Mechanisms of Extreme Precipitation Change Over the Northeast

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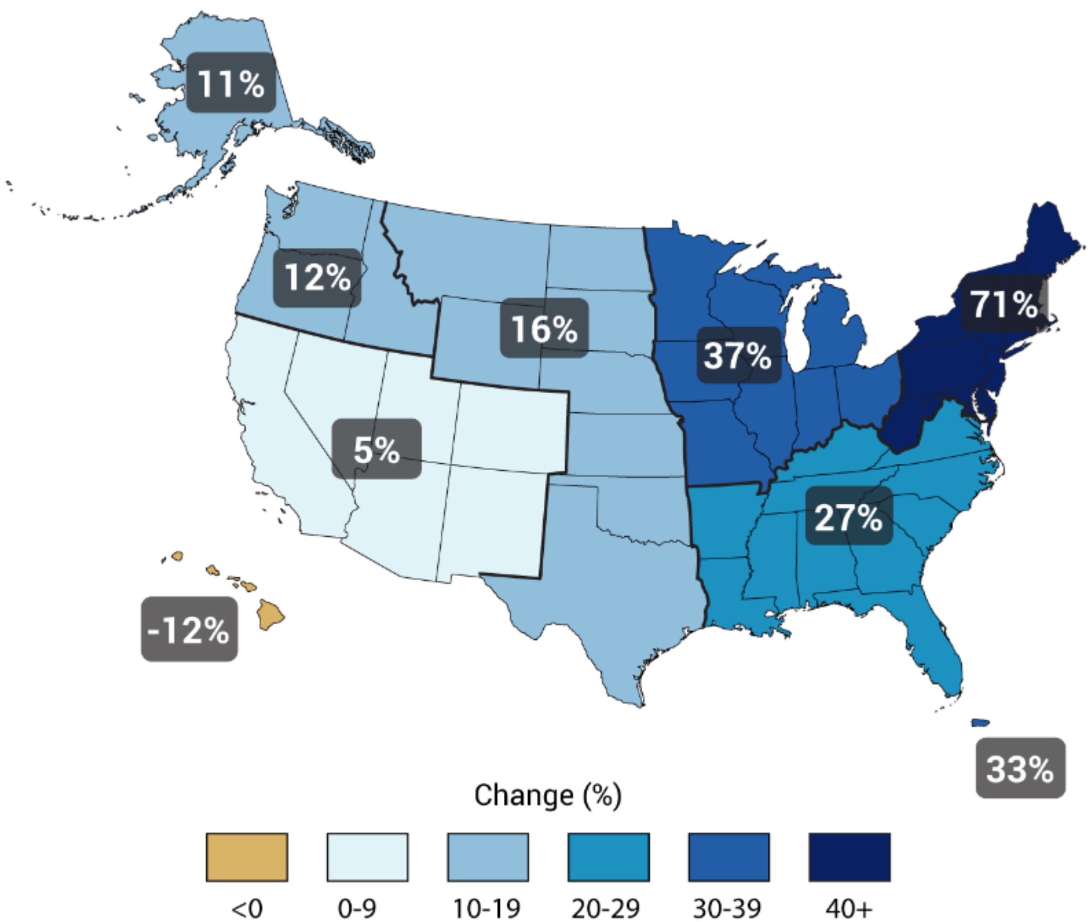
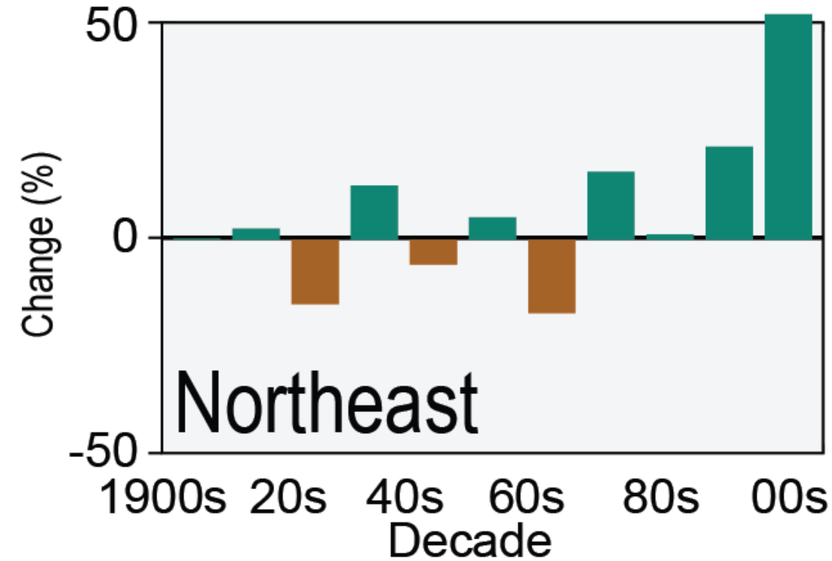
BREE
Basin Resilience to Extreme Events
in the Lake Champlain Basin

Vermont EPSCoR

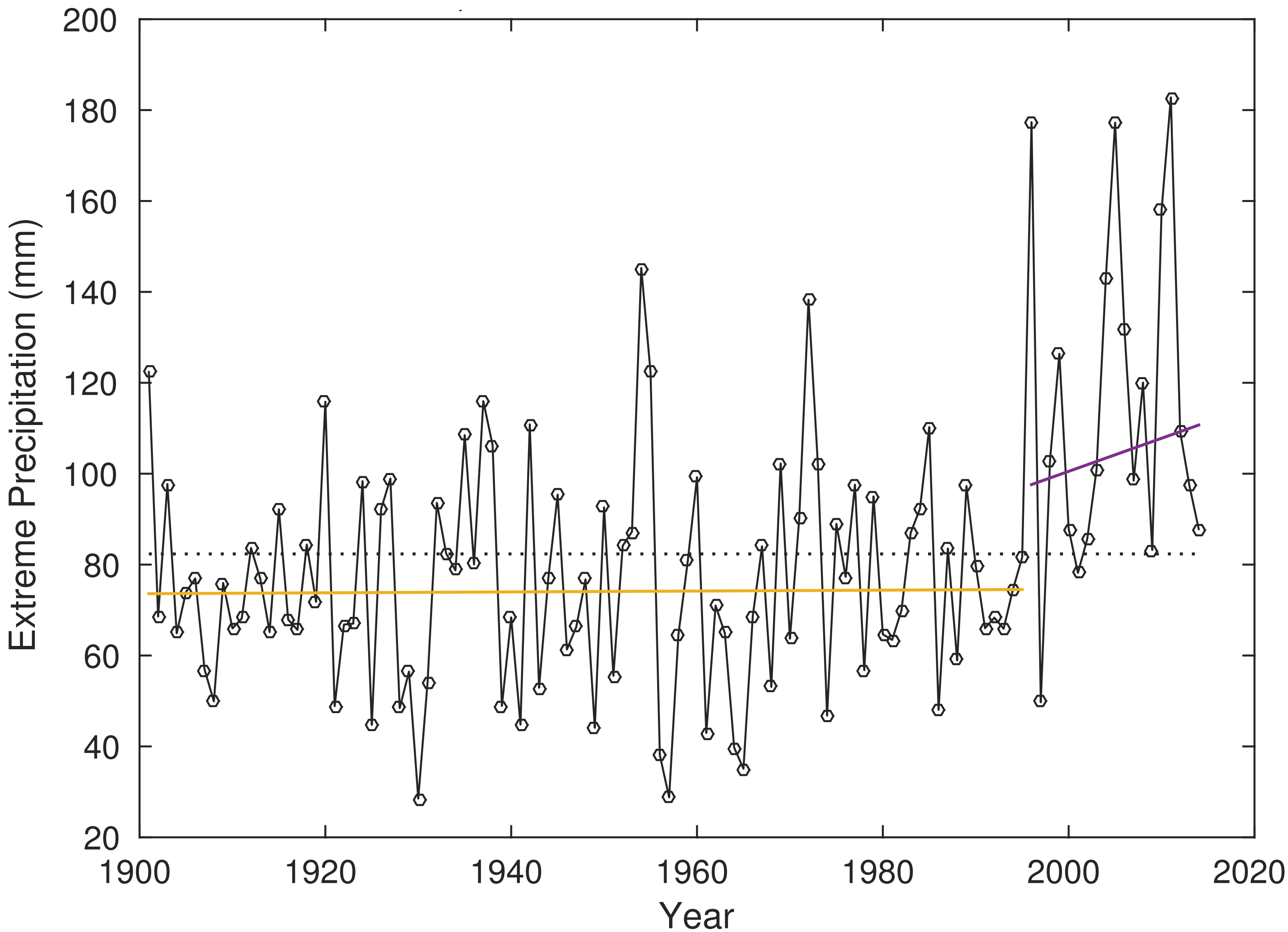
Northeast Extreme Precipitation Events Increased Dramatically 1960-Present





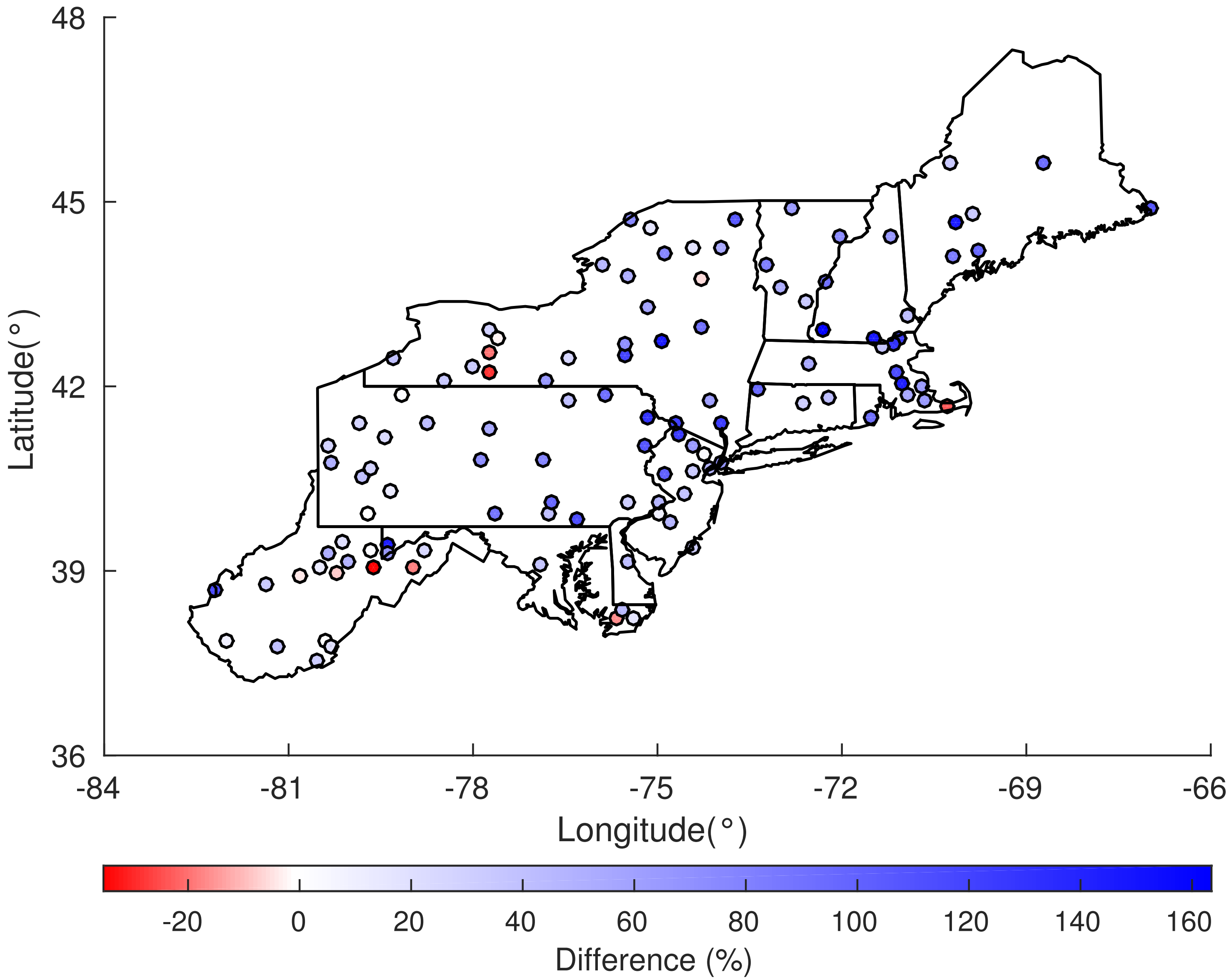
USGCRP, 2014; Goodwin, 2013

Northeast Extreme Precipitation Increased Dramatically ~~1960~~1996-Present



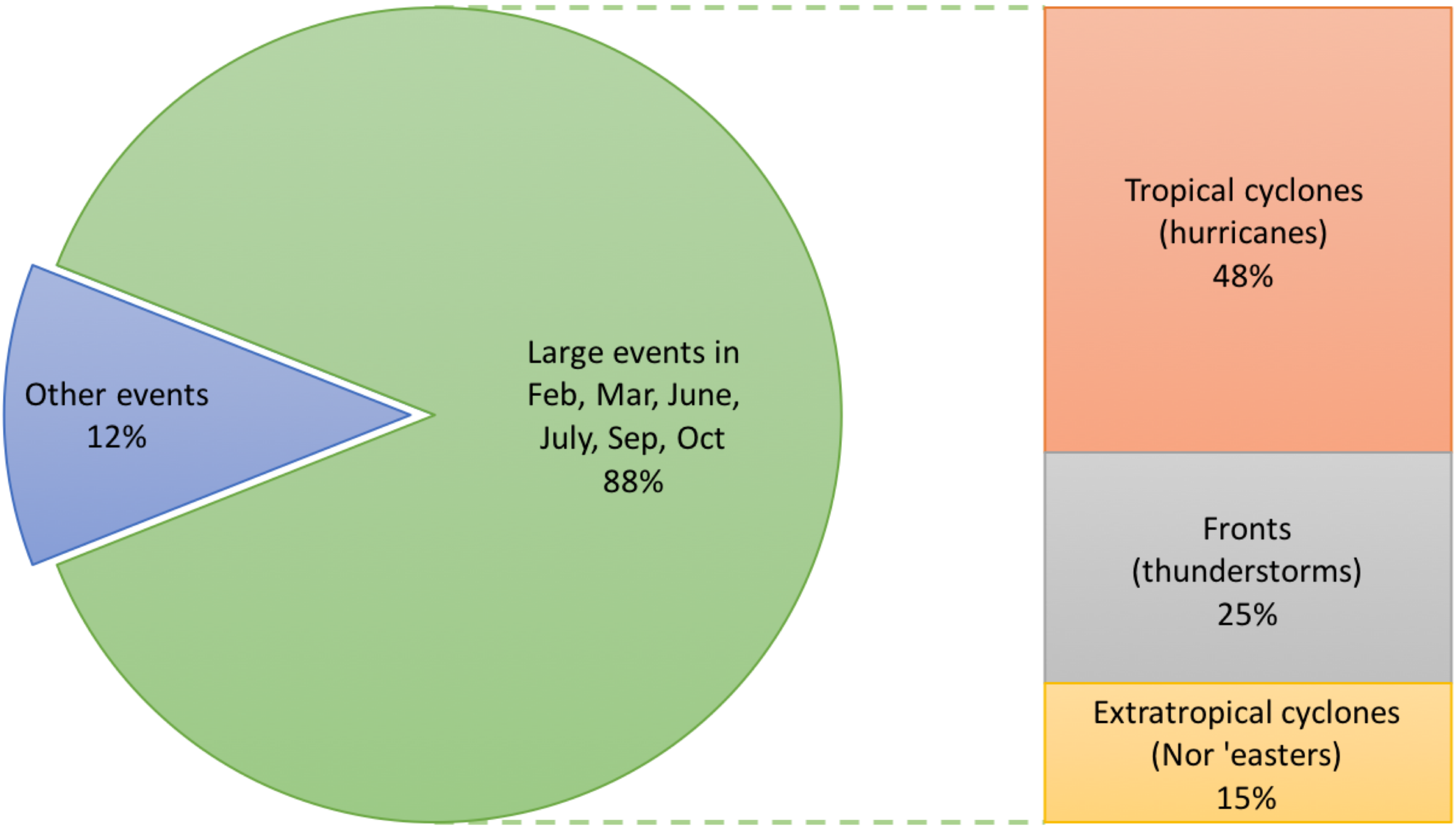
Huang et al., 2017; Frei et al., 2015

Northeast Extreme Precipitation Increase is Widespread



Huang et al., 2017

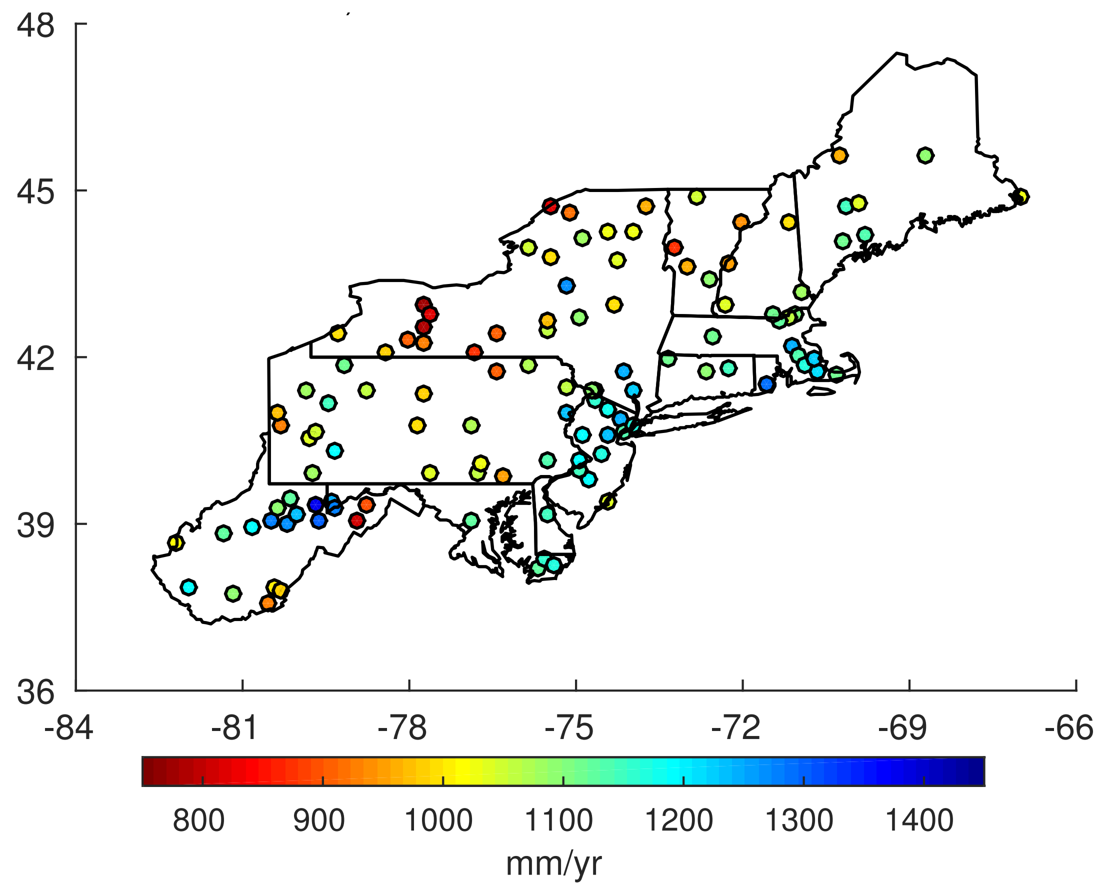
Blame Tropical Cyclones (and Fronts and Extratropical Cyclones)



Huang et al., 2018

GHCN-D, LI2013, NARR over the Northeast

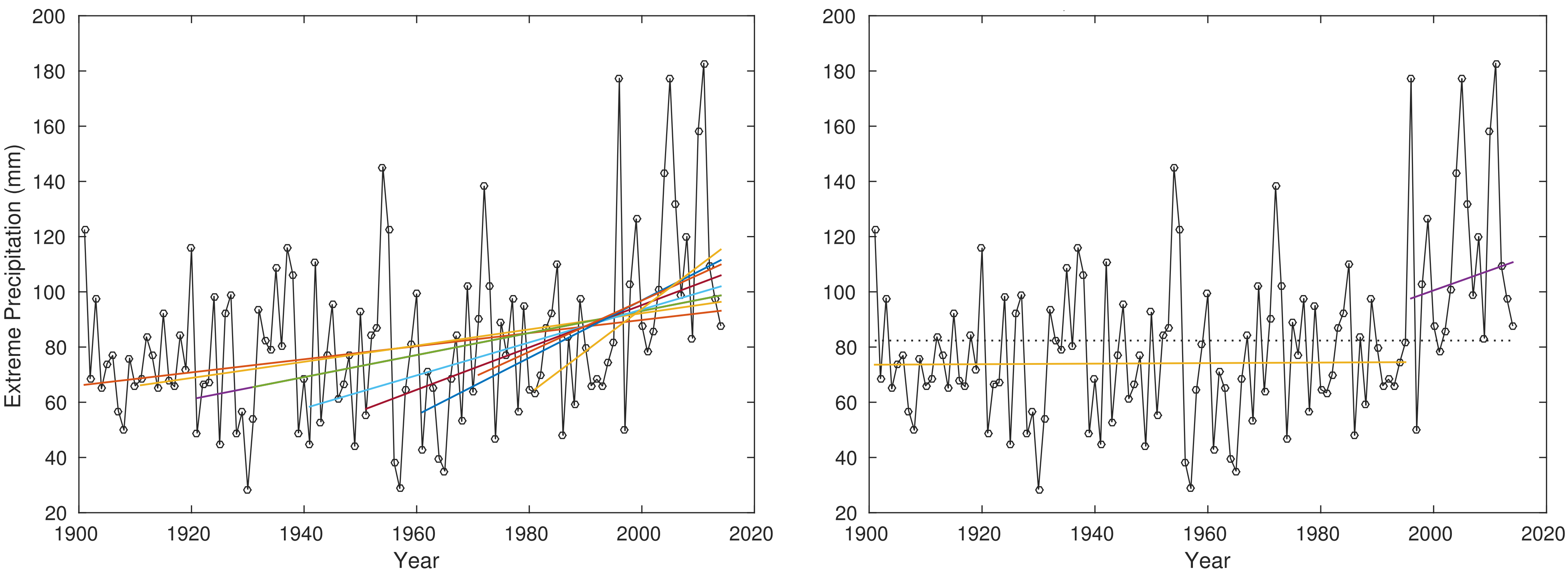
- Global Historical Climatology Network – Daily: GHCN-D; Menne et al. 2012; 1901-2014
- Gridded observations of Livneh et al.: LI2013; Livneh et al. 2013; 1915-2011
- North American Regional Reanalysis: NARR; Mesinger et al. 2006; 1979-2014



Huang et al., 2017

Trends Sensitive to Start Year, Changepoint Analysis Better Characterizes Time Series

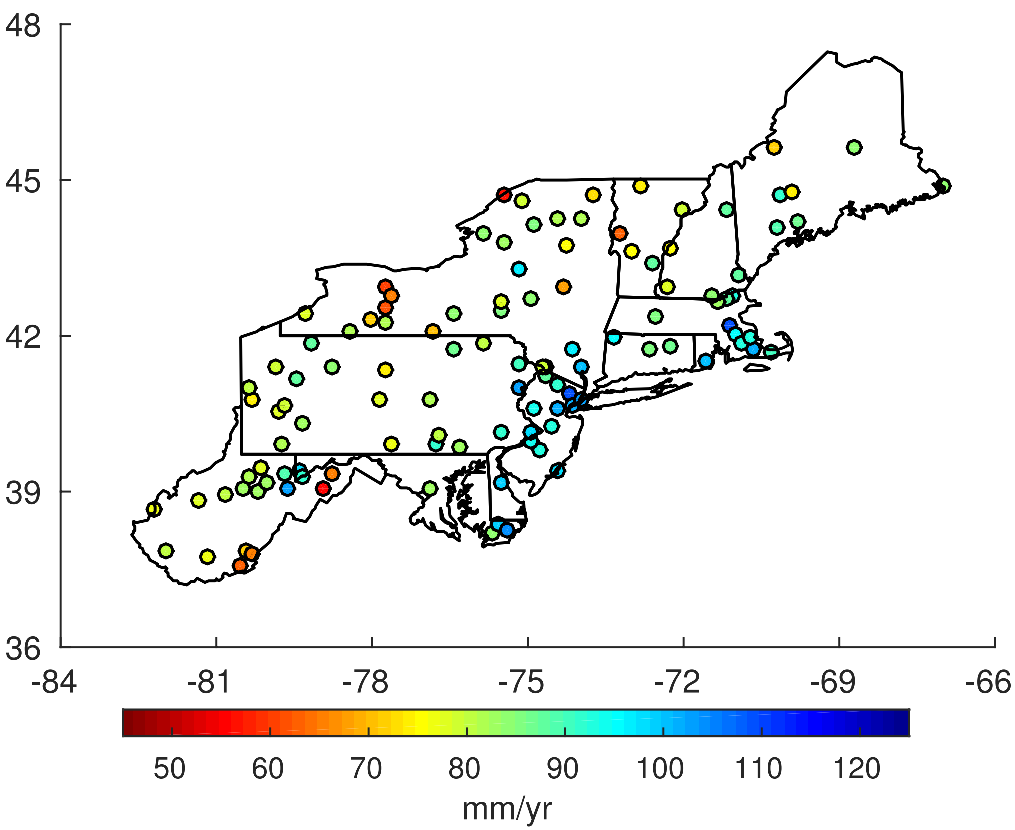
- Trends generally increasing with later start year: 2.4 mm decade^{-1} (1901-2014) to 14.7 mm decade^{-1} (1979-2014)
- Change in extreme best characterized as a shift in 1996: 53%

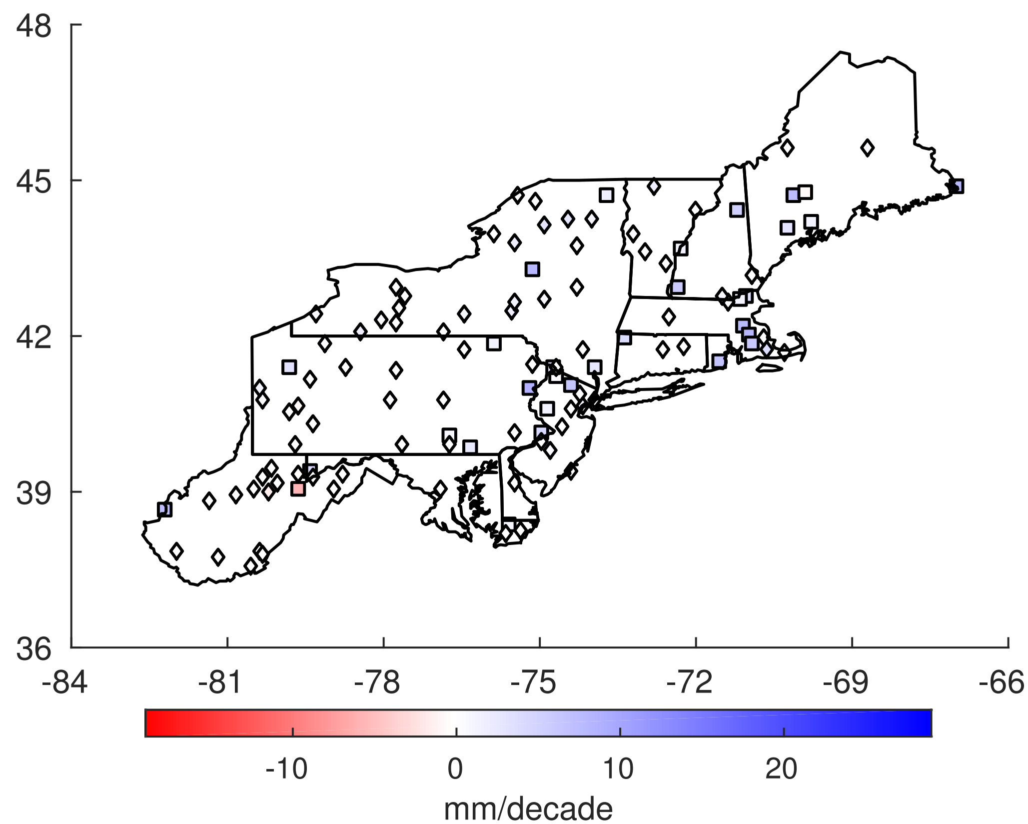


Huang et al., 2017

Extreme Precipitation: Averages Higher on Coasts, Trends Consistent over Domain

- Annual extreme precipitation (mm decade^{-1}) increased in 58 (50%), 30 (25%) of which were statistically significant
- Five (4.3%) stations had negative trends, two of which were significant

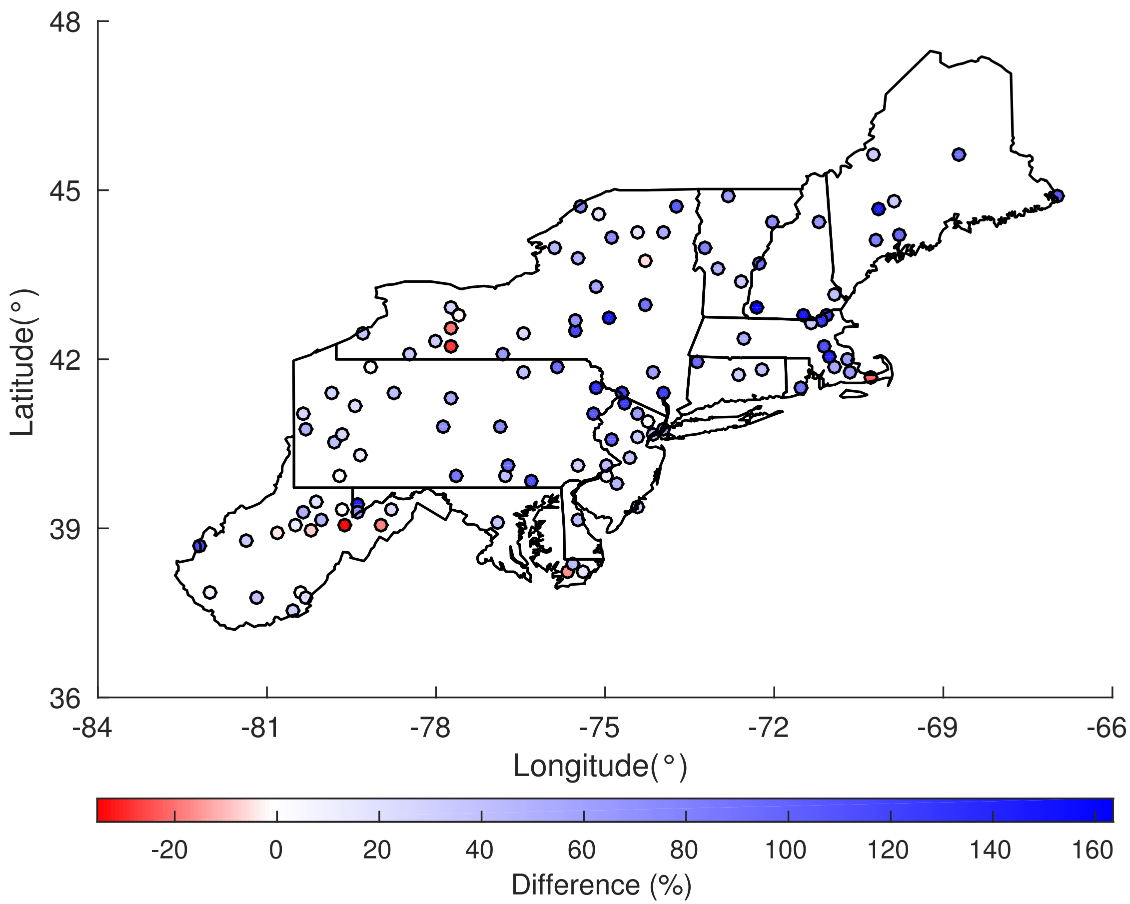




Huang et al., 2017

Extreme Precipitation: Difference between 1996-2014 and 1901-1995

- Annual extreme precipitation (%) was higher in 105 stations (91%) after 1996, with 56 stations exceeding a 50% increase
- Decreases east of Lake Erie (western NY and PA) and northeast WV



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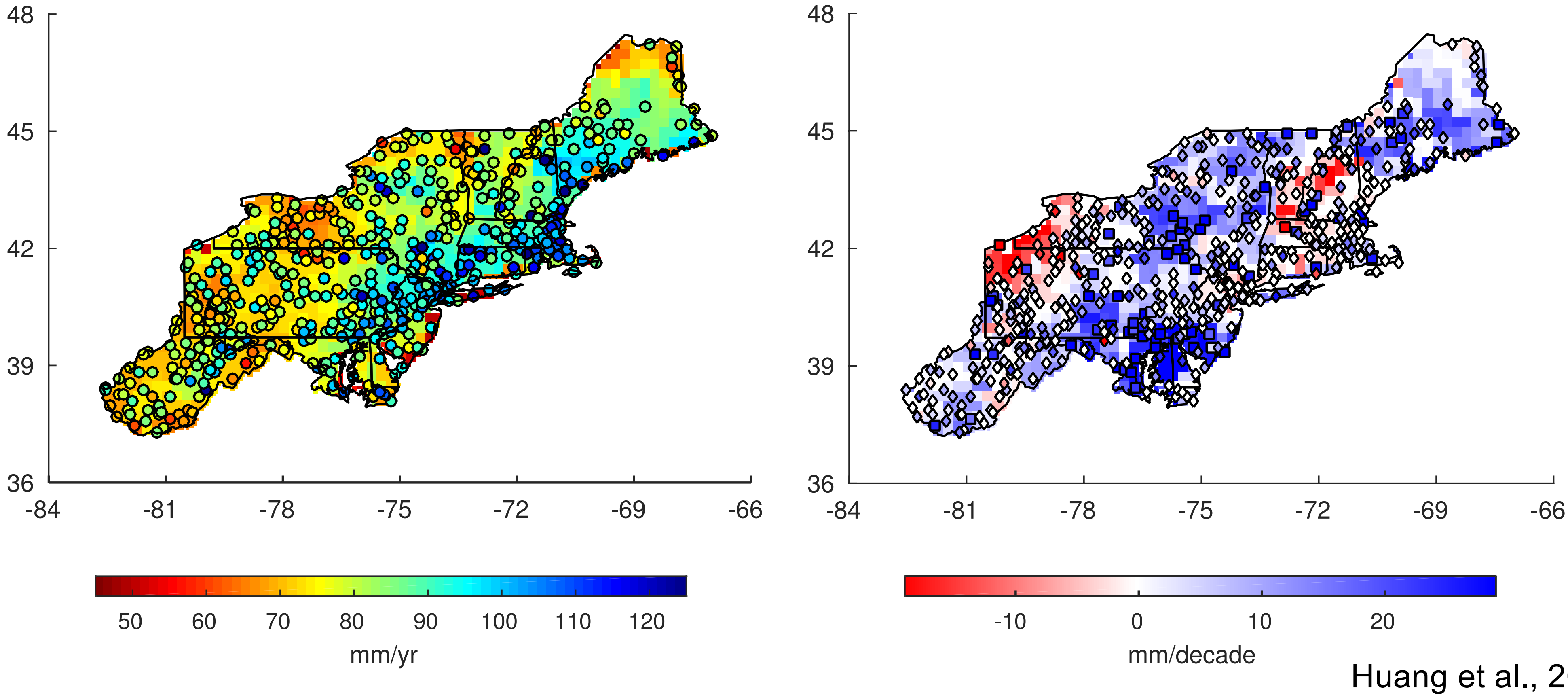
Extreme Precipitation Trends Most Difficult for Gridded Observations and Reanalysis

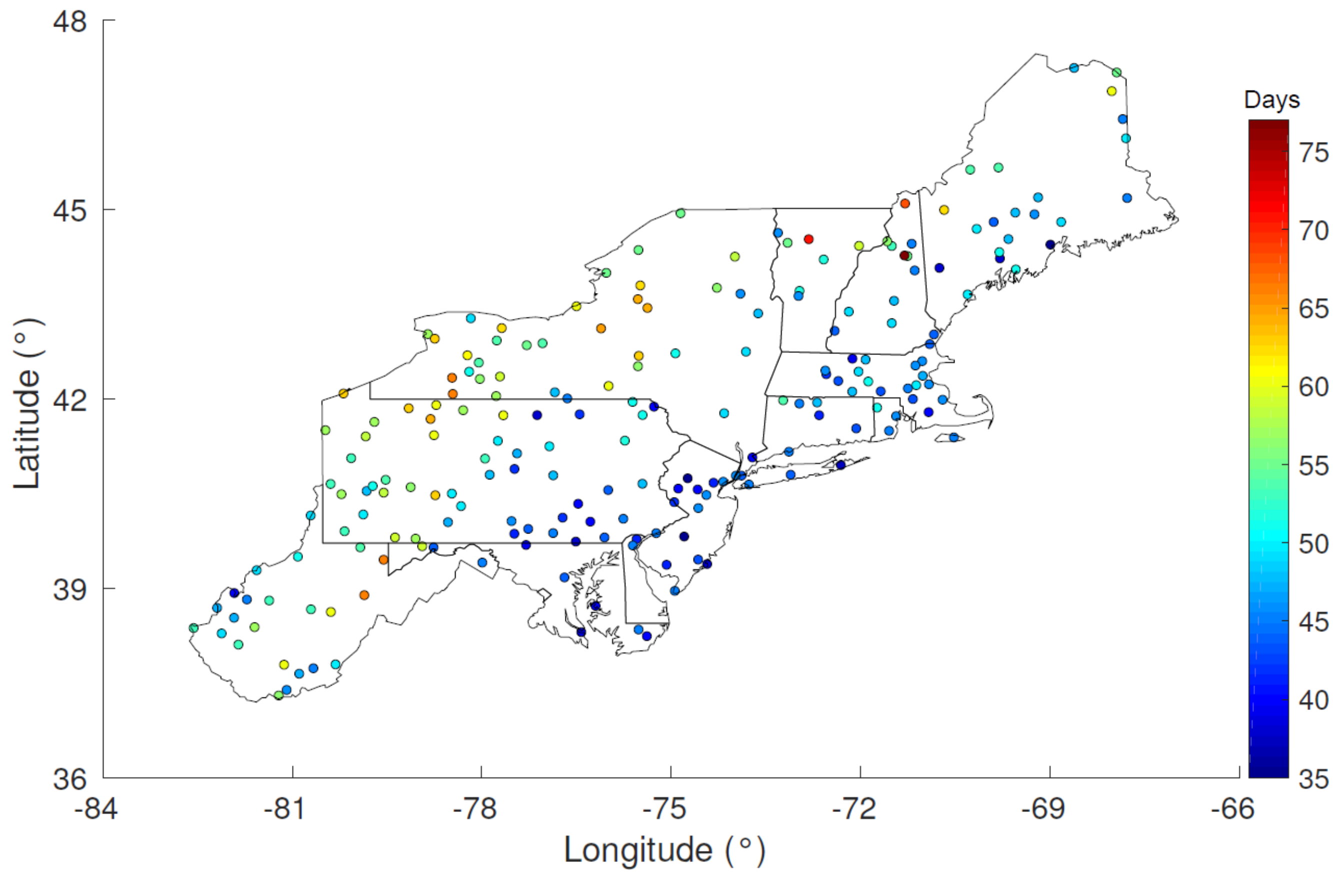
- LI2013 reproduces GHCN-D extreme precipitation, but underestimates GHCN-D extreme precipitation trends
- NARR underestimates GHCN-D extreme precipitation, and NARR extreme precipitation trends are sensitive to end year



Huang et al., 2017

Why Has Extreme Precipitation Increased?

- Global Historical Climatology Network – Daily: GHCN-D; Menne et al. 2012; 1979-2016
- US Daily Weather Maps: NOAA 2017; 1979-2016
- ERA Interim Reanalysis: ERA-I; Dee et al. 2011, 1979-2016



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Focus on Early Fall (Sep-Oct), Early Summer (Jun-Jul), and Late Winter (Feb-Mar)

Month	Pre-1996 EP mean ($mm\ yr^{-1}$)	Post-1996 EP mean ($mm\ yr^{-1}$)	Absolute EP change ($mm\ yr^{-1}$)	Relative EP change (%)
1	1.7	2.2	0.5	29
2	1.7	2.2	0.5	29
3	3.2	4.9	1.7	53
4	3.6	4.6	1	28
5	4.6	5.7	1.1#	24
6	7.8	10.9	3.1	40
7	9.8	14.3	4.5*	46
8	14.7	12.6	−2.1#	−14
9	9.9	20.3	10.4*	105
10	6.8	12.3	5.5	81
11	6.1	6.4	0.3	5
12	3.2	4.1	0.9	28
Total	73.1	100.5	27.4*	37

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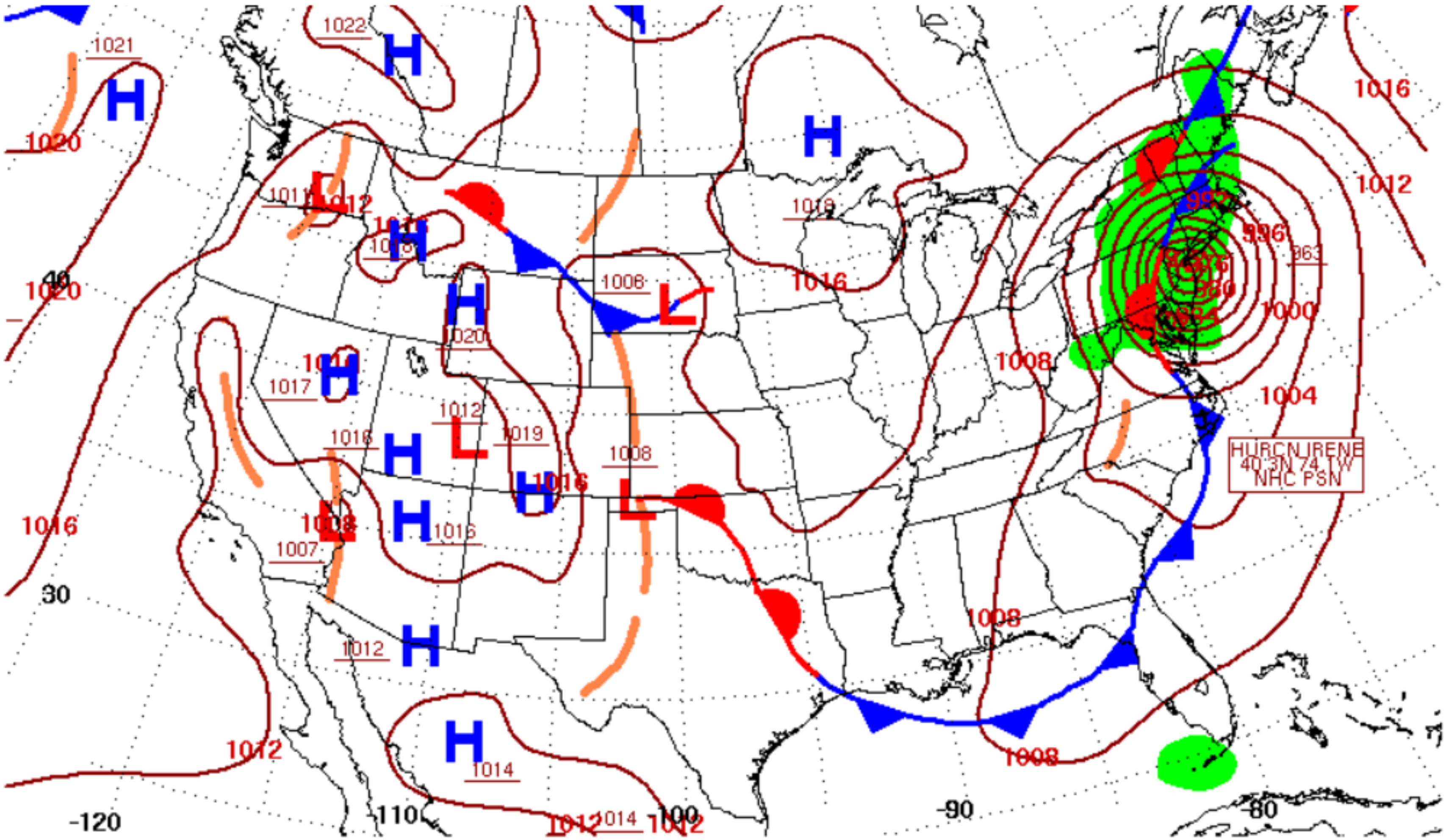
Categorize 273 5+ Station Extreme Precipitation Events (by Huanping)



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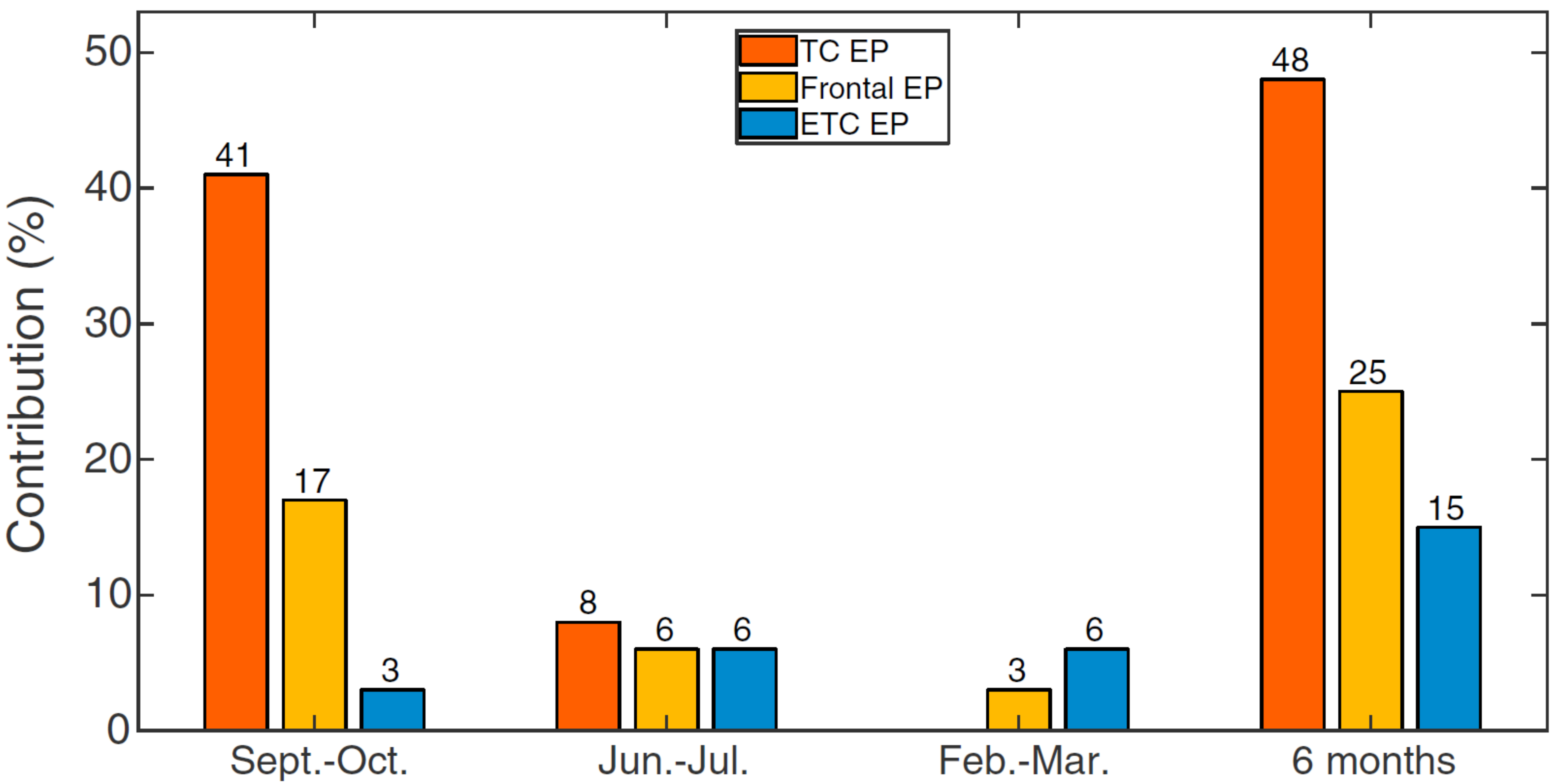
Sep-Oct Tropical Cyclones Dominate Northeast Extreme Precipitation Increase



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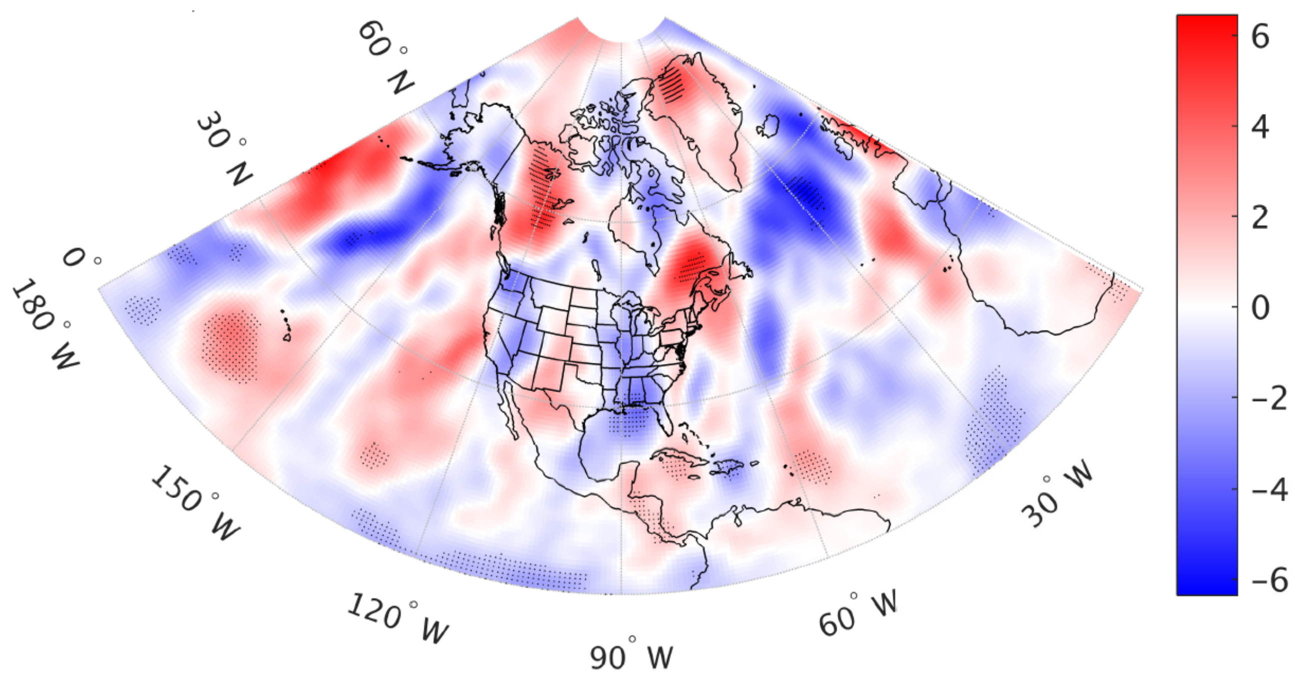
Analyze Atmospheric Drivers of the Extreme Precipitation Increase

- Composite potential driving fields on extreme precipitation days for pre-1996 (1979-1995) and post-1996 (1996-2016)
  - Total column water vapor
  - Geopotential height at 500 hPa
  - Sea level pressure
  - Zonal and meridional winds at 850 hPa and 250 hPa
  - Vertical velocity
  - Sea surface temperature (SST)



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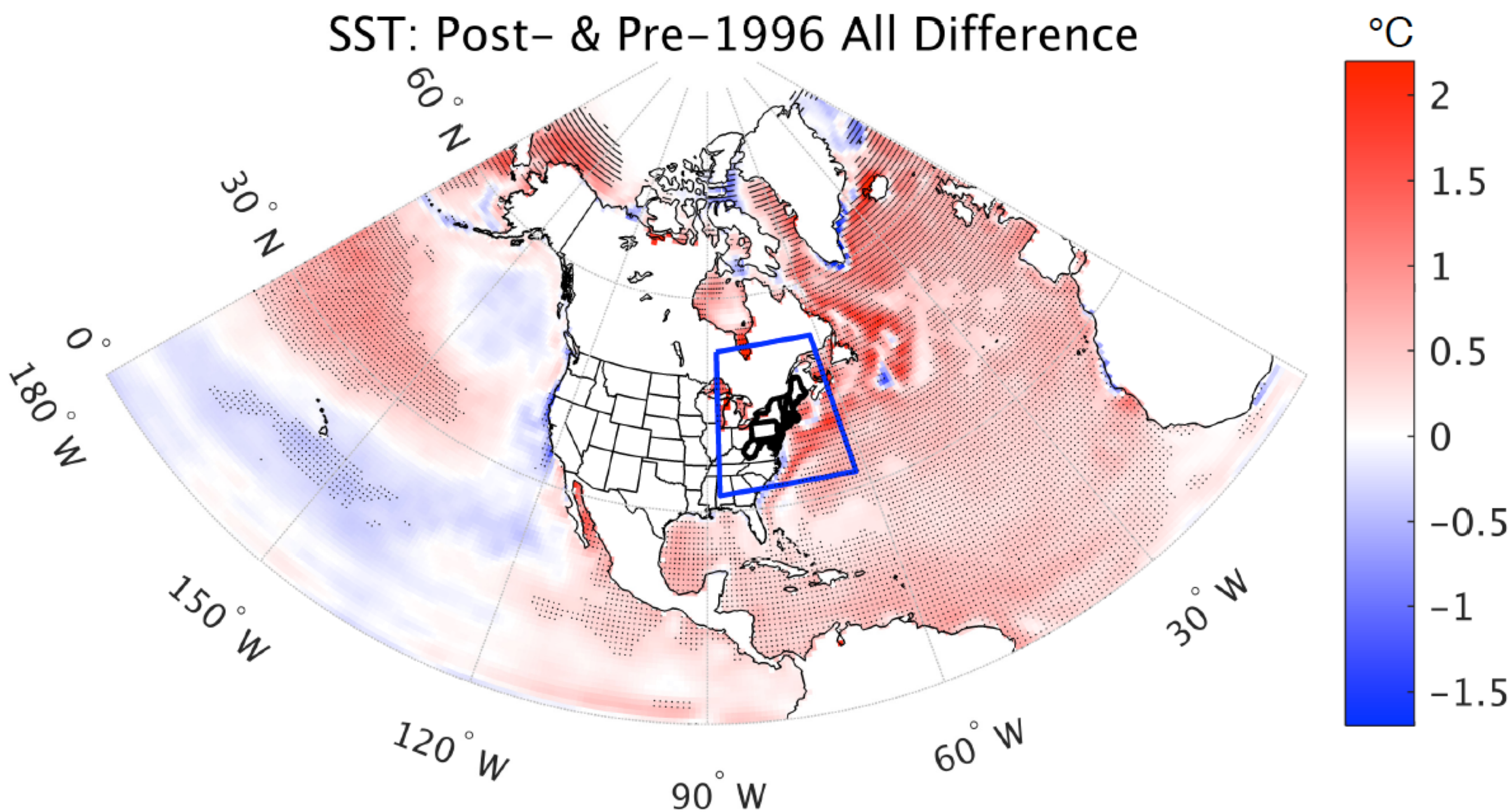
Tropical Cyclone Extreme Precipitation Correlated with Sea Surface Temperatures



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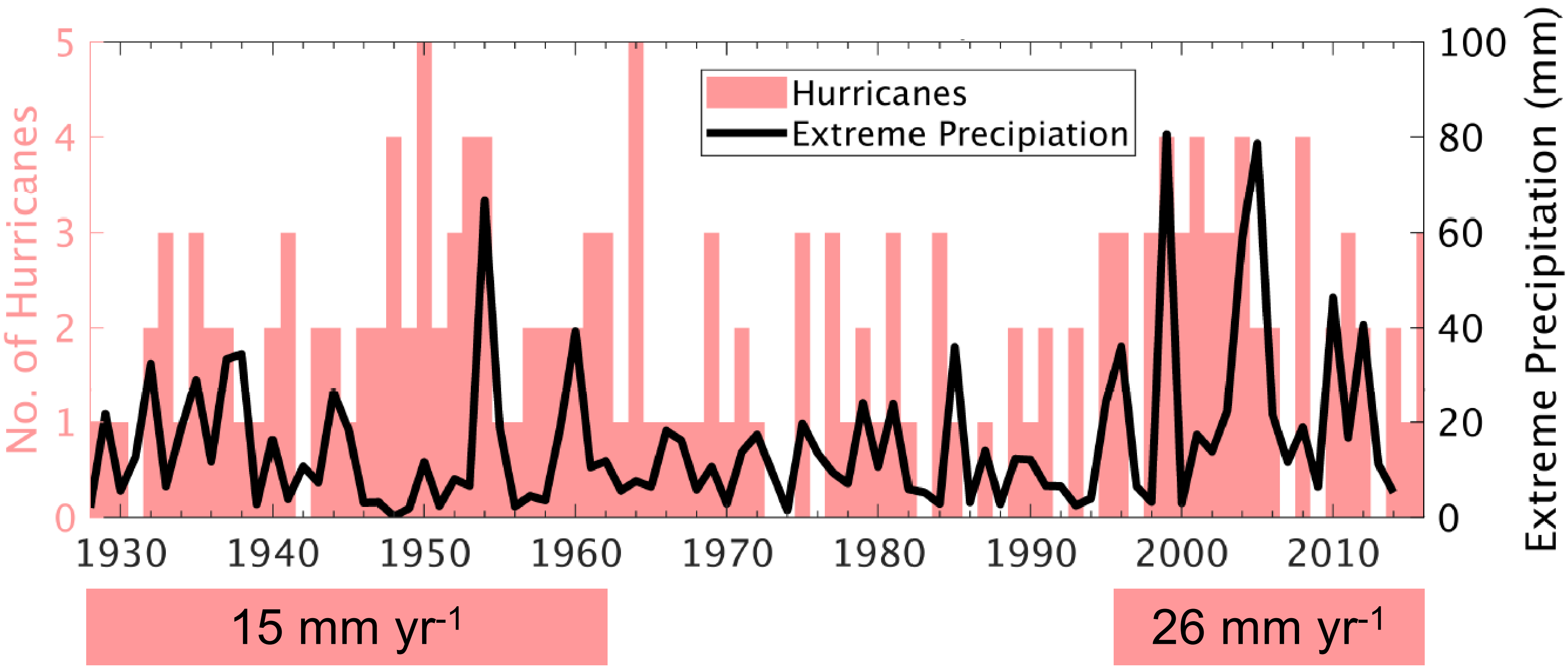
Why Less Extreme Precipitation During Last AMO+ Phase (1928-1962)?



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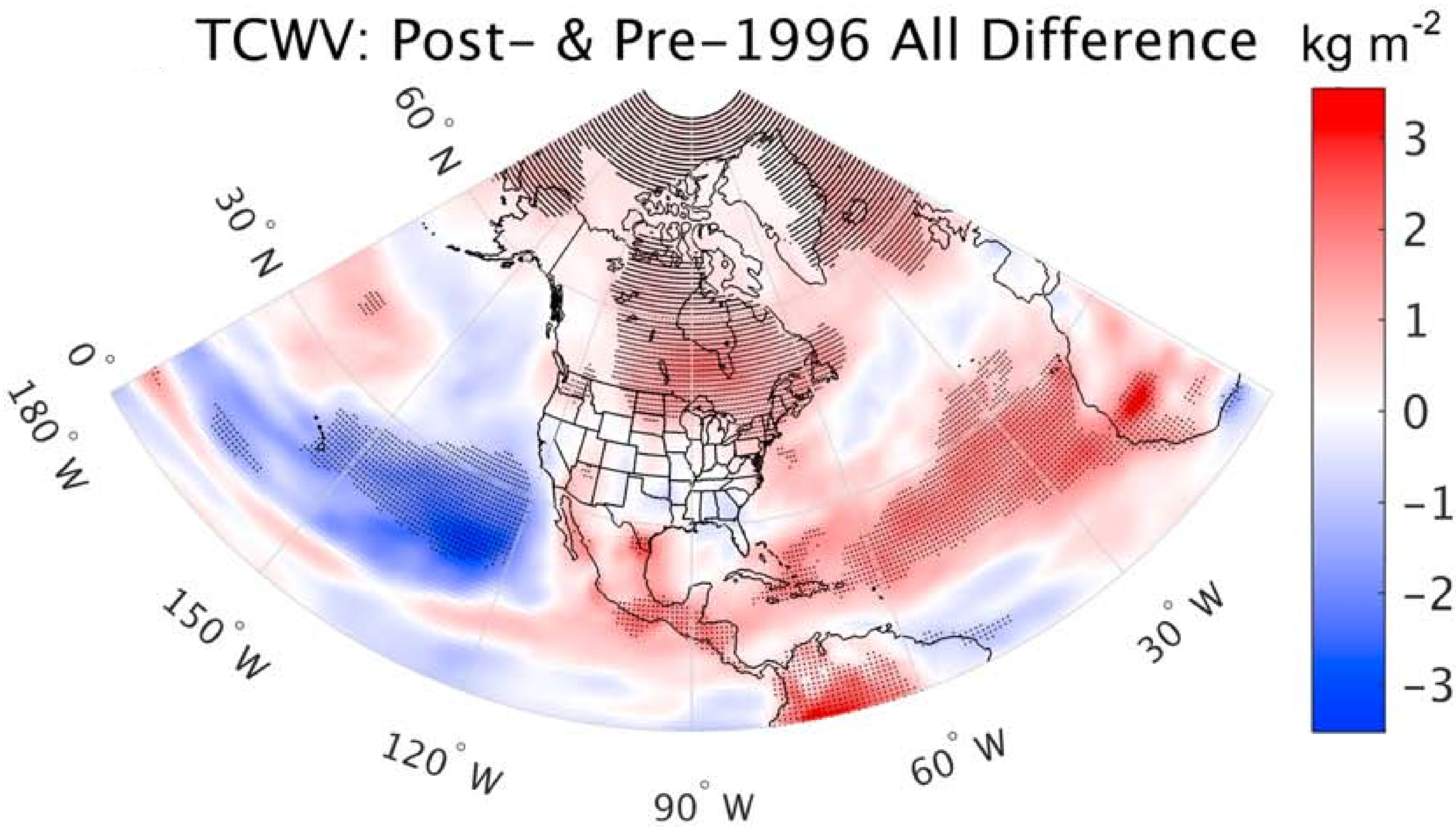
Increased Total Column Water Vapor in Hurricane Main Development Region



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Conclusions

- Recent increases in Northeast extreme precipitation are best characterized as an abrupt shift of 53% after 1996
- Extreme precipitation increases are distributed uniformly throughout the Northeast except western NY/PA and WV
- There are differences between GHCN-D and NARR, LI2013 extreme precipitation trends
- Eighty-eight percent of the abrupt 1996 extreme precipitation increase is explained by 5+ station events in early fall, early summer, and late winter
- The 1996 extreme precipitation increase is caused by tropical cyclones (48%), fronts (25%), and extratropical cyclones (15%)
- Increased extreme precipitation is associated with warmer Atlantic sea surface temperatures and more water vapor