Understanding the Spatial Variation in Timescales of Extreme Precipitation Across The United States

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Abstract

Understanding potential changes in the distribution of extreme events is essential for assessing regional scale impacts of climate change. These changes are difficult to ascertain due to the fact that atmospheric processes vary across many spatial and temporal scales and are correlated with other processes at disparate scales. As climate change occurs, understanding the nature of this cross-correlation becomes essential for successful mitigation efforts. Here, we present a methodology combining wavelet multiresolution and information theory approaches for quantifying the scalewise nature of extreme precipitation and the correlation structure with low frequency climate signals. We apply this methodology to the United States Historical Climate Network (USHCN) observations of daily precipitation values. The wavelet decomposition allows us to determine the dominant temporal scales of precipitation dynamics at each station. Utilizing information theory metrics such as the relative entropy, we can quantify which temporal scales of the extreme value distributions are most sensitive to alteration by low-frequency climate forcings and regional circulations including El Nino and the Pacific Decadal Oscillation. By examining the spatial variation in these metrics, we will show the spatial distribution of sensitivity to the regional circulation patterns on the extreme precipitation across the United States. These results will highlight the nature of precipitation extremes for assessing potential impacts of climate change on the hydrological cycle.

USHCN Trends

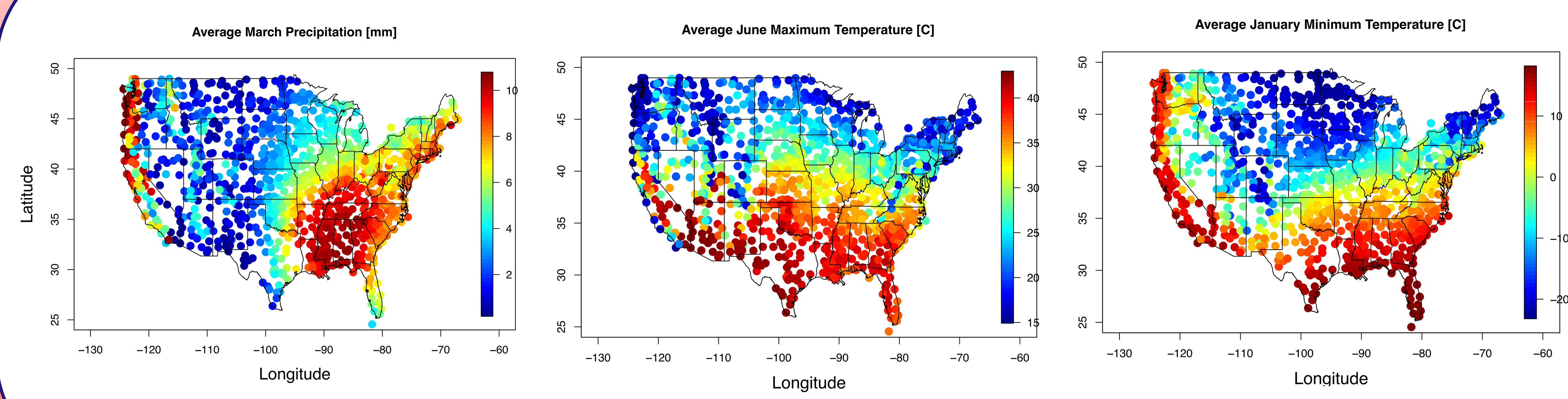

Figure 1: Average Precipitation, Maximum Temperature and Minimum Temperature for 1218 USHCN Stations.

Information Theory

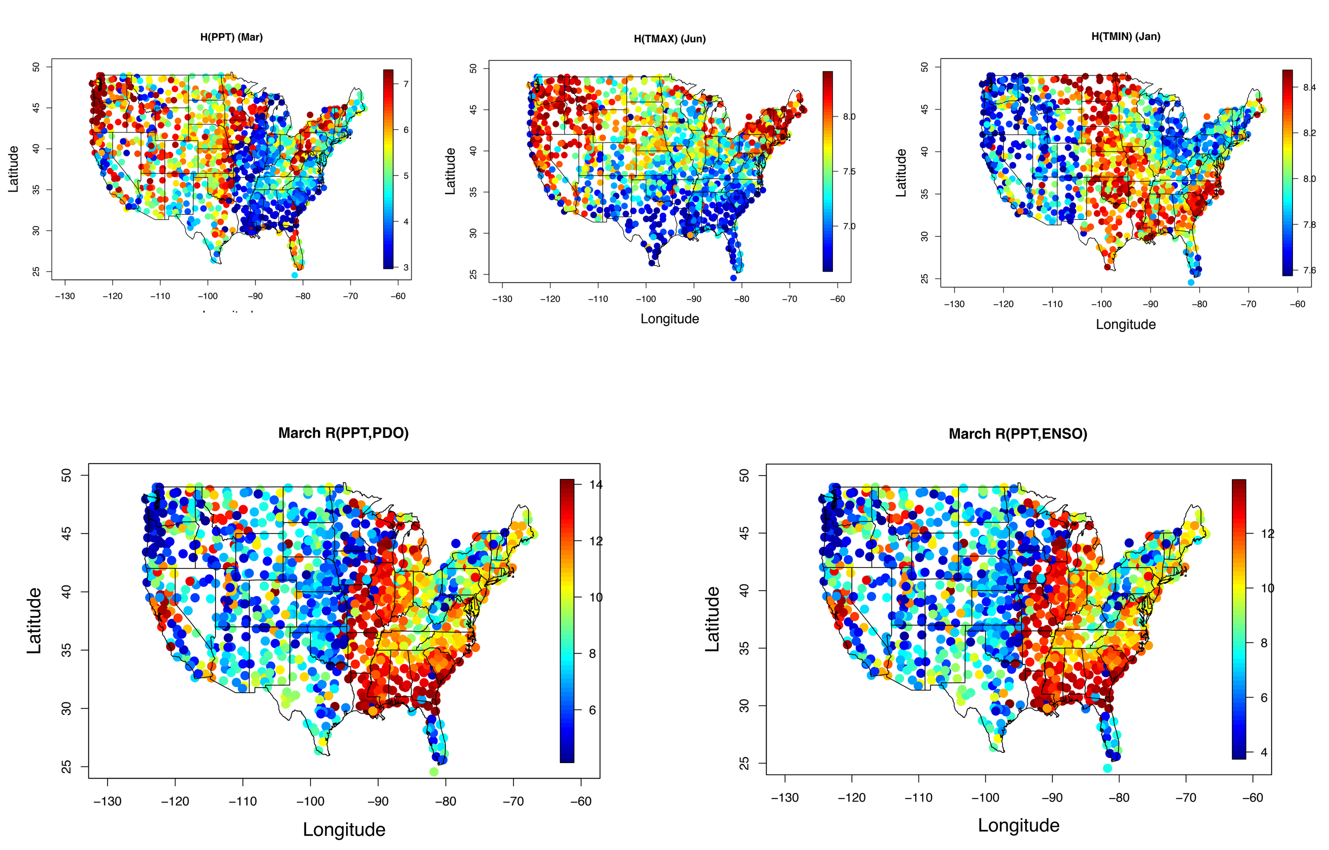

Figure 3: Entropy & Relative Entropy calculations for each station and respective months

Extreme Trends

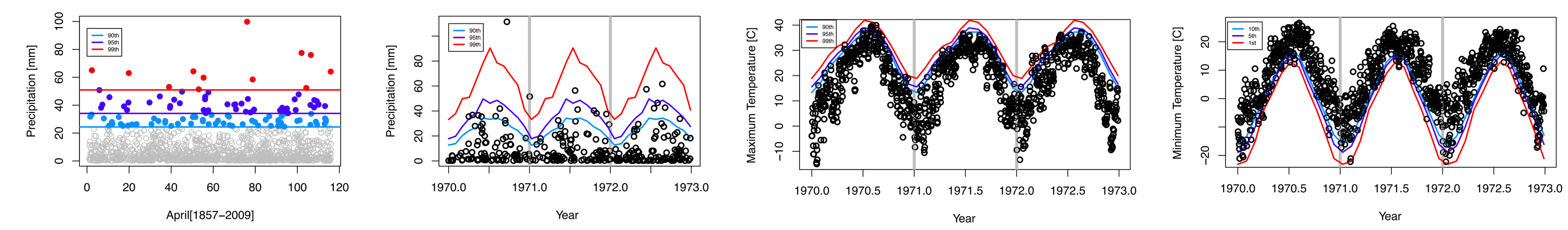

Figure 2a: Lawrence, KS Extreme Trend Analysis

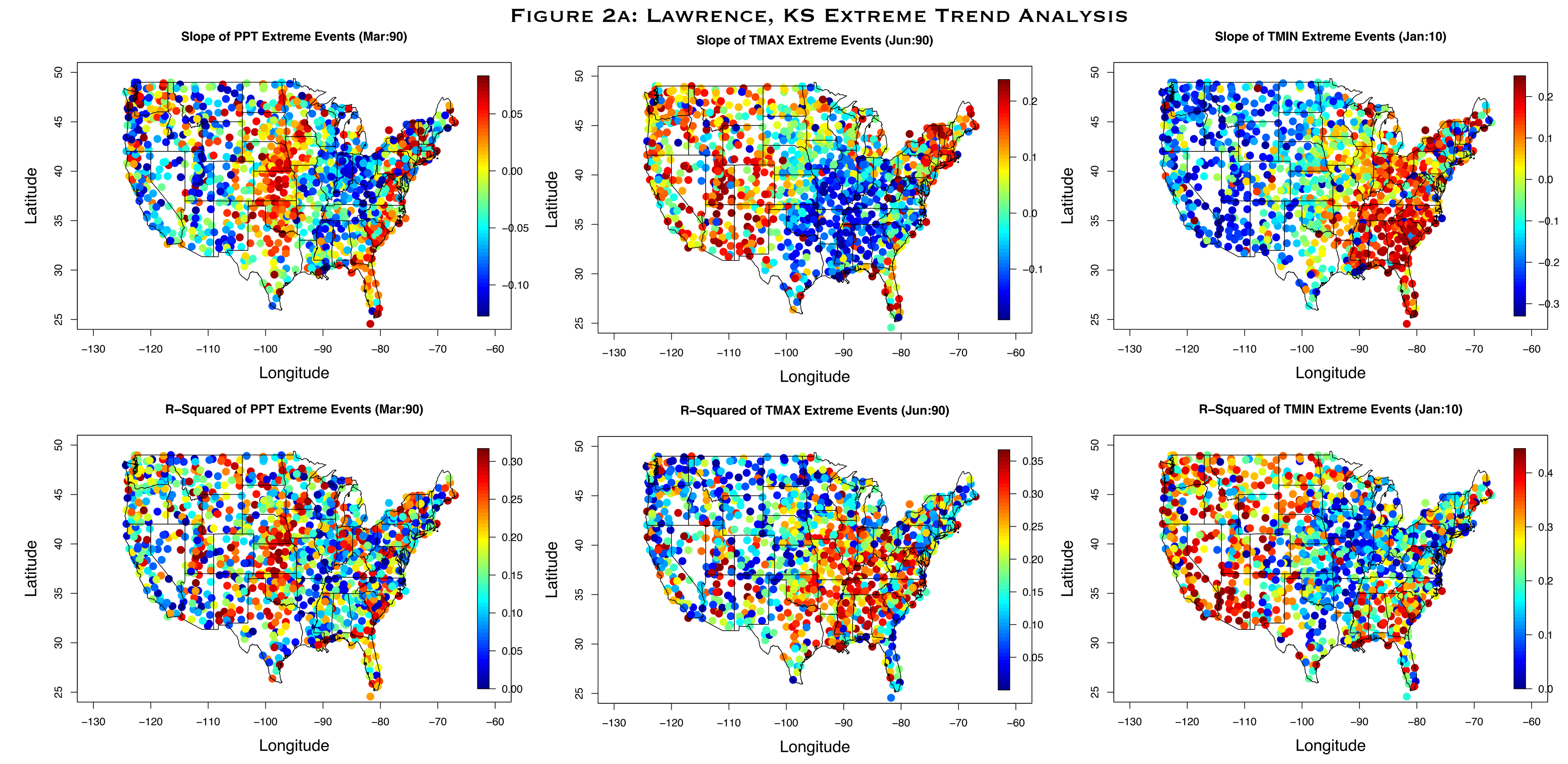

Figure 2b: Change in number of extreme events per year over station length and respective R-squared values

Wavelet Multiresolution Analysis

Correlation
MR Entropy
MR Relative Entropy

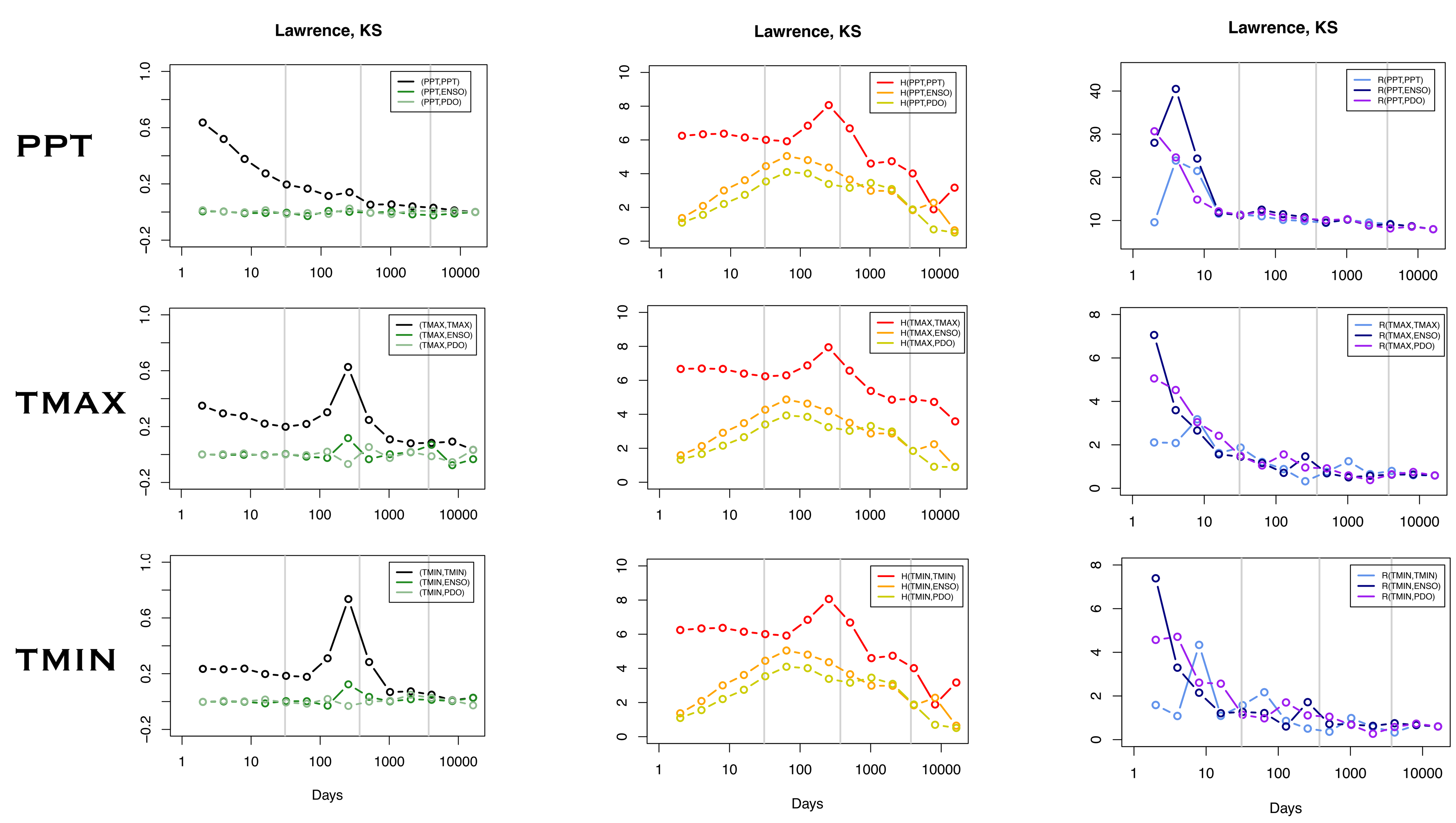

Figure 4: Wavelet Multiresolution analysis, scale 1:14, grey bars indicate monthly, yearly and decadal time periods respectively

Conclusions

The United States Historical Climate Network (USHCN) was examined. Understanding the potential changes in extreme weather events is essential for assessing regional scale impacts of climate change.

Preliminary findings show:

- Strong spatial patterns (in particular in the Great Plains and Appalachia) within the trends associated with the change in number of extreme weather events each year.
- Correlations for maximum temperature and minimum temperature peak on the annual and sub annual scale. Where precipitation only peaks on the sub annual scale.
- The low frequency oscillations peak on the annual and decadal timescale.
- Multiresolution entropy for maximum temperature, minimum temperature and precipitation results show peaks in the annual time scale.
- Entropy plots show good spatial coherence throughout the months.

Future research will be spent on:

- Analyzing the change in magnitude of these extreme weather events.
- 20th century trends analyzed further with the use of a stochastic weather generator.
- 20th and 21st century assessment using same techniques.

Acknowledgements

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