



Severe Hail over the United States and its Relationship to the Climate System

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European Conference on Severe Storms, Wiener Neustadt, Austria, September 15th 2015

The Problem with Severe Thunderstorm Reports:
Wish/Hope



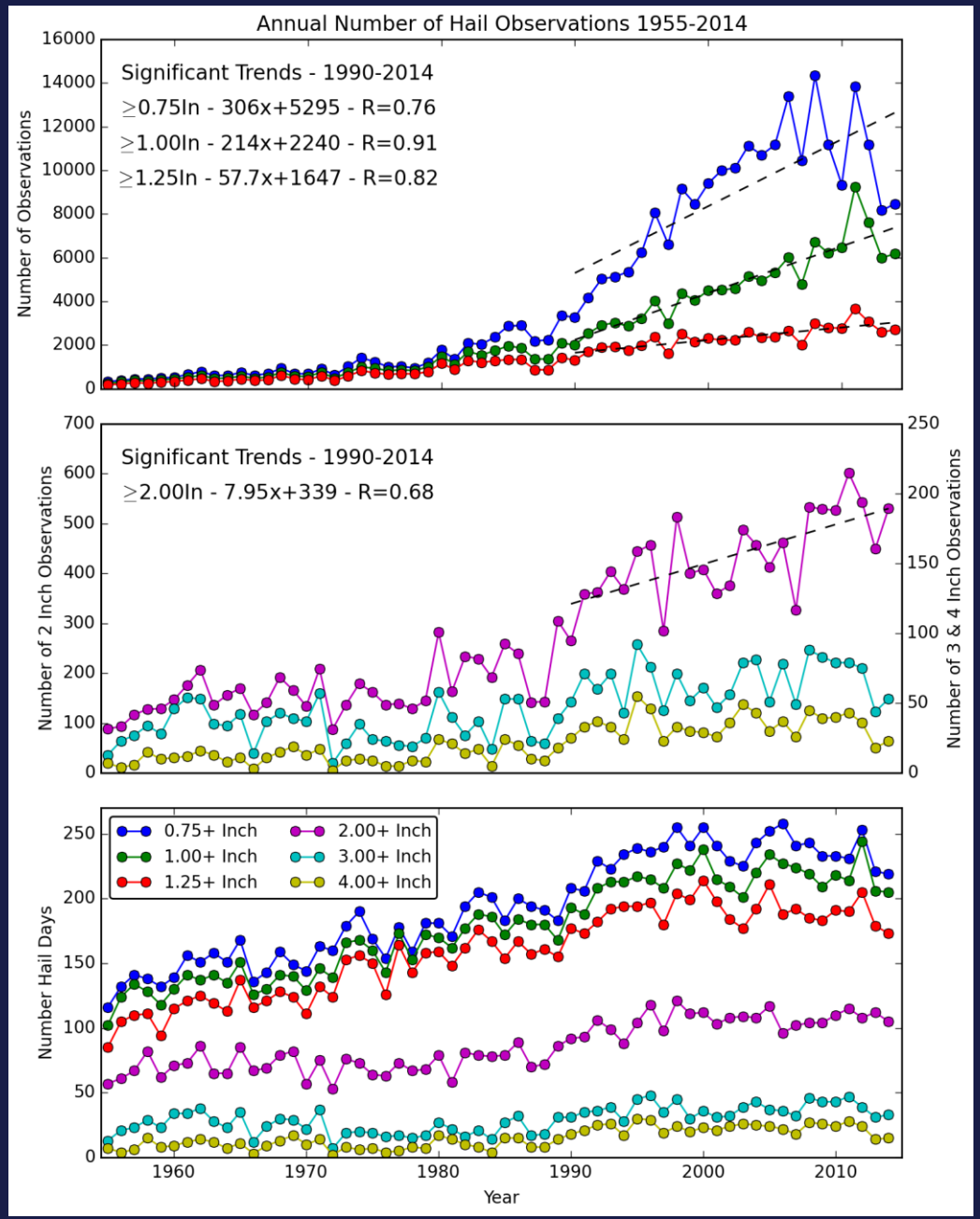






All Measures of Severity and Reference Objects are Arbitrary!

US Hail Reports Increase, but not Hail Days

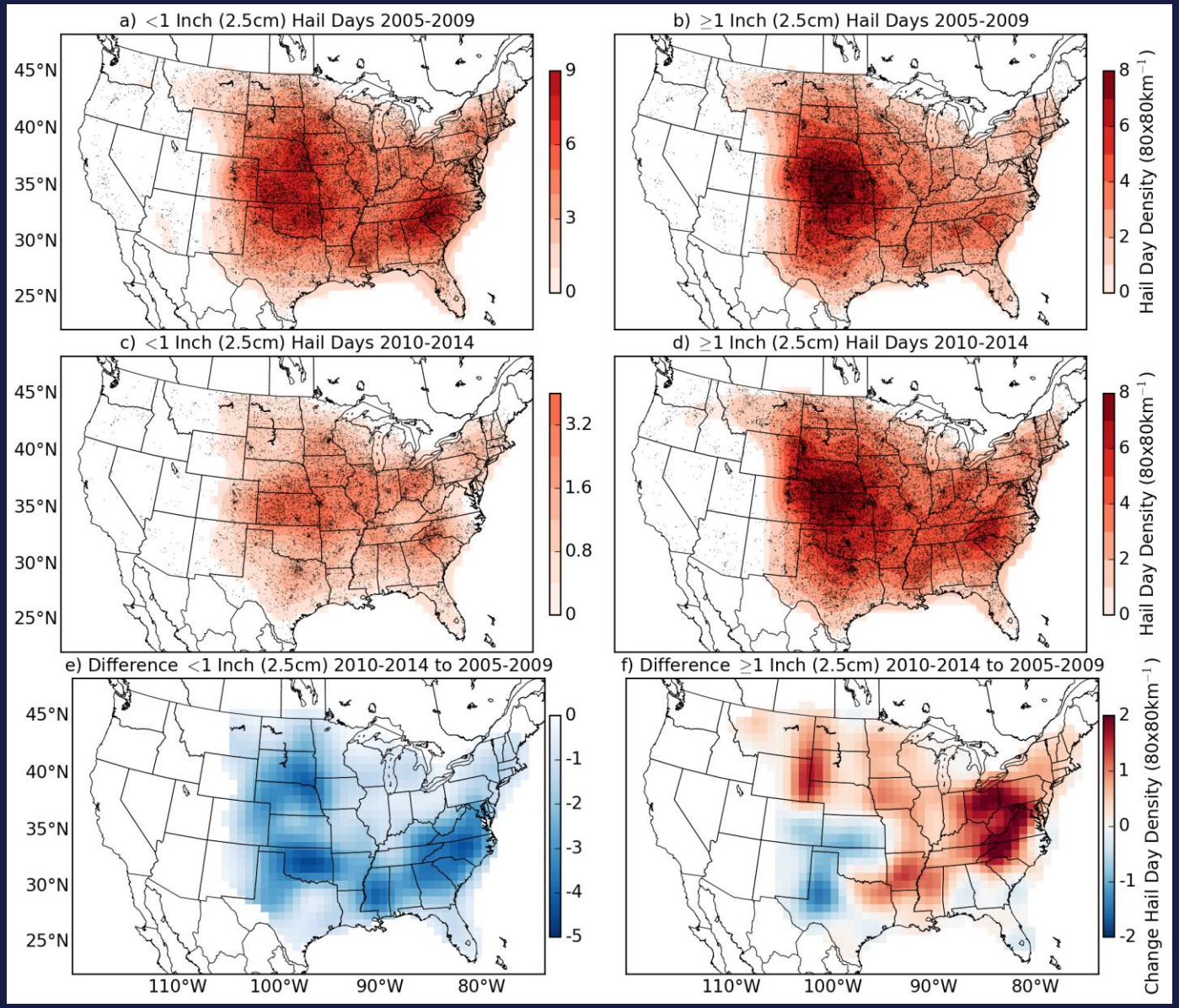


Top and Middle:
Trends in observed hail reports stratified by size for the period 1955-2014. Only significant trends shown.

Bottom:
Trends in number of days in which at least 1 hail event is reported somewhere in the US.

Allen & Tippett, 2015 (EJSSM)

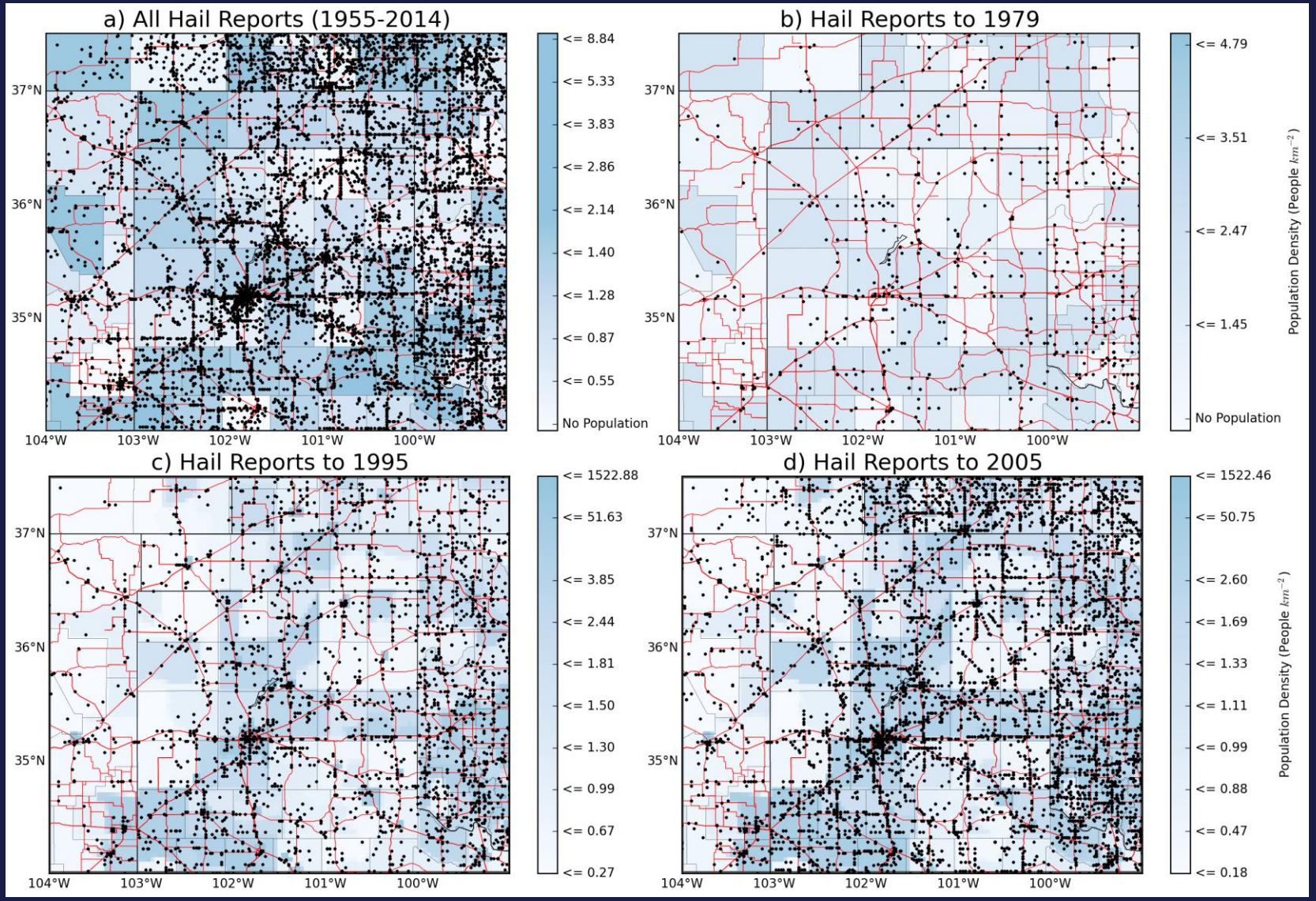
Non-Meteorological Bias: Arbitrary Change – Arbitrary Result



The influence of the severe hail criteria change in 2010.

Allen & Tippett, 2015, (EJSSM)

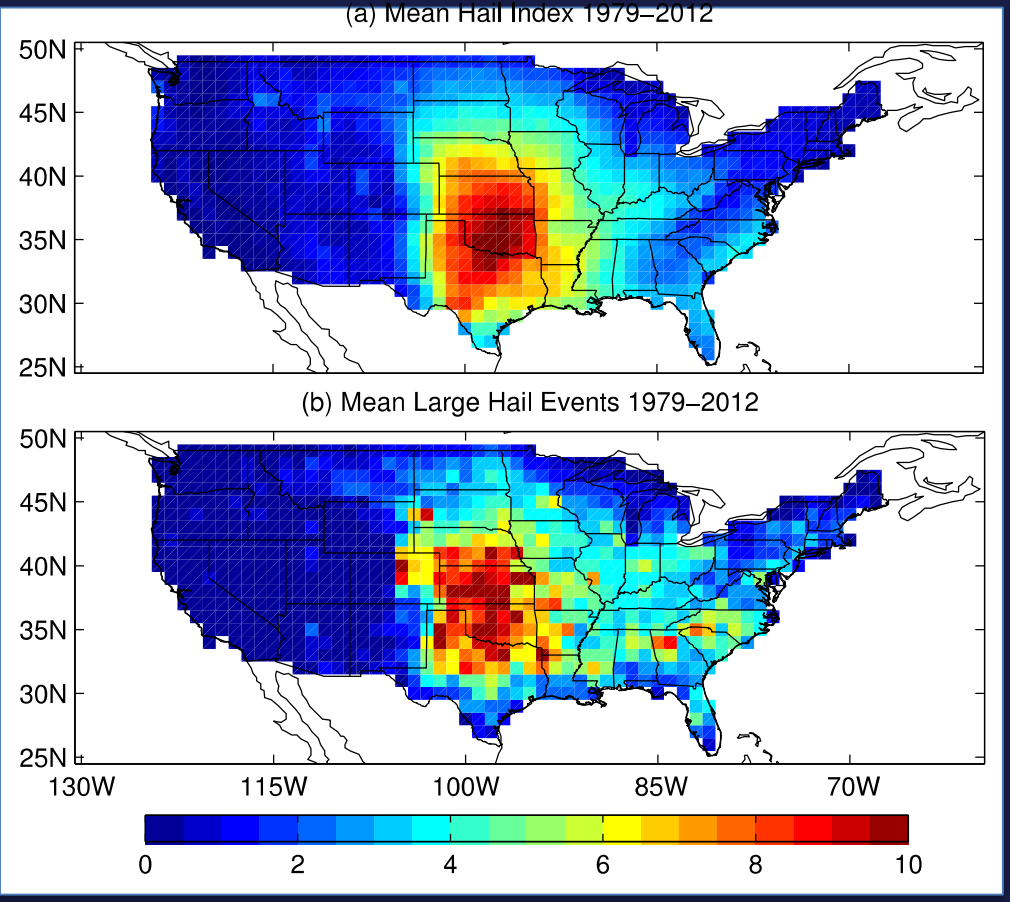
Biases beyond Population in Reported Locations of Hail

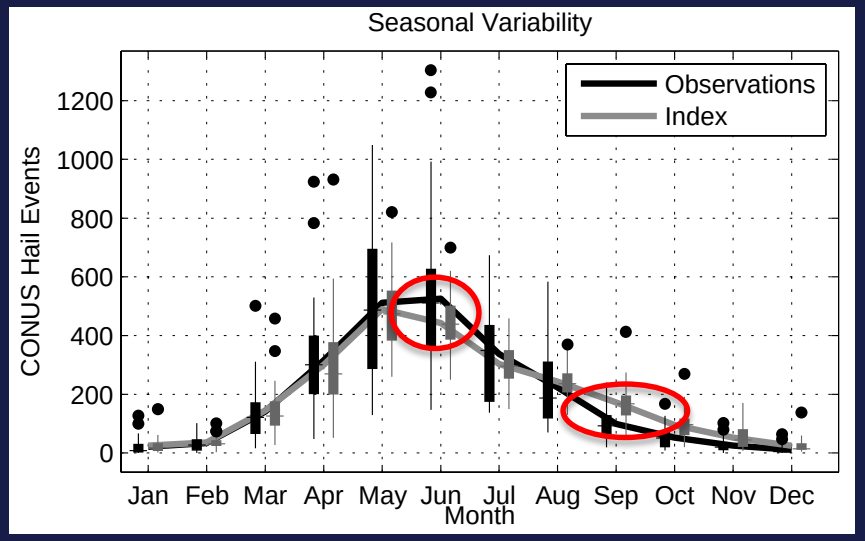


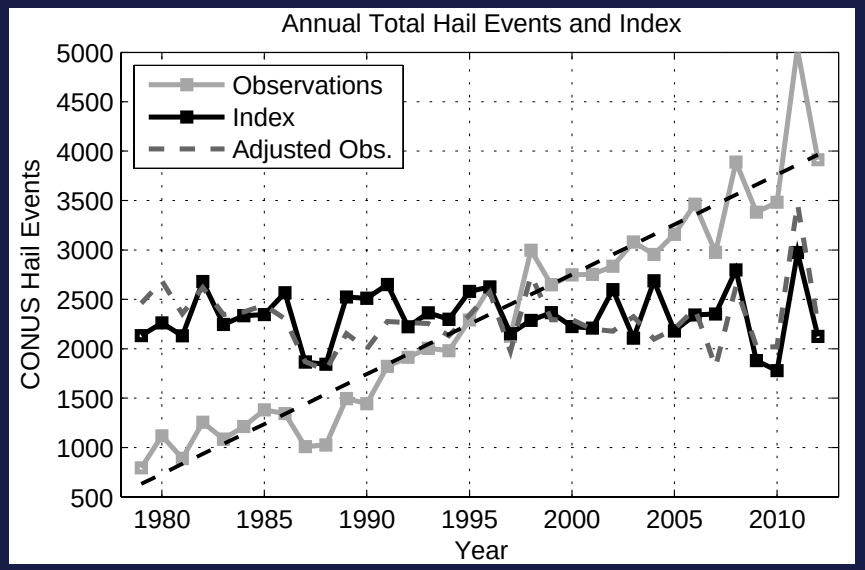
Point reports for hail greater than 0.75 inch 1955-2014 for the TX Panhandle showing clustering towards both population and road networks.

Allen & Tippett, 2015, (EJSSM)

‘Cleaning Up’ - An Environmental Index for Hail Occurrence





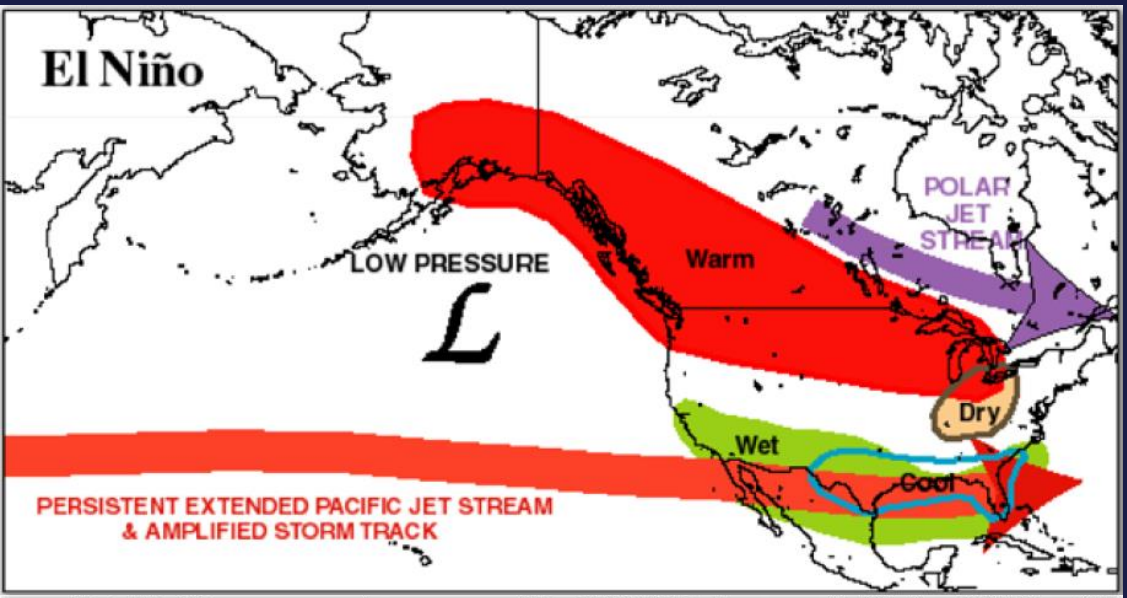


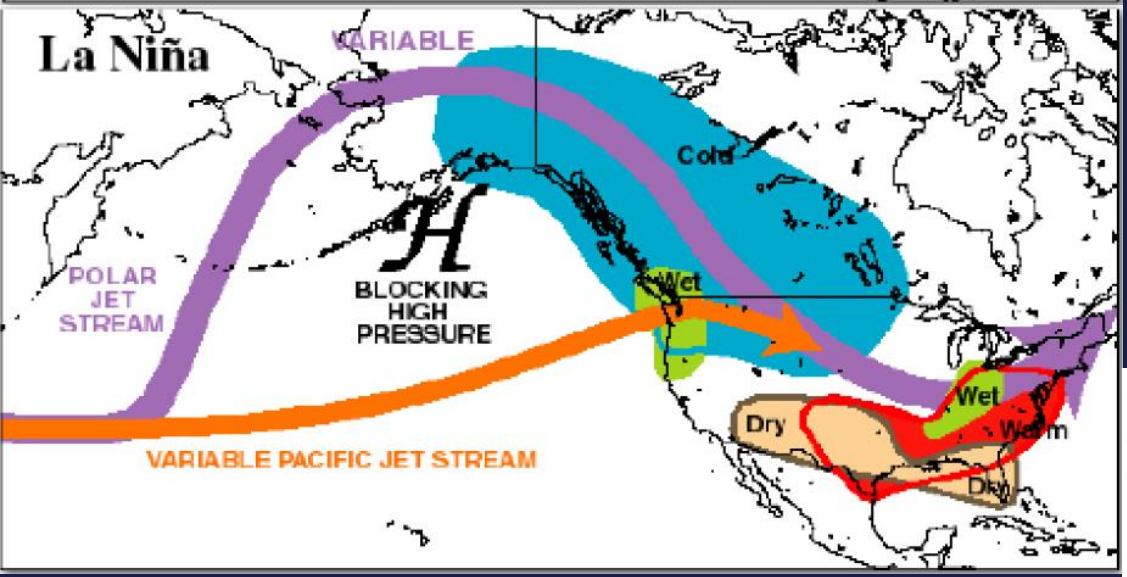
$$\mu(\mathbf{x}) = \exp(-10.18 + 0.97\log(\mathbf{cPrcp}) + 1.13\log(\mathbf{SRH}) + 1.00\log(\mathbf{MLCAPE}) - 0.31\mathbf{Q}_{\mathbf{mean}} + \mathbf{offset})\,.$$

Hail Environmental Index (NARR reanalysis) compared to Observations – 1979-2012.

Allen et al. 2015 (JAMES)

So what influences variability in severe thunderstorms?

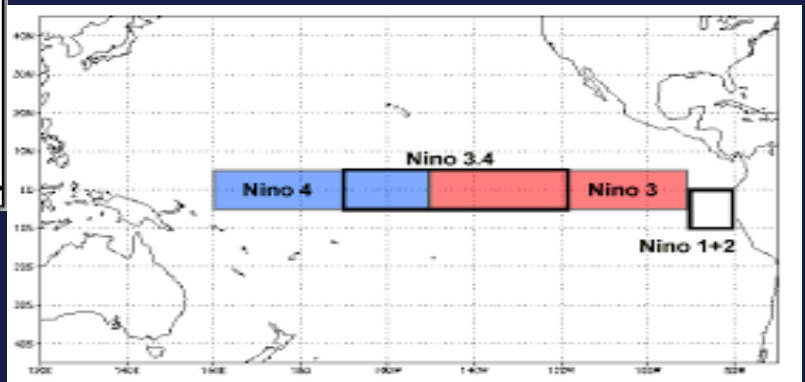




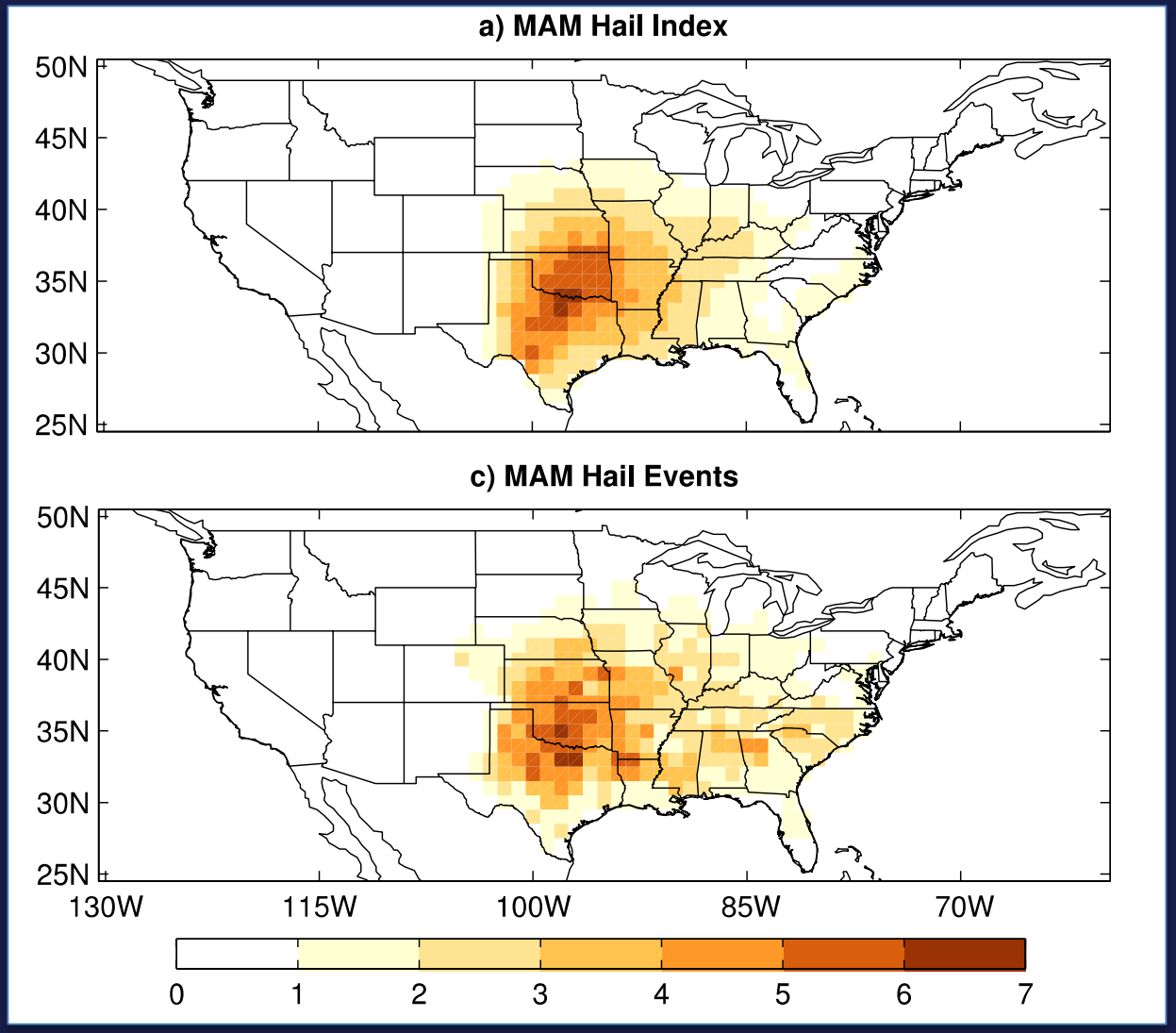
ENSO modulates the jet streams via tropical convection (or lack thereof).

Observations can't get a robust relationship. Spring peak of severe thunderstorms seems to lag ENSO signal.

Hypothesis: ENSO modulates favorable environments for severe thunderstorms.



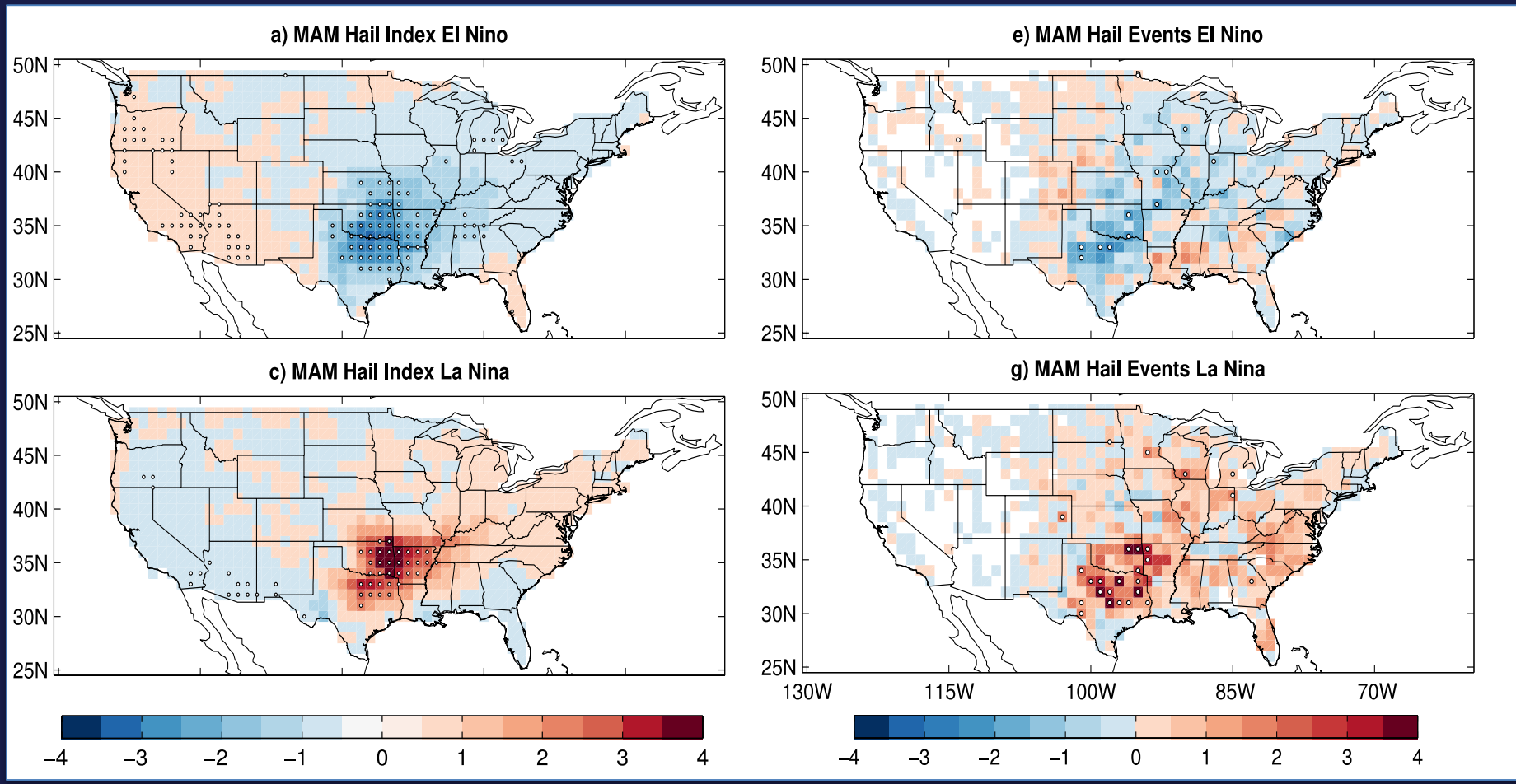
MAM Climatology of Hail (Obs. & Index)



Mean MAM Climatology for Hail and Tornado Index, Tornadoes and Hail Events for the period 1979-2012

Allen et al. 2015 (Nature Geoscience)

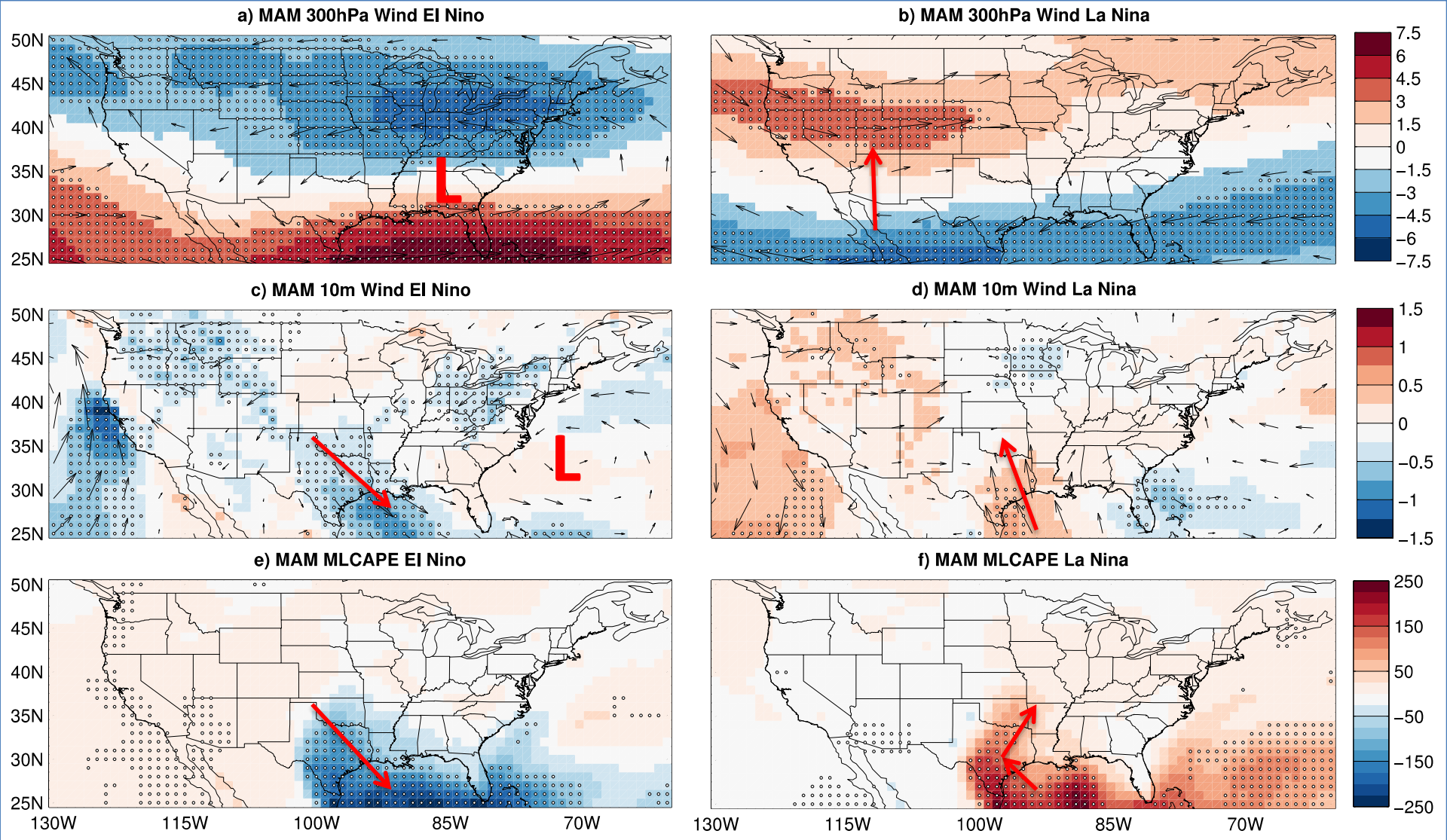
Modulation of Hail by ENSO Teleconnection - MAM



Composites of El Niño and La Niña MAMs based on 7 and 6 year composites respectively selected using ONI ±0.5 . Stippling is for Monte Carlo derived significance at the two-tailed 95% level.

Allen et al. 2015 (Nature Geoscience)

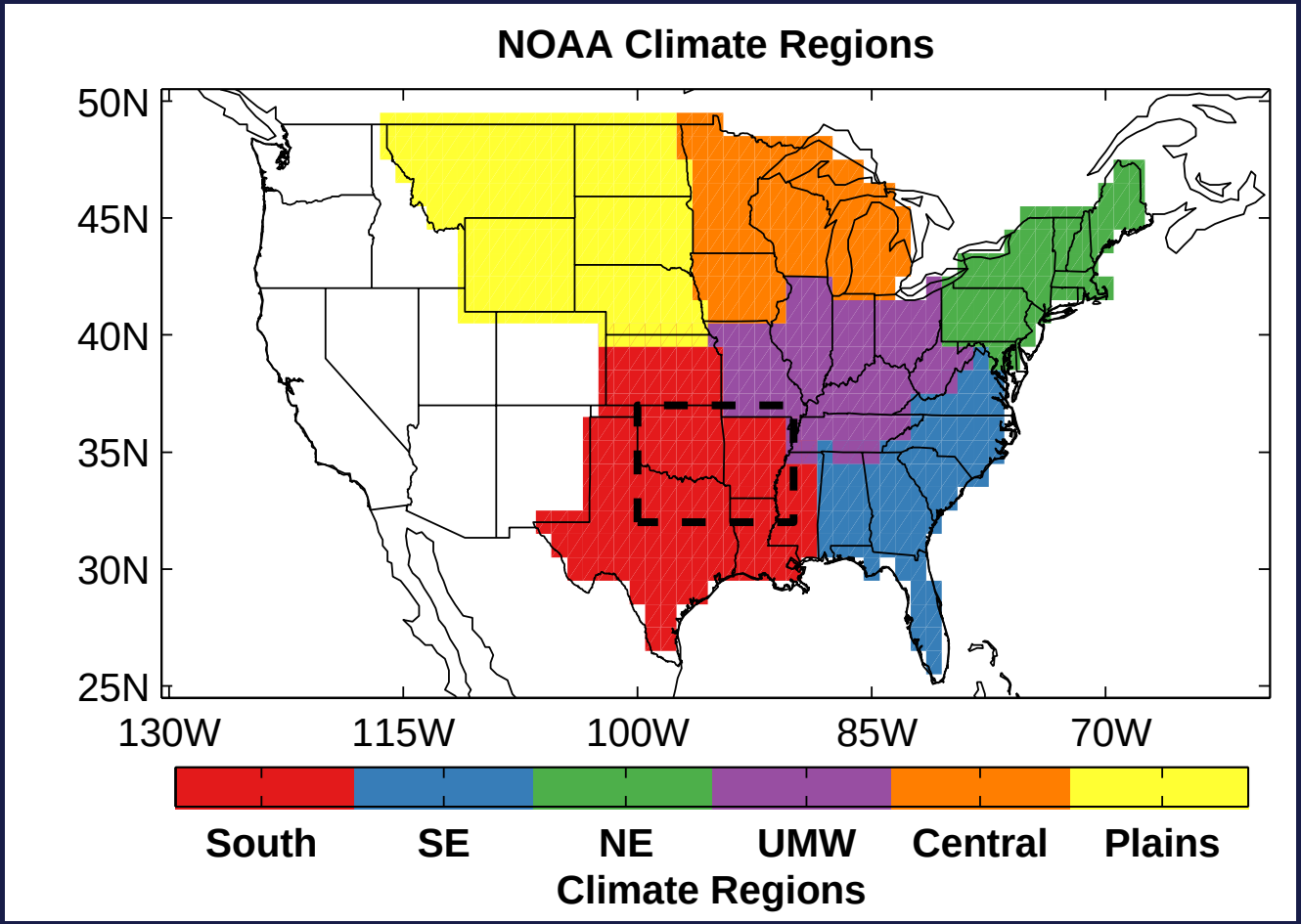
ENSO Teleconnection MAM – Synoptic and Environment



MAM Composites of Environmental variables for El Niño and La Niña

Allen et al. 2015 (Nature Geoscience)

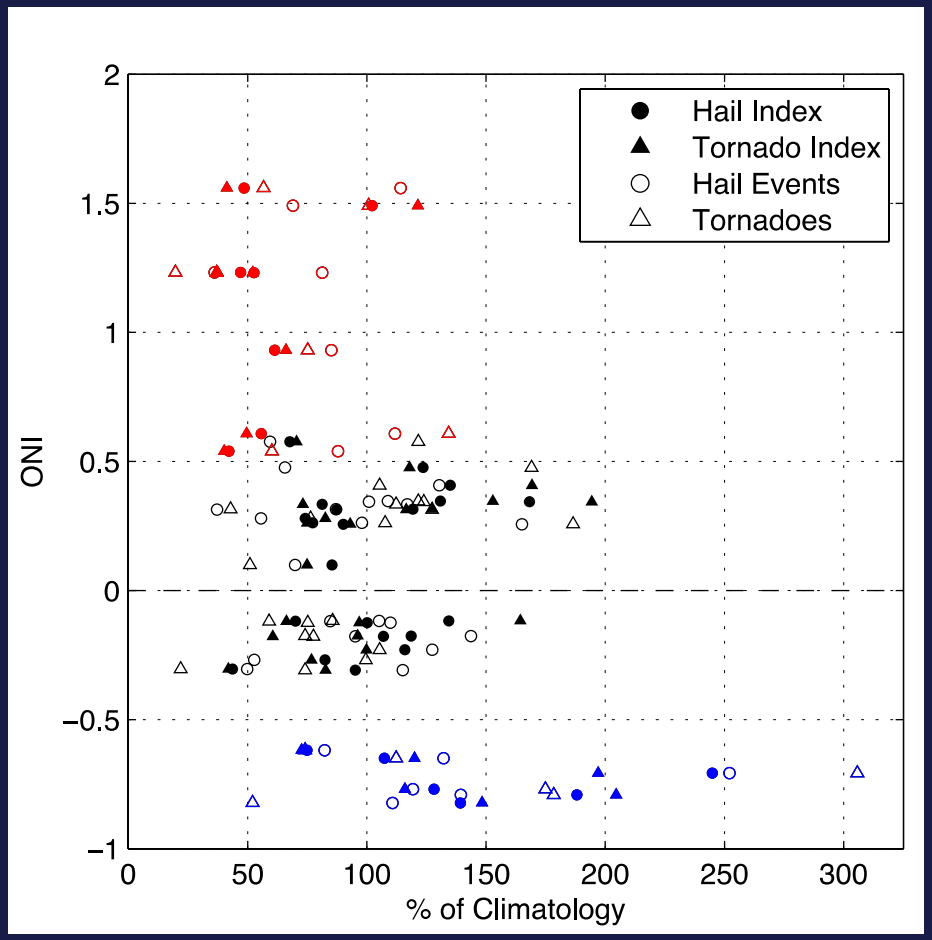
Application – Seasonal Predictability: DJF forecasting MAM

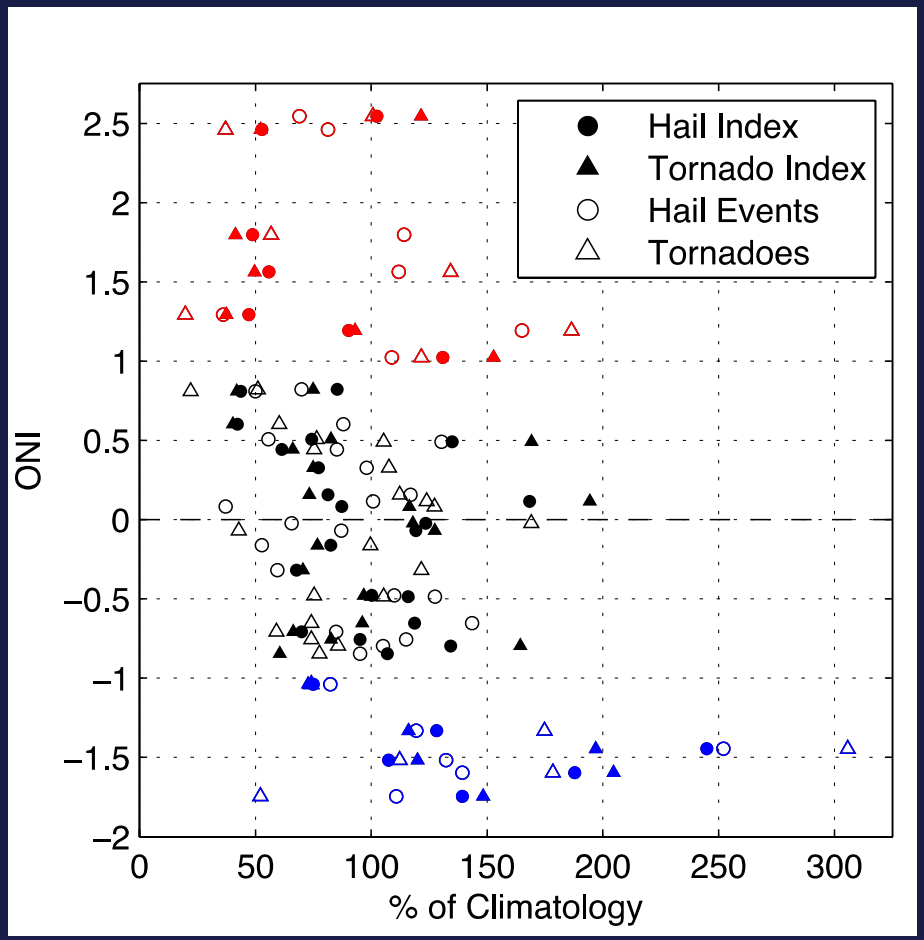


Define a box around area with most noticeable signal bounded by 100-90W and 31-36N – what does frequency look like compared to climatology for each year?

Allen et al. 2015 (Nature Geoscience)

ENSO Signal – Seasonal Predictability: DJF forecasting MAM

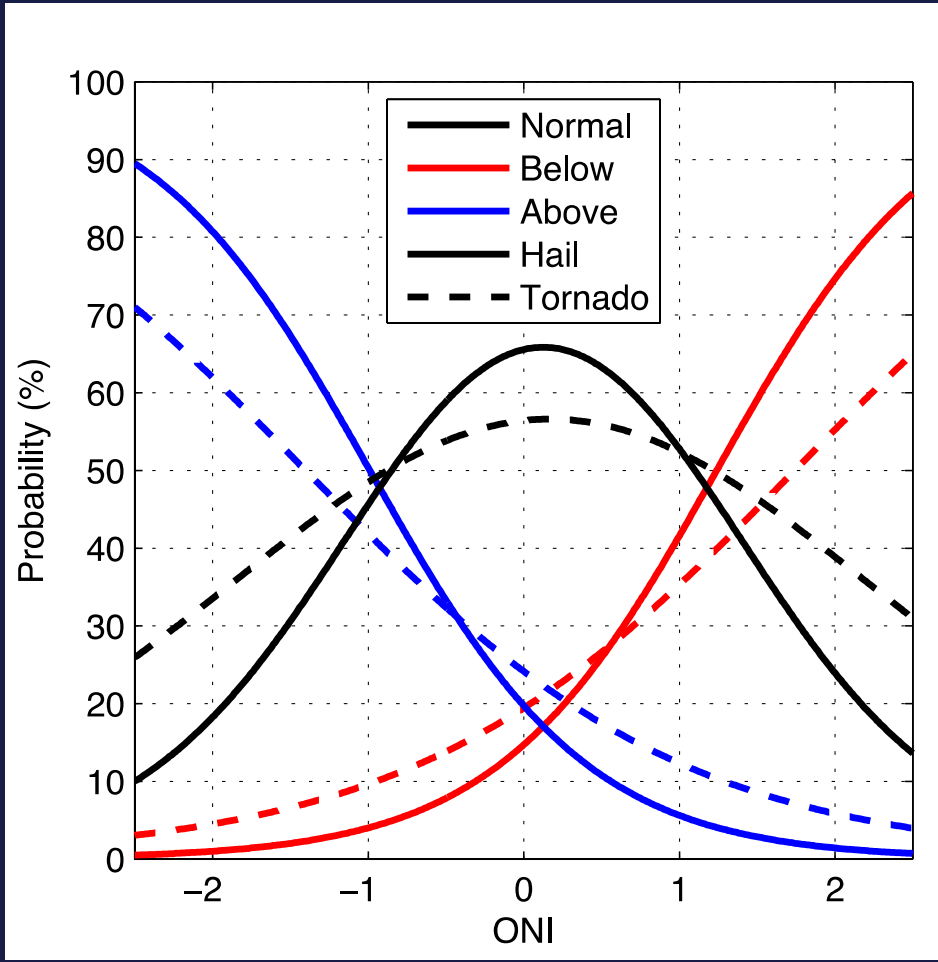


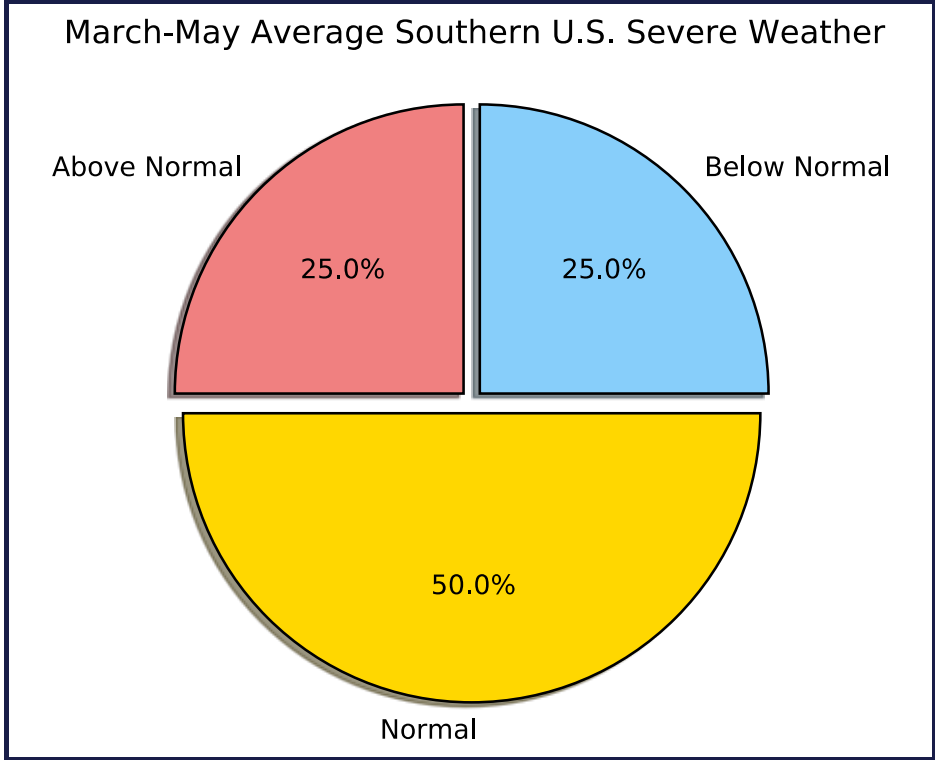


Scatter of box (bounded by 100-90W and 31-36N) total index for hail and observed hail events against seasonal ONI for a) MAM ONI b) Preceding DJF ONI. Shapes are as indicated in the legend. Red shapes correspond to the 7 El Niño seasons and blue icons correspond to the 6 La Niña seasons used in the composite respectively.

Allen et al. 2015 (Nature Geoscience)

ENSO Signal – Seasonal Predictability: DJF forecasting MAM



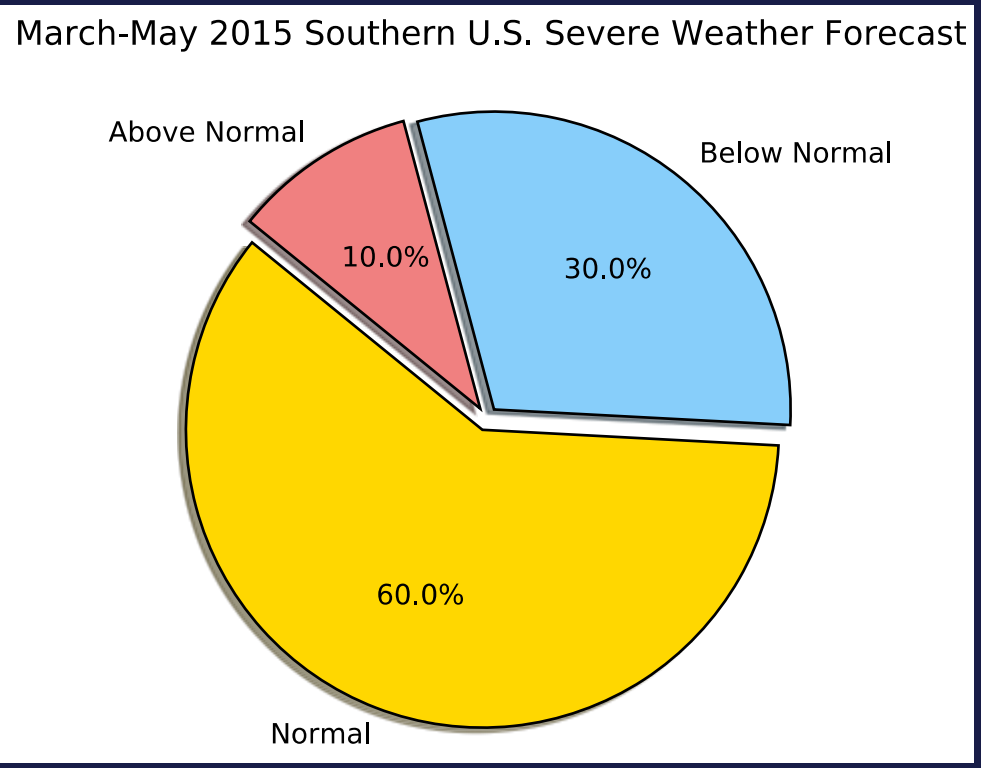


Extended Logistic Regression for MAM tornado and hail index probability conditional on the ONI state of the prior DJF for the defined area – Note these aren't your ordinary terciles (25%/50%/25%)

Allen et al. 2015 (Nature Geoscience)

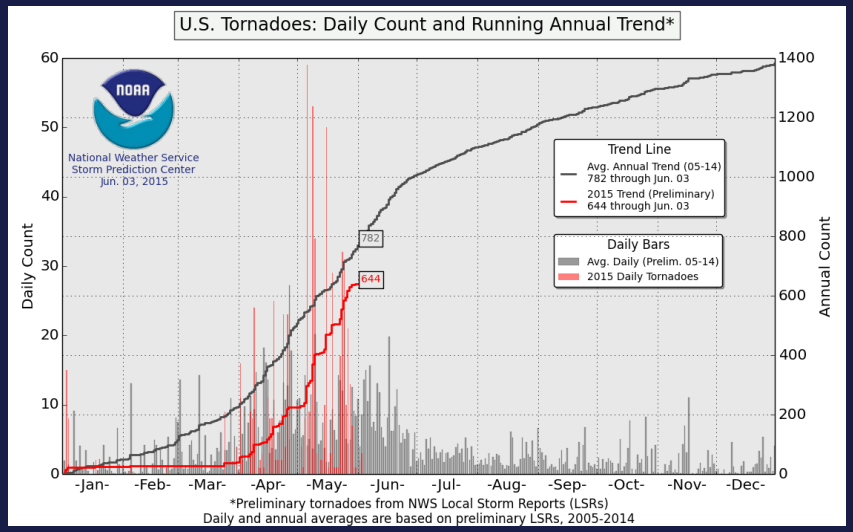
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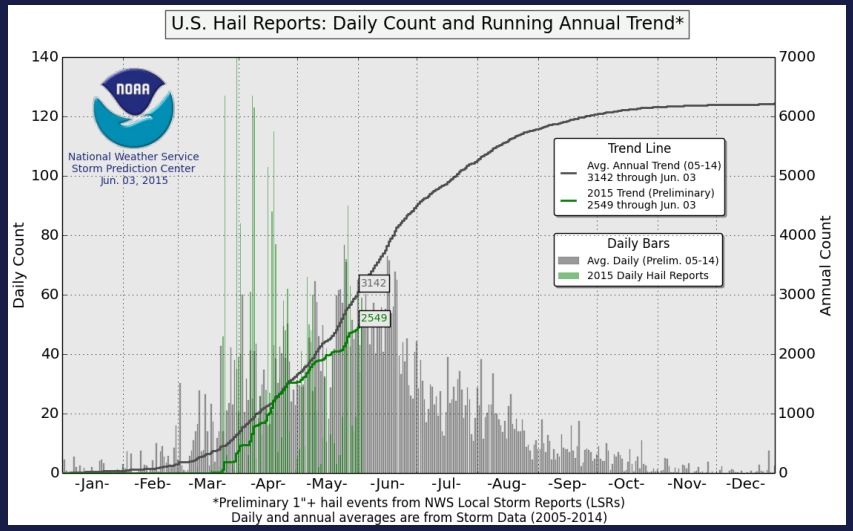
Forecast (March Issued)



Probabilistic forecast of severe weather occurrence based on DJF ONI data for the 2015 spring severe weather season.

Verification





Despite active May – MAM was 17% below normal – the forecast wasn't bad.

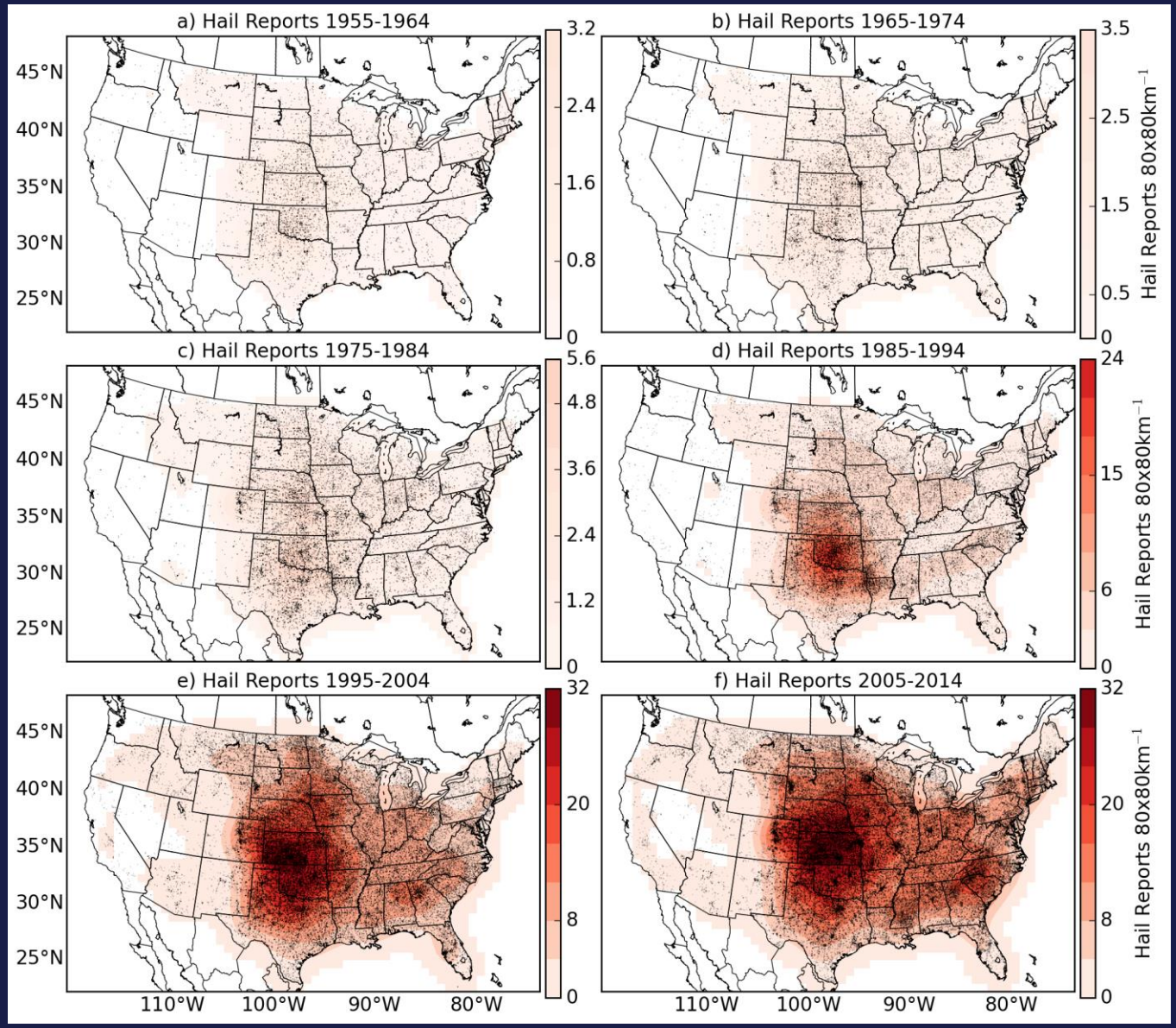
Summary

- Observations of hail cannot be taken at face value for climate problems. **Changes made at an administrative level lead to break points (so please don't).** Need to team up observations with environmental proxies to make it meteorological.

- There is a **statistically robust relationship between ENSO frequency of springtime tornado and hail environments.** This produces **significant negative anomalies in El Niño (25-50%),** and an **eastward shift and increased frequency in La Niña (20-150%).**

- These results provide **the first reliable spring seasonal predictability (3+ months) for moderate to strong ENSO signals using DJF ONI (**but it is only the tip of the iceberg – see keynote talk tomorrow**).**

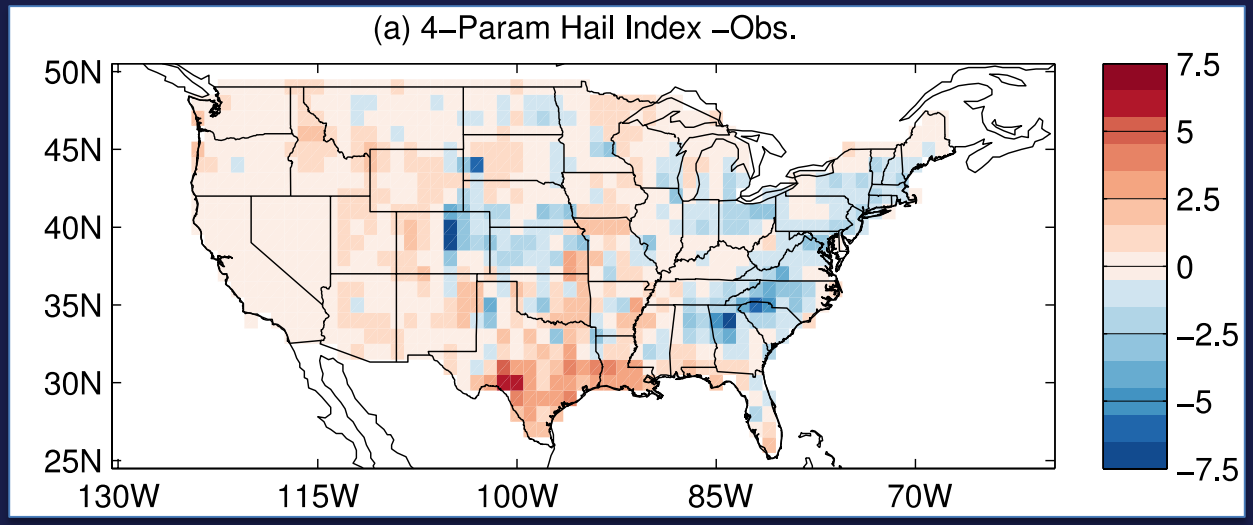
Temporal Changes not Spatially Uniform

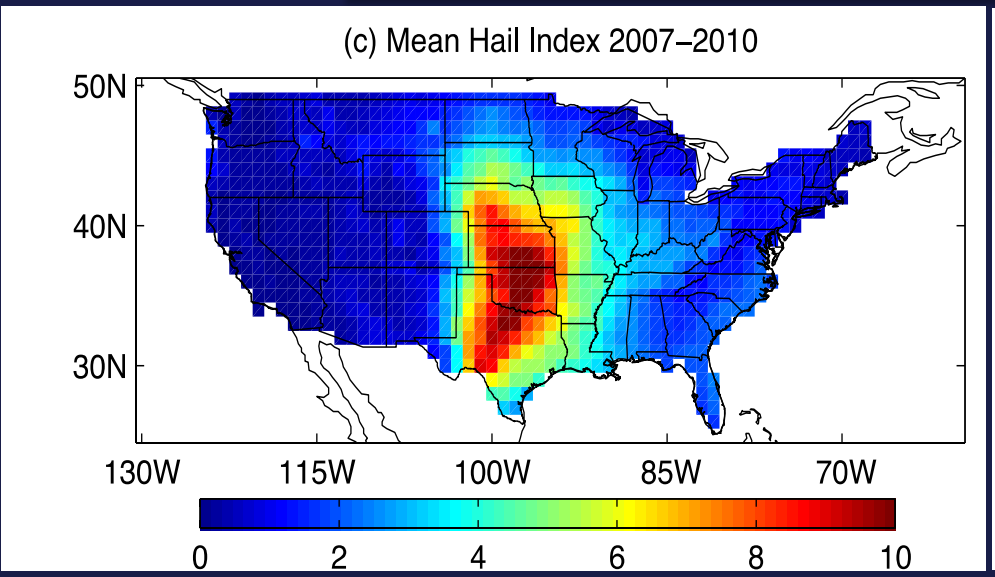


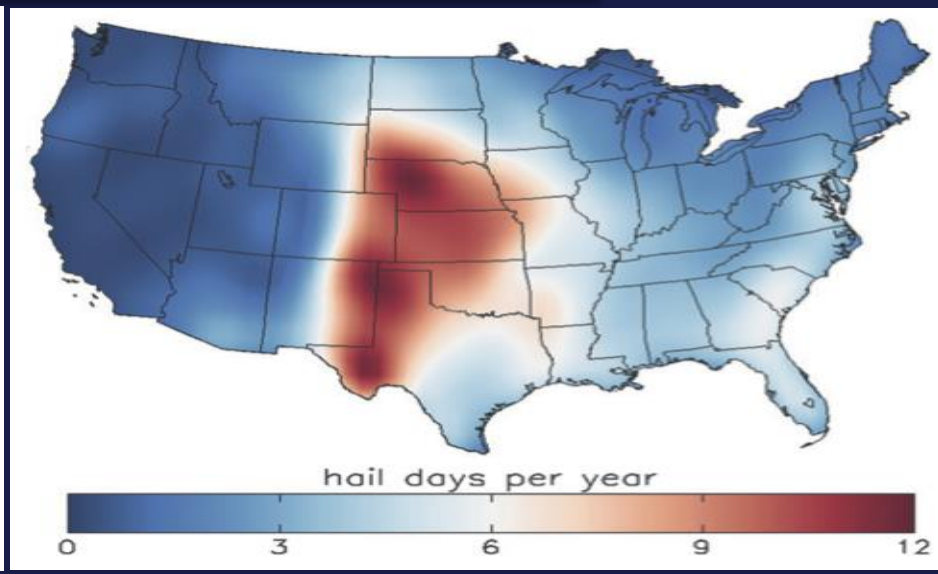
Spatial Changes in Hail Report Density (≥0.75In.) 1955-2014.

Allen & Tippett, 2015, (EJSSM)

Evaluating Index Using Observations and Radar Proxies







Top: Differences between Mean annual observed hail and hail index.
Left: Mean annual Hail index for hail greater than one inch 2007-2010.
Right: Radar derived mean annual hail frequency from Cintineo et al. (2012)

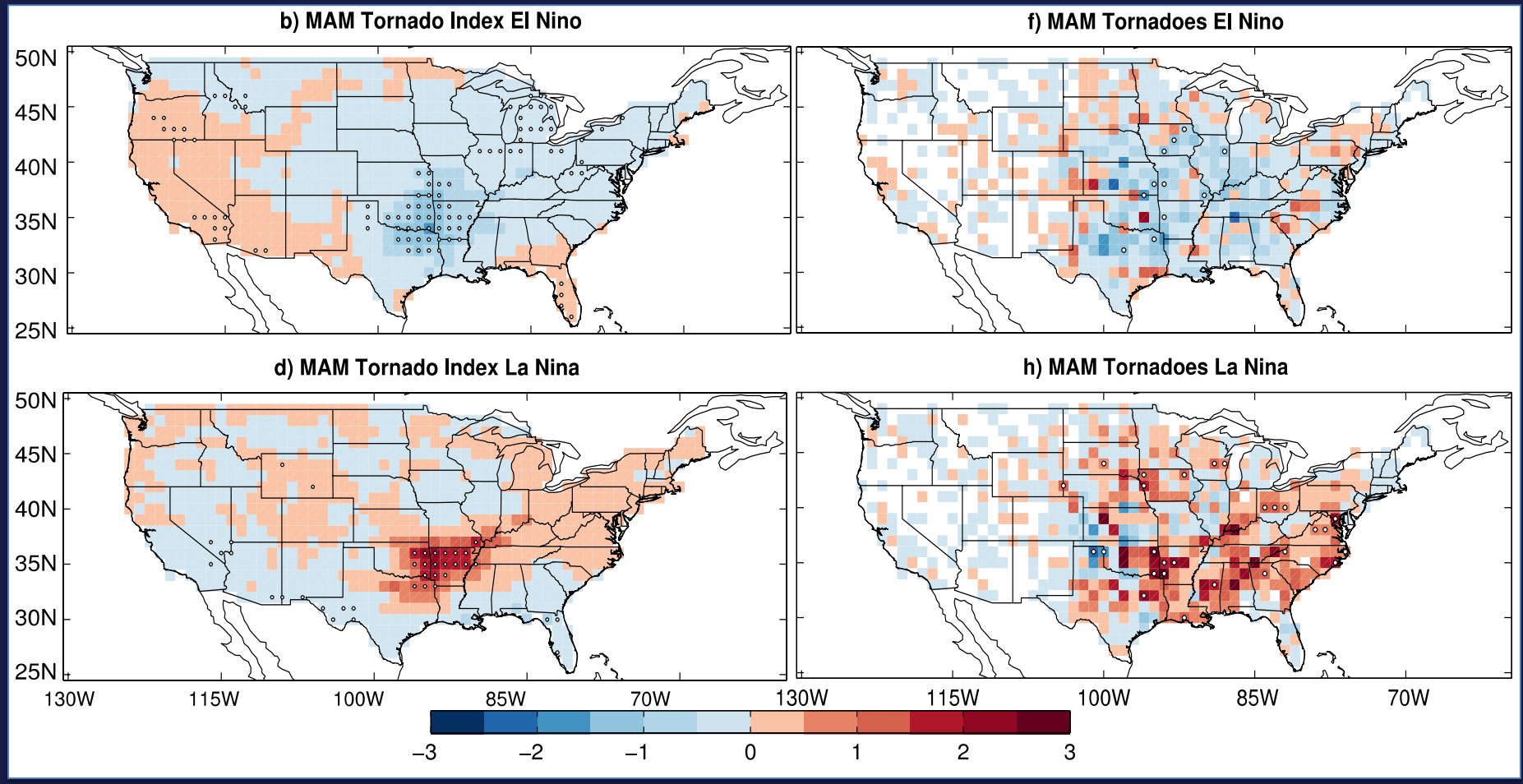
Performance – Correlations Index as Compared to Obs.

		U.S.	Sth	SE	NE	CEN
MAM						
Full	Tornado	**0.71 (0.64)**	**0.58 (0.55)**	**0.43 (0.57)**	**0.65 (0.37)**	**0.77 (0.69)**
1996-2012	Tornado	**0.72 (0.53)**	**0.53 (0.45)**	**0.43 (0.42)**	**0.68 (0.46)**	**0.76 (0.69)**
Full	Hail	**0.58 (0.43)**	**0.49 (0.45)**	**0.39 (0.37)**	**0.72 (0.46)**	**0.79 (0.70)**
1996-2012	Hail	**0.59 (0.26)**	**0.58 (0.47)**	**0.65 (0.58)**	**0.71 (0.72)**	**0.79 (0.74)**
DJF						
Full	Tornado	**0.57 (0.48)**	**0.49 (0.40)**	**0.41 (0.40)**	0.15 (0.17)	**0.65 (0.67)**
1995-2011	Tornado	**0.59 (0.59)**	**0.50 (0.44)**	**0.45 (0.42)**	0.10 (0.22)	**0.70 (0.74)**
Full	Hail	**0.65 (0.61)**	**0.60 (0.59)**	**0.52 (0.64)**	**0.38 (0.43)**	**0.67 (0.47)**
1995-2011	Hail	**0.93 (0.94)**	**0.79 (0.82)**	**0.49 (0.61)**	0.29 **(0.36)**	**0.81 (0.72)**

Pearson and (Rank) correlations between the Respective Indices and Obs. For listed periods (Full is 1979-2012).

Allen et al. 2015 (Nature Geoscience)

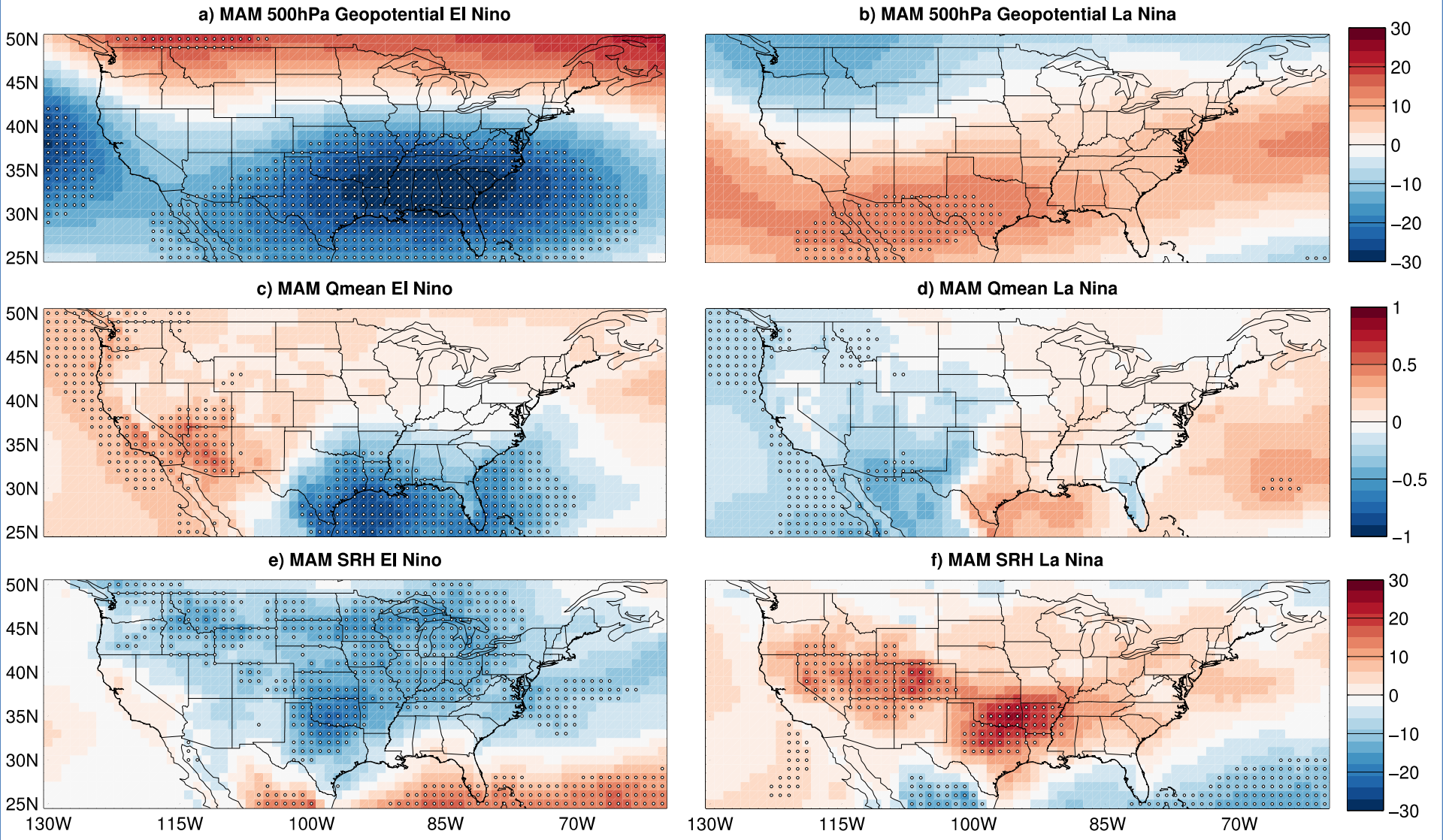
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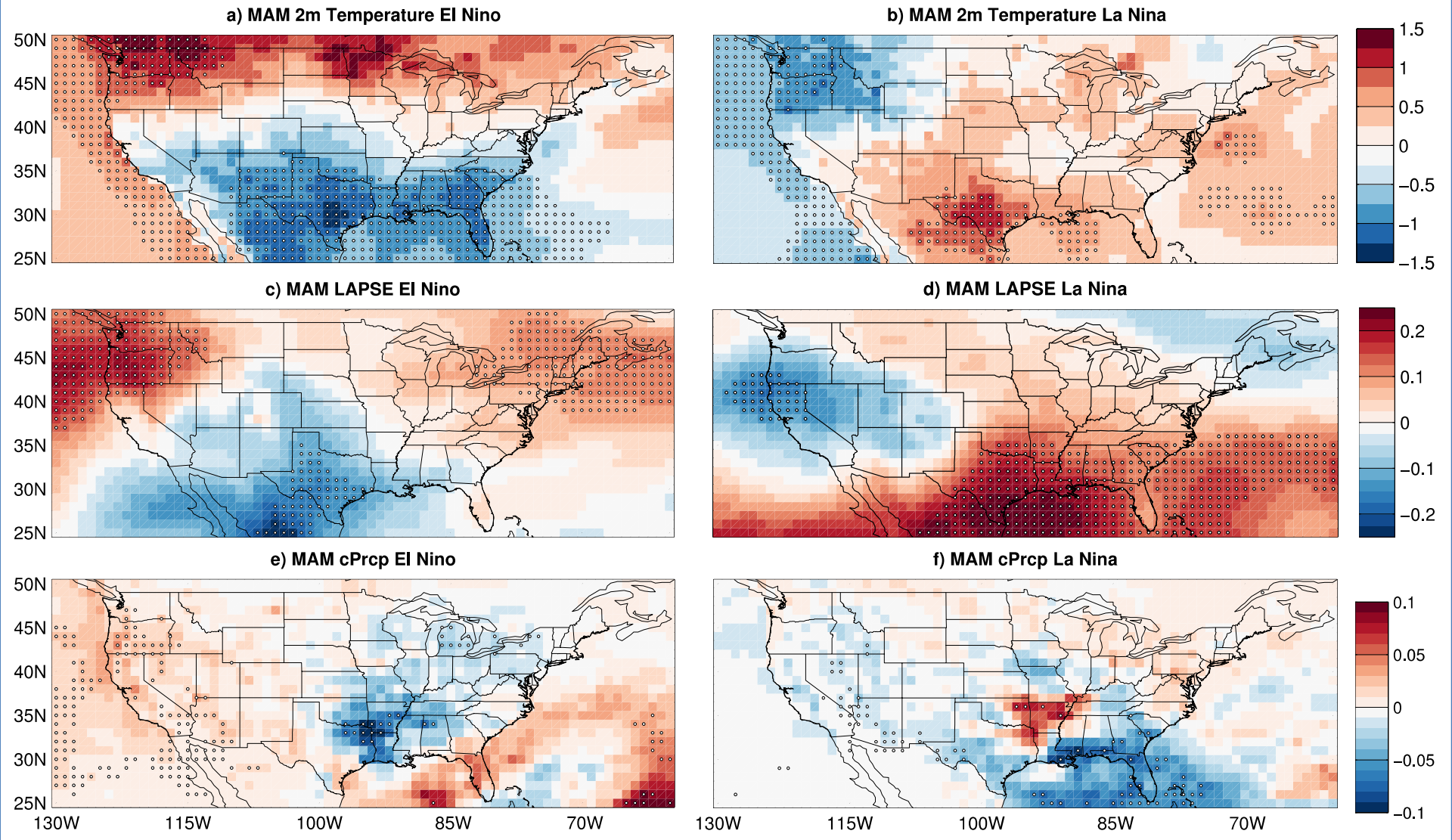
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