JP282

Contact: esther.white@ou.edu

Trends In Heavy Precipitation in the SCIPP Region of the Southern United States

Esther White[1,2], Mark Shafer[1] and James Hocker[1]

[1]Oklahoma Climatological Survey and Southern Climate Impacts Planning Program, Norman, OK. [2]School of Meteorology, University of Oklahoma, Norman, OK.

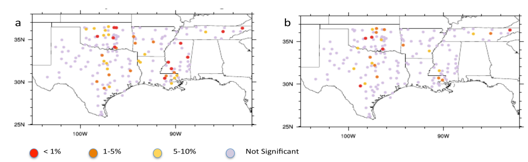
1. Introduction

- The Intergovernmental Panel on Climate Change (2007) suggests increasing global average temperatures will very likely lead to changes in the distribution and intensity of heavy precipitation. Warmer air is able to hold more water vapor and thus enhance the hydrological cycle, with different regional impacts.
- This study examines daily precipitation time series for six states: Texas, Oklahoma, Arkansas, Louisiana, Mississippi and Tennessee; the geographical domain of the Southern Climate Impacts Planning Program (SCIPP).
- We examine individual station records back to 1900 when available, and climate division records from 1948 for precipitation thresholds between 0.01 and 5 inches per day. The top 0.3% of events between 1948-2008 are binned into decades to examine changes in the frequency of local high magnitude events for a given station.

2. Data and Methodology

- Rain gauge data is obtained from the National Weather Service Cooperative network. Stations were included only if they had 5% of less missing data as well as a record exceeding 60 years. Temporal resolution is once daily, typically measured at 06Z or 18Z.
- Simple definitions of heavy and extreme precipitation events were used, which were dependant on location. Heavy events defined as 1.5 inches/day for west Texas, 2 inches/day for Oklahoma and Central Texas, and 2.5 inches/day across Arkansas, Louisiana, East Texas, Mississippi and Tennessee.
- For Climate Divisions we examined total number of events at 0.01, 1, 2, 3 and 5 inches/day between 1948-2009, normalized by station number within each division.
- Linear and 10 year moving average trends are examined, statistical significance is computed via a simple linear regression. A trend is considered significant with a p-value < 5%.

3



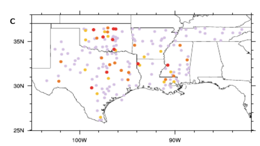


Figure 1: Distribution of significant positive trends of heavy precipitation at < 10% (a) all years in individual station record (varies), (b) 1920-2009 and (c) 1948-2009. Approximately 23% of stations have positive trends significant at the 5% level, reducing to 15% from 1948-2009. Most of these stations are concentrated over Oklahoma into Texas and parts of SE Louisiana into SW through NE Mississippi

4

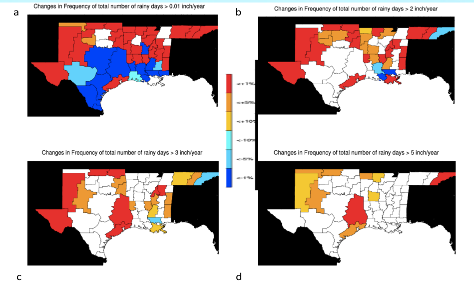


Figure 2: Trends in number of days with precipitation thresholds from 0.01 to 5 inches/day for each climate division. Negative (positive) trends are shown in blue (yellow-orange-red). Significance values range from <1% to 10%, but only those trends less than 5% are considered statistically significant. White areas indicate no notable trend. For heavy Precipitation thresholds between 2 and 3 inches/day, most locations show positive or no trend with Oklahoma, West Texas and parts of Louisiana and Mississippi showing the clearest signal. Above 5 inches/day very few divisions have significant trends (largely due to low frequency of events) but there is a signal for increased total number of events in the Texas and Oklahoma panhandles, and Eastern Texas.

5

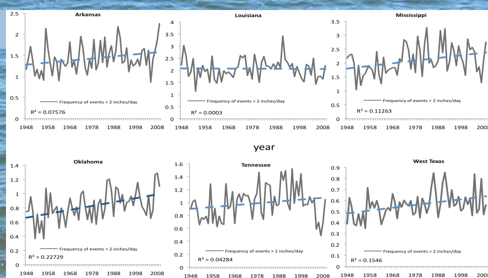


Figure 3: Time series of number of events > 2 inches/day per year, normalized by station number within each climate division and summed over climate divisions within each state to compute a state average. States with the significant signals for increased heavy precipitation (as defined here) include Oklahoma, Mississippi and West Texas. Louisiana, despite having some locally significant positive trends does not show a statewide signal for increased frequency of heavy precipitation over this period. Note also the high inter-annual variability of these events, and the general decrease observed across most states during 2000-2009.

6

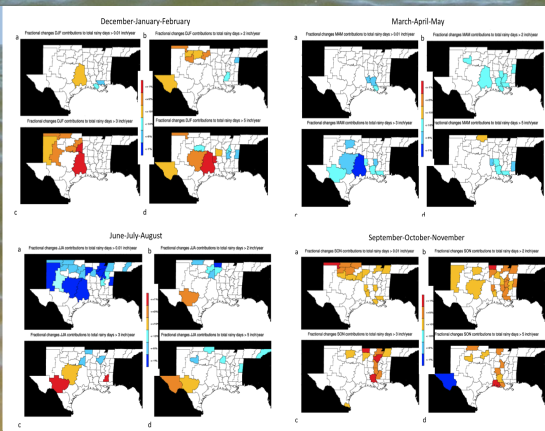


Figure 4: Seasonal trends in precipitation between 0.01 and 5 inches/day. Color definitions are the same as Fig 2. Different locations have different tendencies, however, note an overall decrease in the number of rainy days during the summer for much of the region, and a tendency for increases in precipitation at all thresholds during the fall and winter over Oklahoma, Arkansas, Mississippi and parts of Northern and Western Texas in particular. The spring season shows very little large scale trend, however, where there are trends, they are nearly always negative.

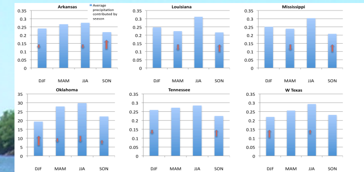
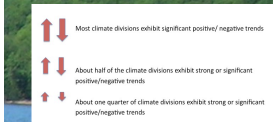


Figure 5

Average fractional contributions to total annual precipitation by season. Arrows are a schematic representation of the direction and magnitude of observed seasonal changes between 1948 and 2009. Upward (downward) arrows indicate an increase (decrease) in the seasonal contribution by heavy precipitation events (2-3 inches/day).



7

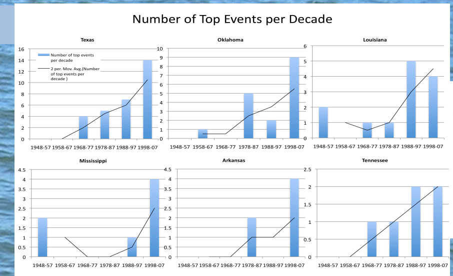


Figure 6: Top 0.3% of events broken down by decade for all stations with strong or significant trends in heavy precipitation. Stations were grouped into decadal 'bins' between 1948 and 2008. The number of top events in each station were summed for each decade and then each decade was ranked. Shown here are the number of stations with their greatest number of top events in a given decade. For each State, most high magnitude events have occurred in the latter few decades of the period, particularly 1988-2008.

8. Implications

- Our results indicate that for some regions, there have been significant increases in the frequency of heavy precipitation over the 20th century, although the signal is mixed. Generally the western states have more significant trends.
- Our results are consistent with previous studies examining regional and nationwide precipitation trends over the 20th Century, e.g. Karl et al. (1998), Kunkel et al. (1999), Groisman et al. (2004) among others. Studies of future regional precipitation changes under global warming by Giorgi (1998) and the NARCCAP (2005) are qualitatively in agreement in some cases (e.g. regional increases in winter and fall heavy precipitation).
- Increases in the overall amount of precipitation may have beneficial results, e.g. recharge of groundwater, and improved water availability.
- Increases in the intensity of precipitation events can increase the risk of flooding, particularly flash flooding. The precise impacts depend on local geography, intensity, duration and timing (e.g. Trenberth 1999).
- Although the relationship between flooding and heavy precipitation is complex, projected changes in precipitation patterns will modify the probability of a region being inundated, especially if the region is already vulnerable (e.g. Pielke 1999).
- There is considerable capacity for adaptation and mitigation of flood hazards by adoption of new behaviors and flood policies – most of our vulnerability relates to human choice.
- Policymakers must be aware of potential changes to flooding behavior from future changes in precipitation from global warming, and make judgments about how to incorporate this information in urban planning, transportation and other infrastructure.

9. Future Work

- Examine trends in multi-day precipitation events, e.g. 2, 3 and 7 day in a companion study.
- Investigate the types of precipitation events that typically lead to flooding in the SCIPP region in terms of magnitude, duration and precipitation rates where possible. Examine trends in these types of events.
- Prepare a regional 'risk map', highlighting regions where more significant trends are evident in historical data, which, along with future climate change projections, may be used by stakeholders for present and future policy decisions.

Acknowledgements:

The authors would like to thank Dr. Barry Keim of Louisiana State University for providing his expertise in extreme precipitation analysis, which contributed significantly to this study.
Thanks also to Dr Michael Richman for his insight into statistical evaluation of time series.

References

Giorgi, F., L. O. Mearns, C. Shields, and L. McDaniel. 1998: Regional nested model simulations of present day and 2 xCO2 climate over the central Plains of the U.S., *Climatic Change* **40**, 457– 493.

Groisman, P. Y. et al. 2004: Contemporary Changes of the Hydrological Cycle over the Contiguous United States: Trends derived from in-situ observations. *Journal of Hydrometeorology,* **5,** 64-85

Intergovernmental Panel on Climate Change (IPCC) .2007: Climate Change 2007: The Physical Science Basis, Summary for Policymakers. Contribution of the Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge Univ. Press, Cambridge, U.K.

Karl, T. R., and R. W. Knight .1998: Secular trends of precipitation amount, frequency and intensity of the United States, *Bull. Am. Meteorol. Soc.*, **79,** 231–241.

Kunkel, K. E., K. Andsager, and D. R. Easterling .1999: Long-term trends in extreme precipitation events over the conterminous United States and Canada, *J. Clim.*, **12**, 2515–2527.

North American Regional Climate Change Assessment Program (NARCCAP), 2005: Results. *http://www.narccap.ucar.edu/results/crcm-cgcm3-results.html*

Pielke, R. A. JR. 1999: Nine Fallacies of Floods. *Climatic Change* **42**, 413-438.

Trenberth, K. E. 1999: Conceptual framework for changes of extremes of the hydrologic cycle with climate change. *Climatic Change,* **42,** 327–339.

This project was funded by the Southern Climate Impacts Planning Program Regional Integrated Sciences and Assessment program (RISA) as part of a summer internship.