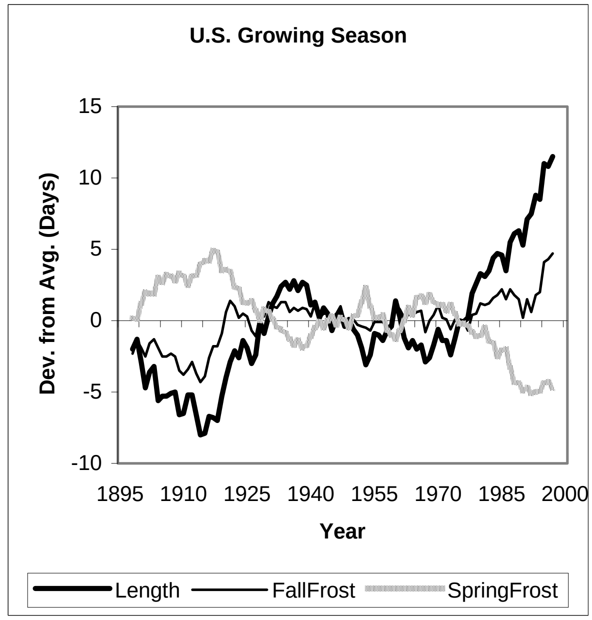

Figure 2. Average U.S. values of the first fall occurrence of frost, the last spring occurrence of frost, and the length of the growing season. The values have been smoothed with a 7-year moving average filter and plotted as a deviation (days) from the period average.

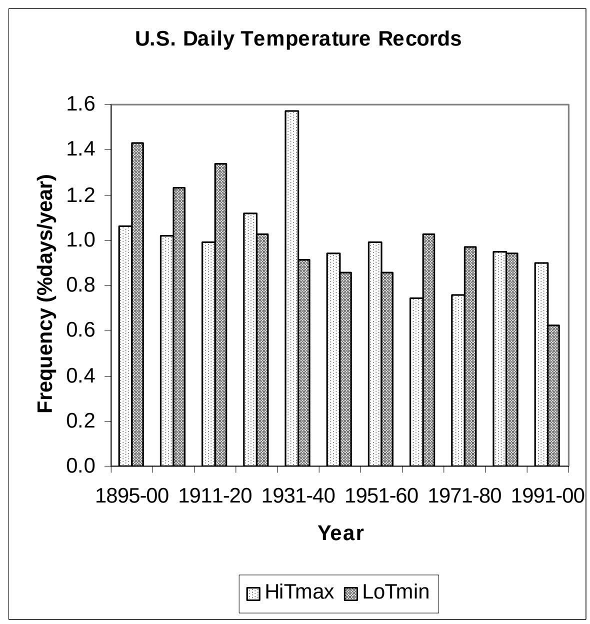

Figure 3. Decadal average values of the frequency of temperature records (high maximum, low minimum) averaged for the U.S.