Increasing Precipitation Extremes in U.S. Urban Areas*

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1 Introduction

- More than 50% of the world's population lives in urban areas, in contrast with only about 10% a century ago. About 80% of total population of the United States lives in urban areas.
- Most modeling and observational studies show increases in extreme precipitation events as climate warms (O'Gorman and Schneider, 2009). The consequences of extreme precipitation can be profound for urban stormwater management.
- Understanding the risk of extreme precipitation events is essential to managing and planning of urban infrastructure as precipitation extremes determine the sizing of stormwater infrastructure

2 Objective:

- To evaluate historic trends and variability in precipitation extremes in major U.S. urban areas.

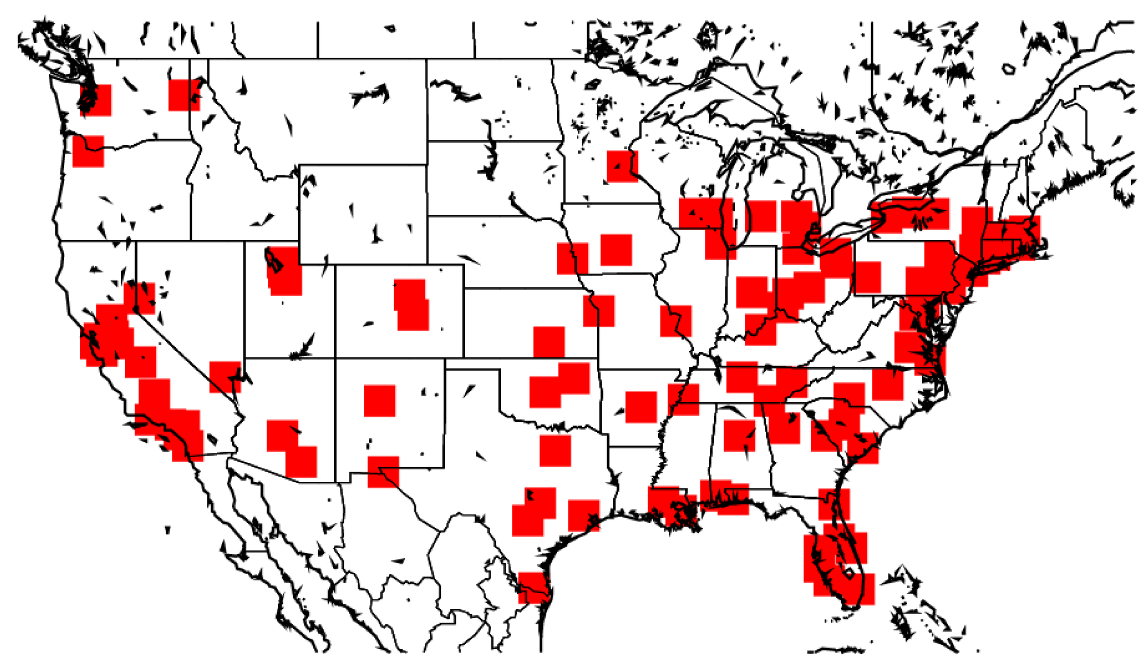

Figure 1. Location of the selected urban areas.

3 Methodology

- We identified the 100 most populous urban areas (Figure 1) in the continental U.S. based on Census 2000.
- The geographic extent of these urban areas was extracted from the *2000 Urban Areas* shape file.
- For each urban area, we identified 1/16 degree grid cells for which gridded meteorological data were generated using the methodology described in *Hamlet and Lettenmaier (2005).*
- For the paired analysis for urban and surrounding non-urban areas, non-urban polygons were selected by constructing buffer regions of 25-km around each urban area.
- We used Mann-Kendall trend analysis and Sen's slope method to estimate trends in precipitation extremes indices in the major U.S. urban areas between 1950 and 2009.

Meteorological Data and Indices for Precipitation Extremes in Urban Areas

Meteorological Data

- Daily precipitation data were obtained from meteorological stations of the National Climatic Data Center (NCDC) for the period 1950-2009.
- Stations that had data entry errors or misinterpretation of data in written records were removed.
- Gridding of meteorological data for the urban and non-urban buffer regions were performed using the stations that were uniquely present only in urban and non-urban regions, respectively.

Indices for Precipitation Extremes

- Annual one day maximum precipitation (MP-1).
- Mean accumulated precipitation for the five most extremes precipitation events in each year (PI-5).
- Number of precipitation events in each year exceeding 90th percentile of 1961-1990 period (NP-90).
- Ratio of heavy and non-heavy precipitation (H-NH).
- Precipitation intensity (P-INT).

4 Results

Trends/decade (%) in Precipitation Indices in Major U.S. Urban Areas

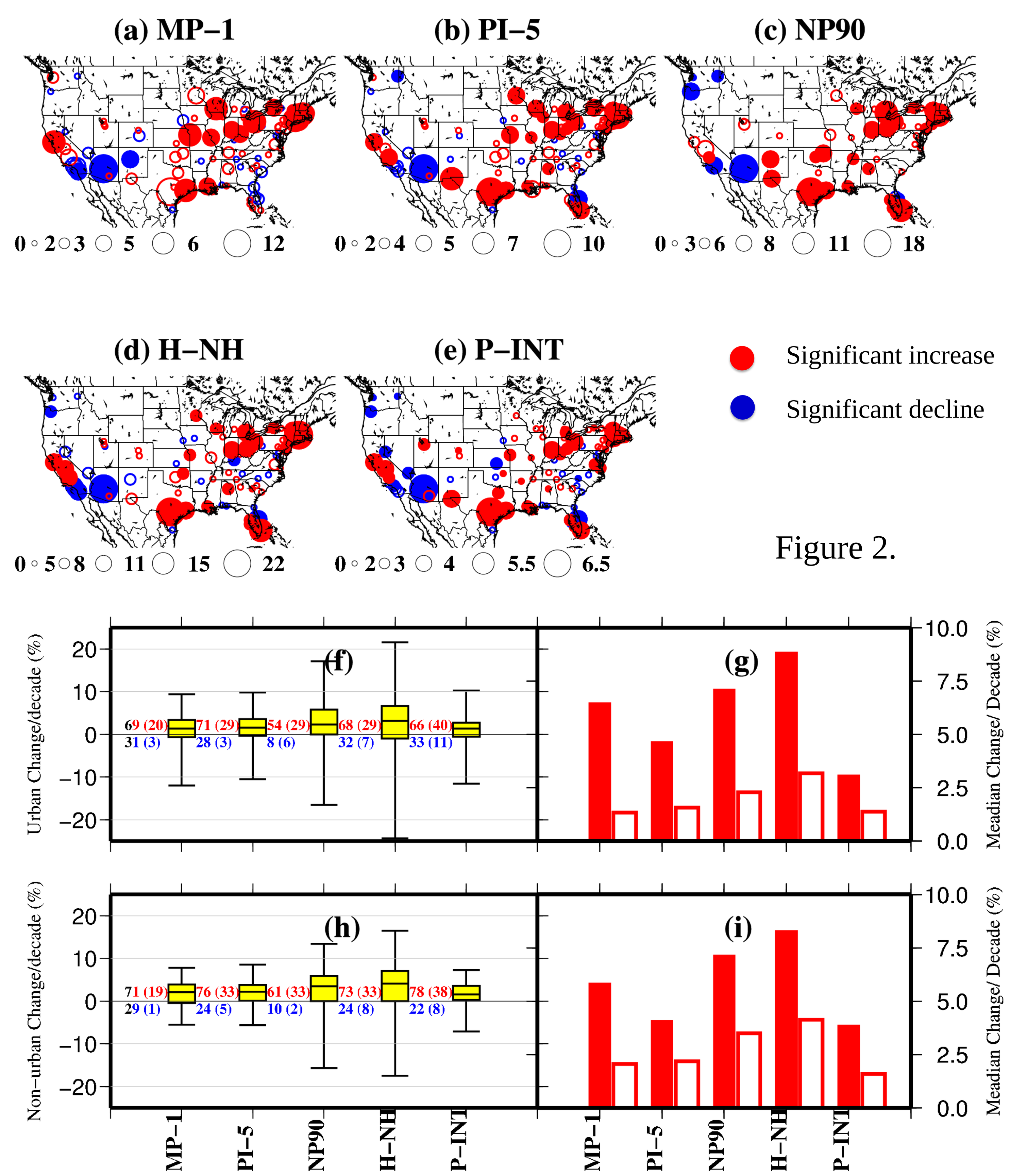

Figure 2.

Figure 2: Trends/decade (%) in precipitation indices: (a) one day annual maximum precipitation (MP-1), (b) precipitation intensity of five most extreme events in a year (PI-5), (c) number of heavy precipitation events (NP90), (d) ratio of heavy to non-heavy precipitation (H-NH), (e) precipitation intensity (P-INT), (f) distribution of changes/decade (%) for urban areas, (g) median trends in dominant direction (solid bar) and for all urban areas (hollow bar), (h) same as (f) but for non-urban areas, and (i) same as (g) but for non-urban areas. Boxes represent median, lower, and upper quartiles, whiskers extend from minimum to maximum vales. Number left of boxes indicate urban areas with positive (upper) and negative (lower) changes. Numbers in parenthesis represent urban/non-urban areas with statistically significant changes at 5 % significance level. Percentage changes are estimated using the non-parametric Mann-Kendall trend test. Red circles show increasing trends while blue circles show decreasing trend. Filled circles represent statistically significant trends at 5% significance level. Precipitation events which exceeded 90th percentile of wet day precipitation (wet day: day when precipitation is more than 1 mm) during 1961-90 period were considered to be heavy precipitation events.

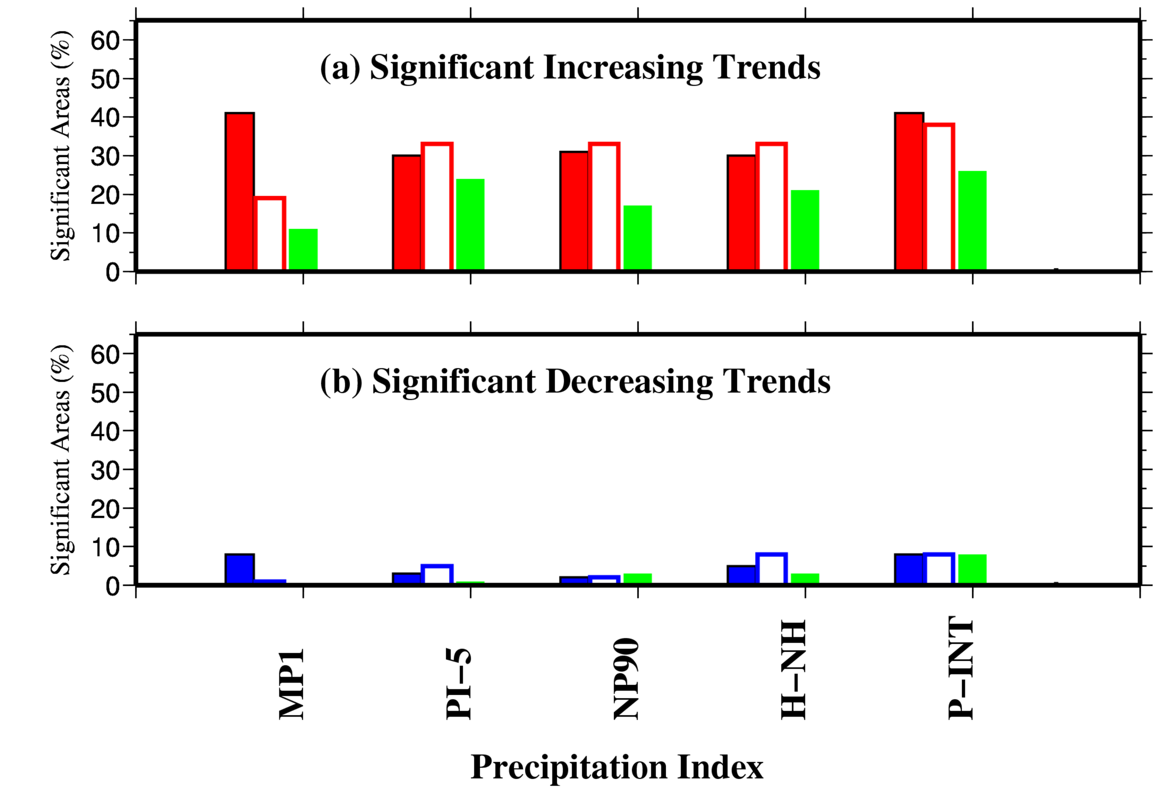

Figure 3.

Figure 3: Comparison of number of statistically significant uptrends (a) and downtrends (b) for urban areas (solid), non-urban areas (open), using all stations outside urban areas, and non-urban areas (green), using only stations more than 25 km from boundary of urban areas.

5 Conclusions

- A strong preponderance of increases in daily precipitation maxima and in the frequency of extreme daily precipitation was found in urban areas across the U.S. during 1950-2009.
- The number of urban areas showing significant increases in precipitation extremes is much larger than those with significant decreases.
- For precipitation extremes, trends are generally consistent for urban and non-urban areas, however, there was some indication of "spill over" effect in precipitation indices.

Bibliography

- Hamlet, A. F., and D. P. Lettenmaier (2005), Production of Temporally Consistent Gridded Precipitation and Temperature Fields for the Continental United States, *Journal of Hydrometeorology*, *6*(3), 330–336.
- O'Gorman, P. A., and T. Schneider (2009), The physical basis for increases in precipitation extremes in simulations of 21st-century climate change, *Proceedings of the National Academy of Sciences*, *106*(35), 14773.

Further Information

*Most of the work reported herein was published in:

- Mishra, V., and D. P. Lettenmaier (2011), Climatic trends in major U.S. urban areas, 1950–2009, *Geophys. Res. Lett.*, 38, L16401, doi:10.1029/2011GL048255
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