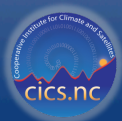


METEOROLOGICAL CAUSES OF OBSERVED EXTREME PRECIPITATION TRENDS IN THE U.S.

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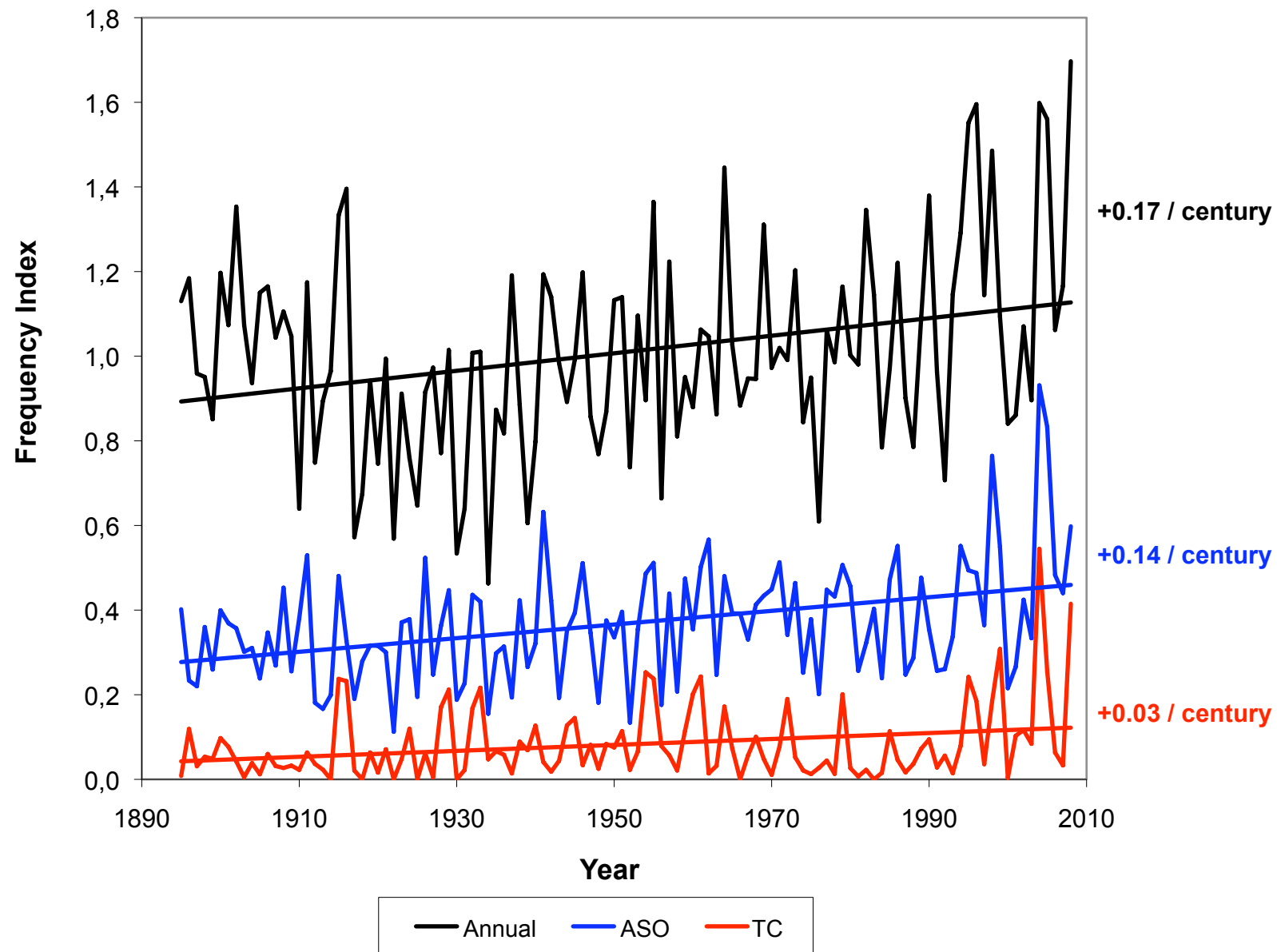


The UNIVERSITY of
NORTH CAROLINA
A Multi-Campus University

NC State University

Past Work

- Many studies have found an upward trend in various measures of heavy precipitation events in the U.S.



Updated from Kunkel, K. E., D.R. Easterling, K. Redmond, and K. Hubbard, 2003: Temporal variations of extreme precipitation events in the United States: 1895–2000, *Geophys. Res. Lett.*, **30**, 1900, 10.1029/2003GL018052

Causes

- Have there been secular changes in the frequency, intensity, and other characteristics of the meteorological phenomena producing heavy precipitation?
- Are the recent increases primarily a result of increases in atmospheric water vapor concentrations?

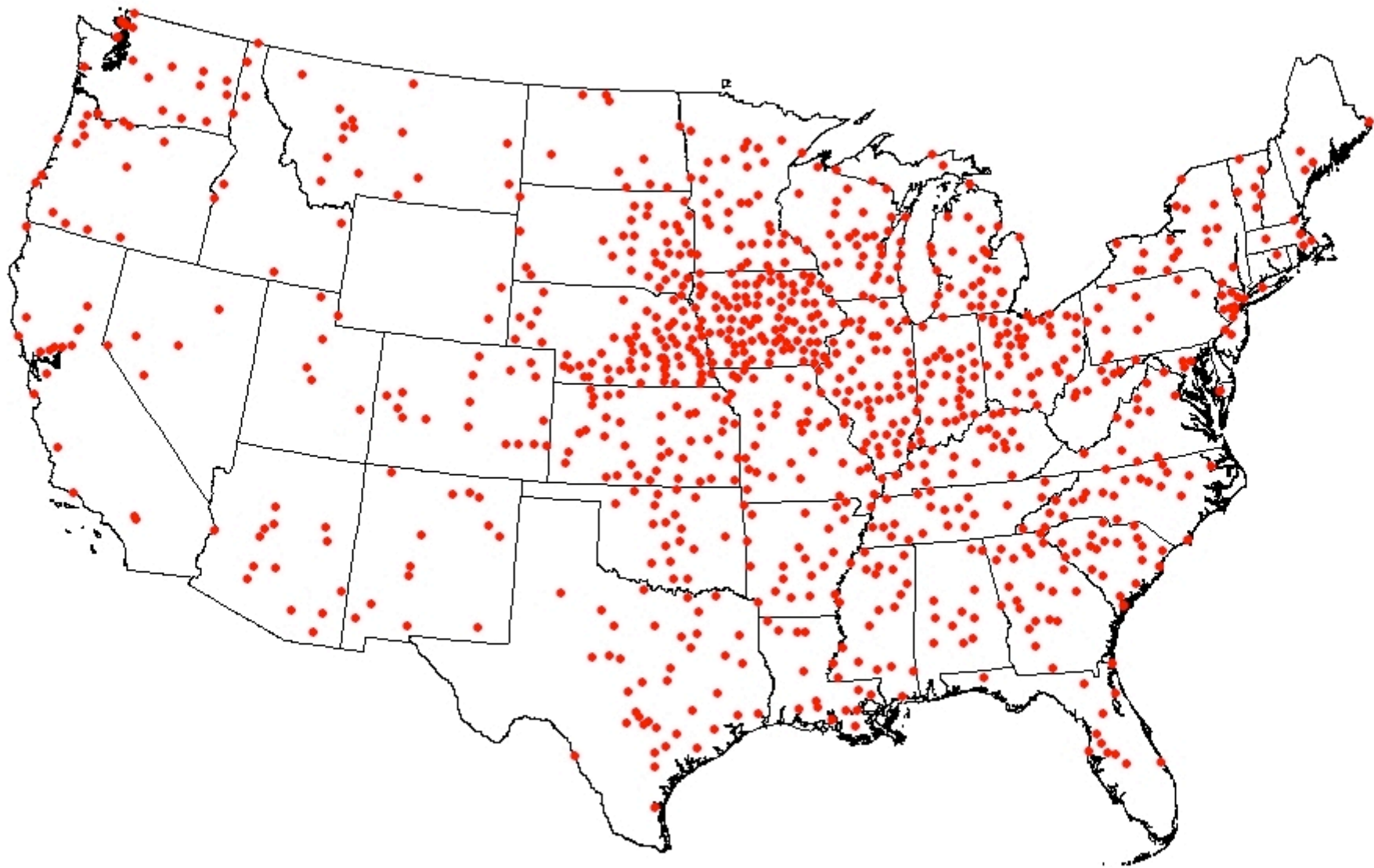
U.S. Climate Data

- U.S. Cooperative Observer Network in operation since late 1880s
- Daily Observations – Max and Min Temp, Precip, Snowfall, Snow Depth

Extremes Definition

- Event Duration – days
- Recurrence (threshold exceedance) –years
- 1-dy duration, 5-yr recurrence

Long-term Precipitation Stations



Meteorological Types

- Extratropical Cyclones
 - Frontal (at least ~300 km away from center of surface or upper low)
 - ETC (near surface or upper low center)
- Tropical Cyclones
- Mesoscale Convective Systems
- Air Mass Convection
- North American Monsoon
- Upslope

Data Sources

- Reanalysis
- Tropical Cyclone tracks
- Surface fields of temperature and precipitation
- Daily weather maps

Identification of Type

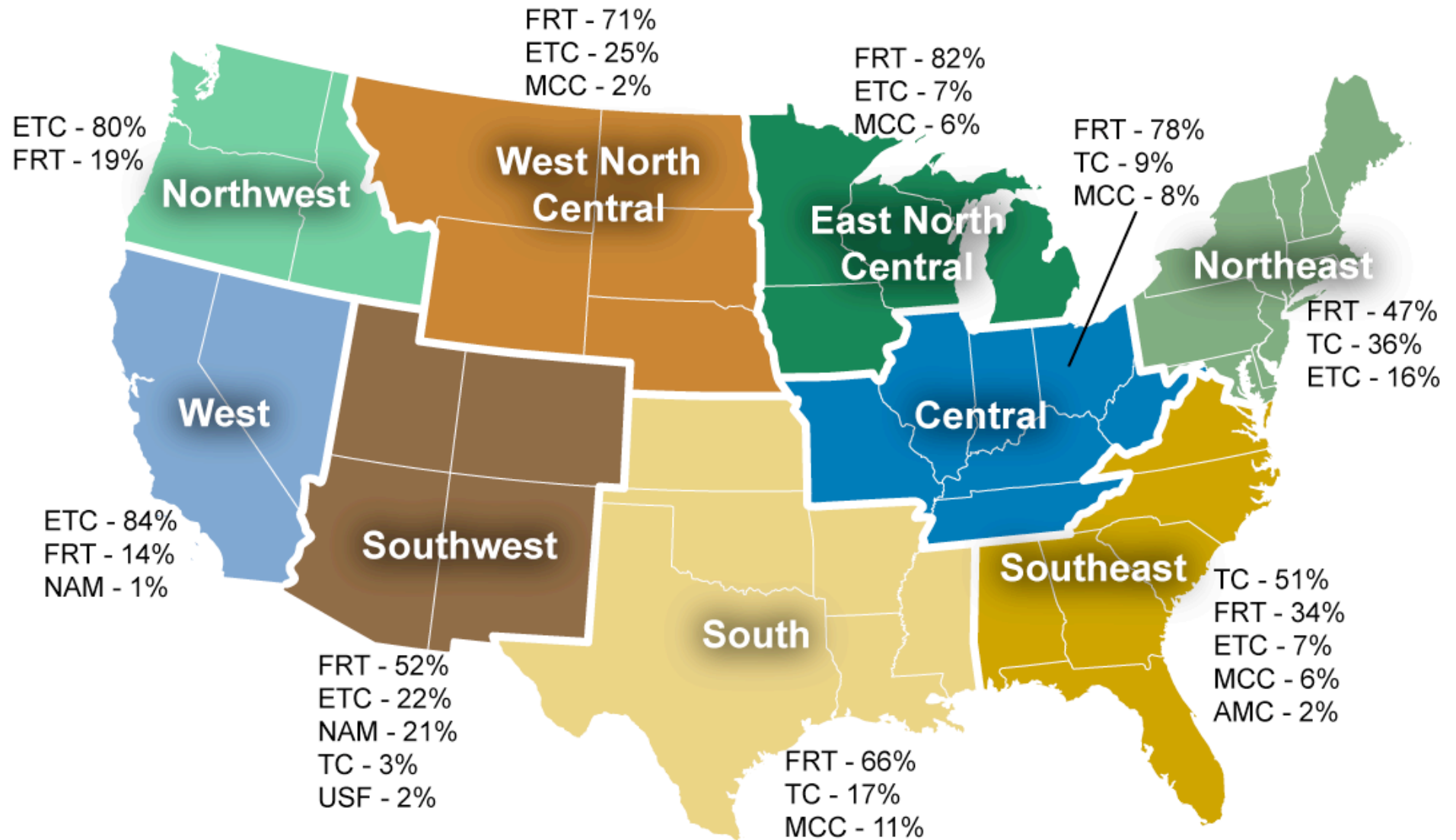
- Mostly based on judgment of authors
- Automated detection of tropical cyclone events based on HURDAT tracks
- We have completed analysis for the period of 1908-2009
- A total of 20,298 events were assigned causes

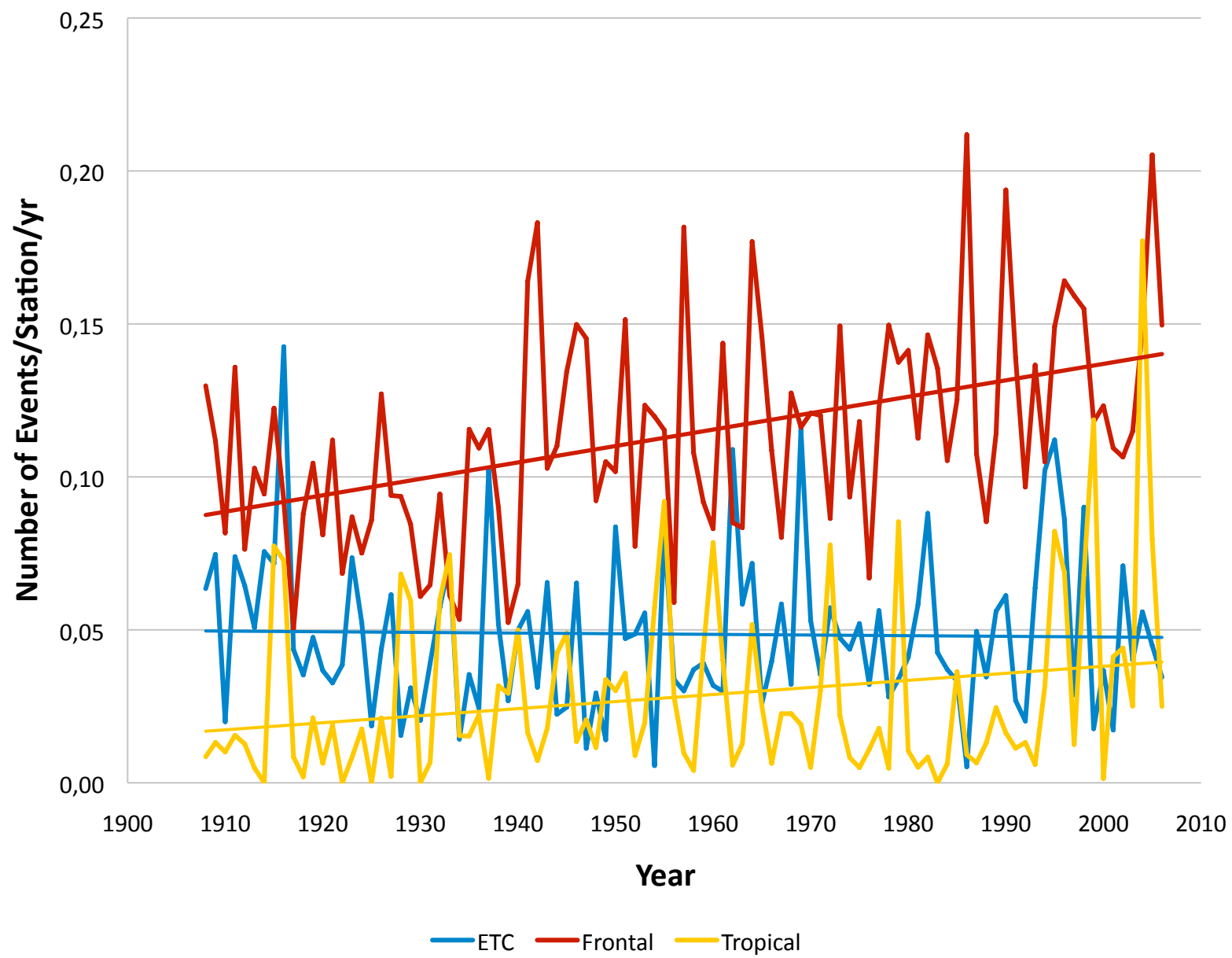
Contributions of Each Type

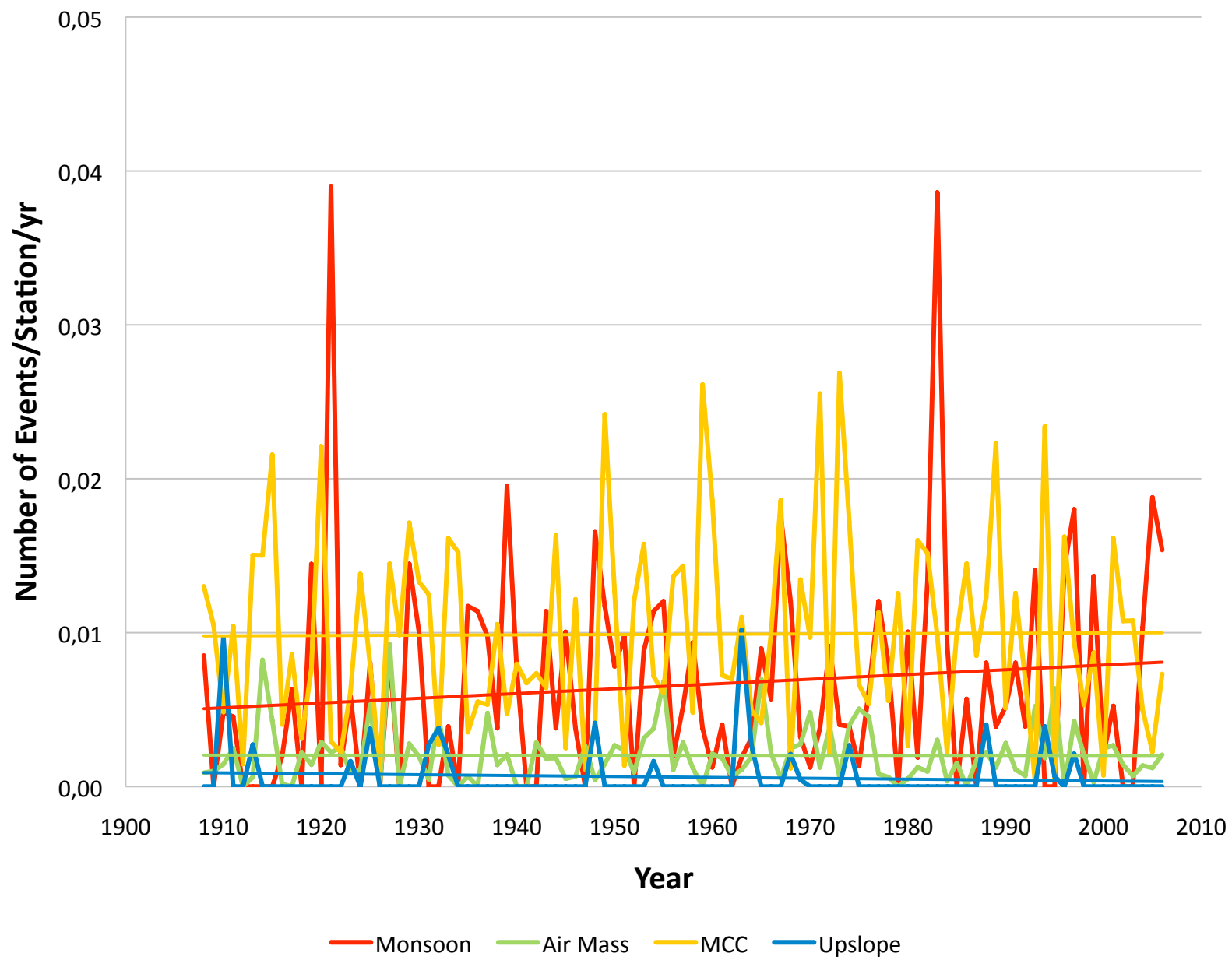
- 54% for Fronts-Extratropical Cyclones
- 24% for Nonfrontal-Extratropical Cyclone
- 13% for Tropical Cyclones
- 5% for Mesoscale Convective Systems
- 3% for North American Monsoon
- 1% for Air Mass Convection
- 0.1% for Upslope Flow

a)

Annual



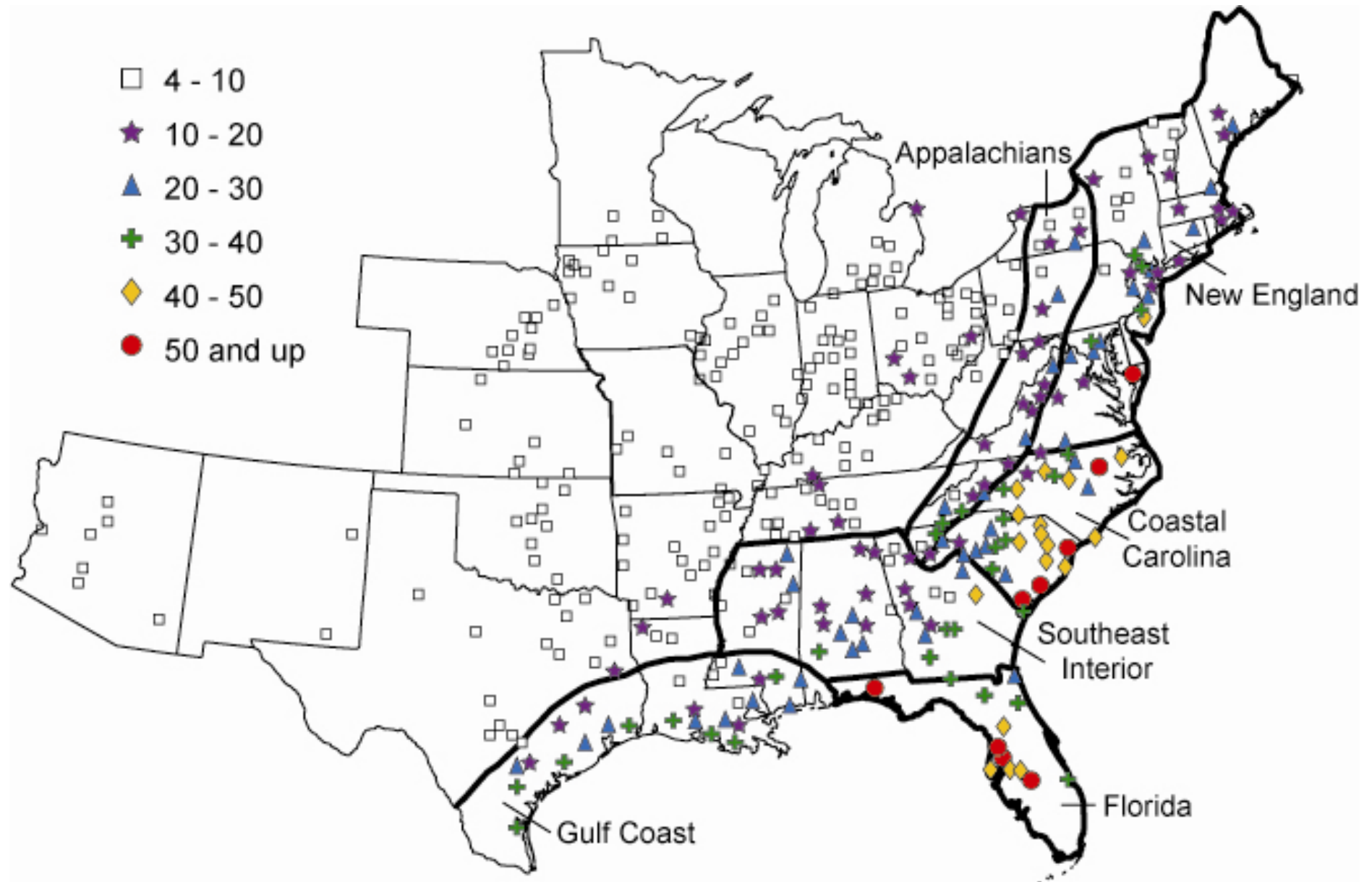




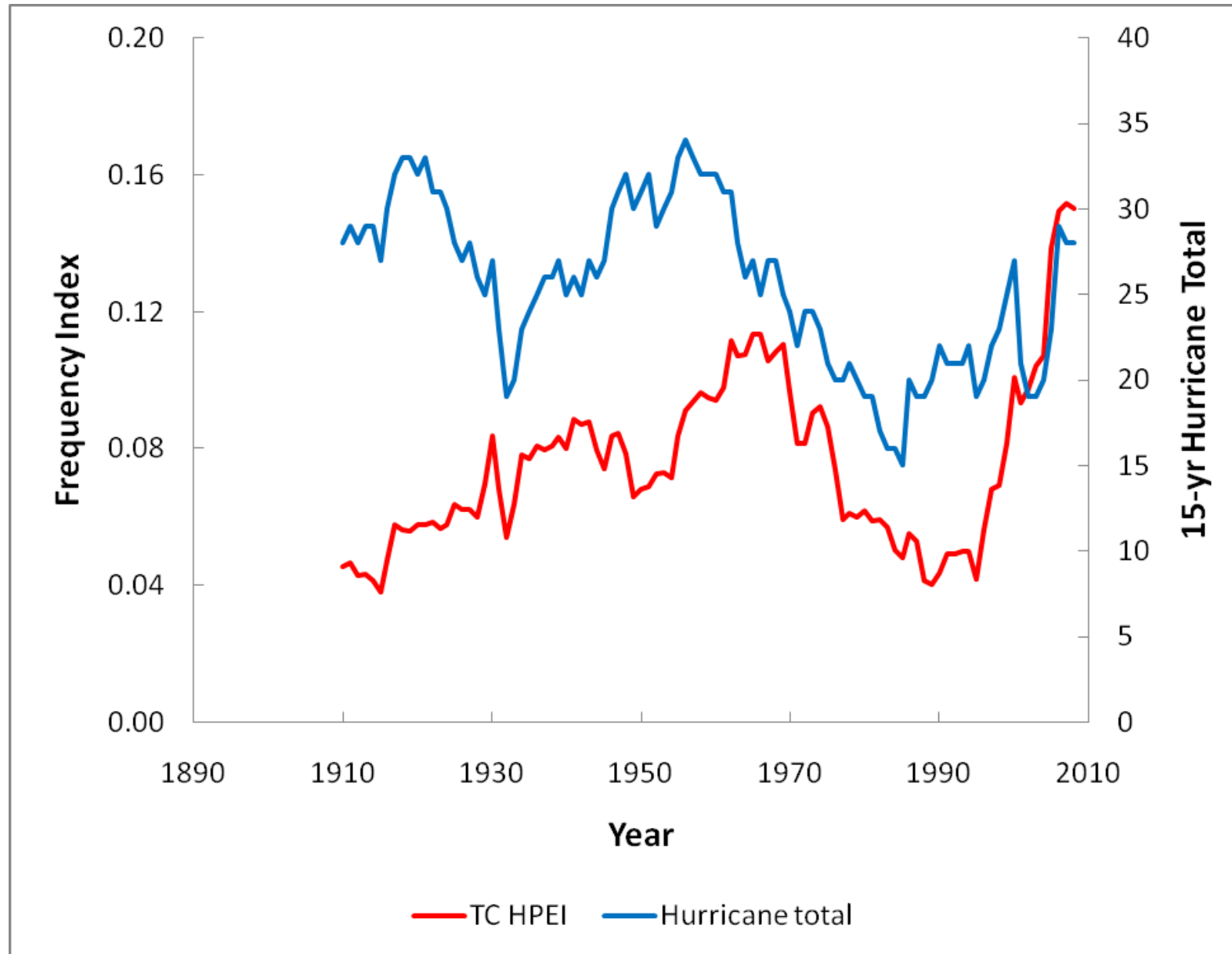
Contribution of Tropical Cyclones

- HURDAT tropical cyclone tracks dataset
- Heavy precipitation event considered to be caused by tropical cyclone if it occurred within 5 degrees of track

Percent of extreme events caused by Tropical Cyclones



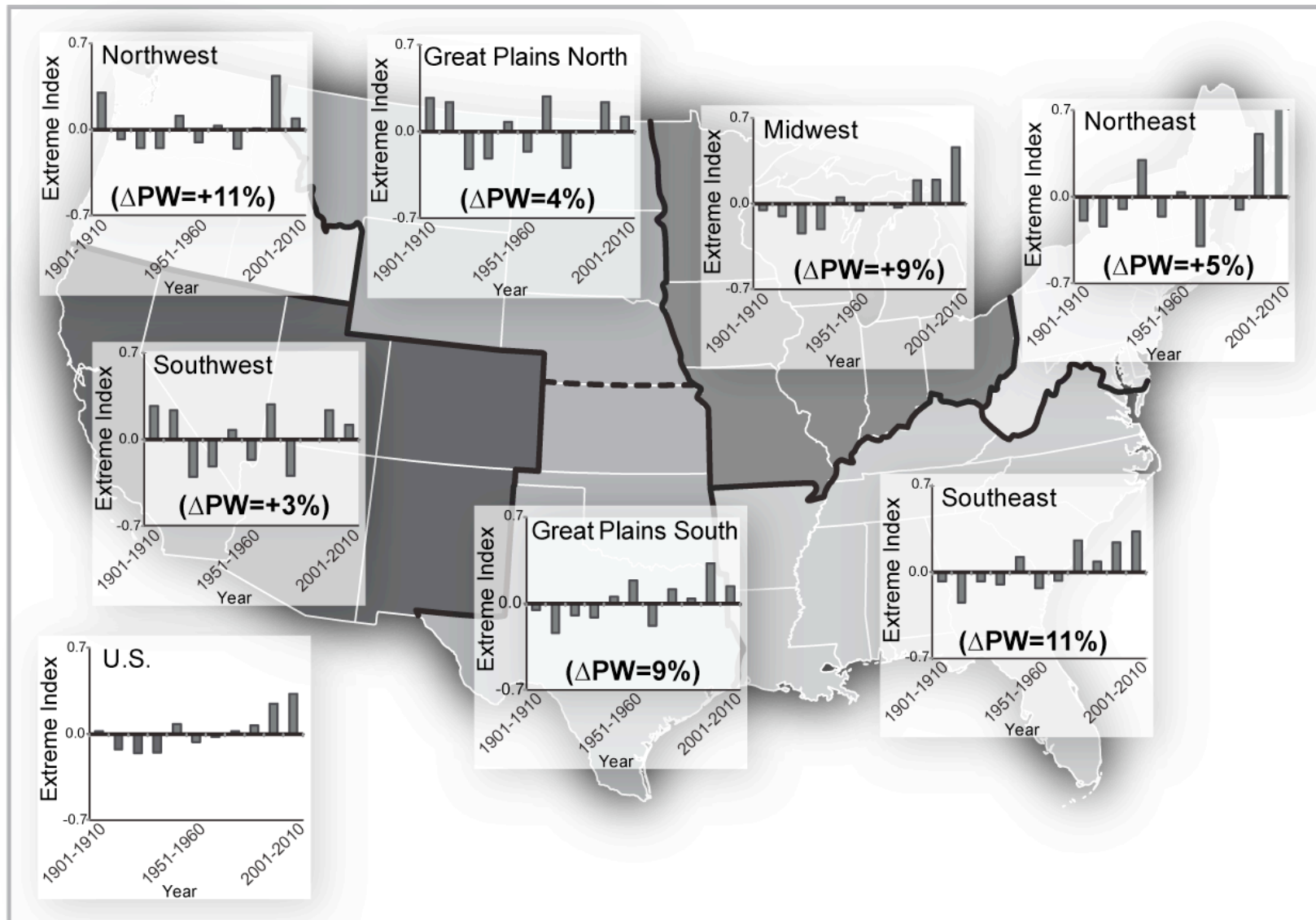
Heavy Event Frequency vs. Landfalling Hurricane Number



ROLE OF ATMOSPHERIC WATER VAPOR

Methods

- Precipitable Water (P_w) from new NCDC radiosonde data set (Integrated Global Radiosonde Archive)
- For each event, obtained 12-hr precipitable water values for radiosonde station nearest to event for day before and day of event
- Took highest of these values
- Averaged over 6 National Climate Assessment regions for
- Two periods: 1969-1989 and 1990-2009



Difference in extreme event precipitable water:
1991-2010 minus 1968-1990

CONCLUSIONS

- The observed national upward trend in heavy precipitation frequency is due primarily to trends during June through October
- Statistically significant upward trends in the # of events caused by frontal systems and tropical cyclones
- Increases in atmospheric water vapor content may be an important factor in these trends

Acknowledgements

- Support for portions of this study was provided by the NOAA Climate Program Office, Climate Observations and Monitoring Program