

The Contribution of ENSO to Hail and Tornado Seasonal Variability

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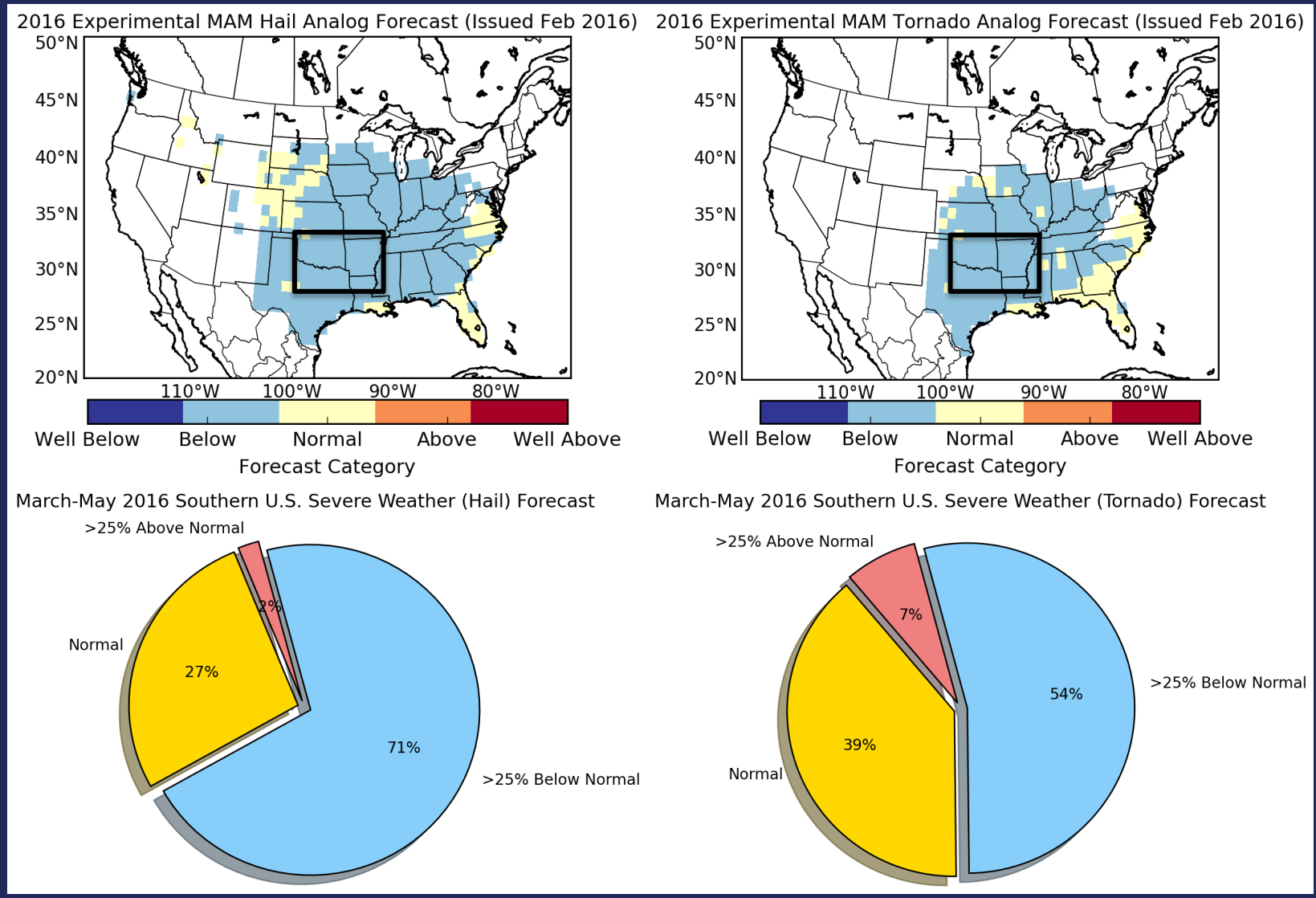
2nd Workshop on Severe Convection & Climate, Columbia University, 9th March 2016

The Problem with Severe Thunderstorm Reports:

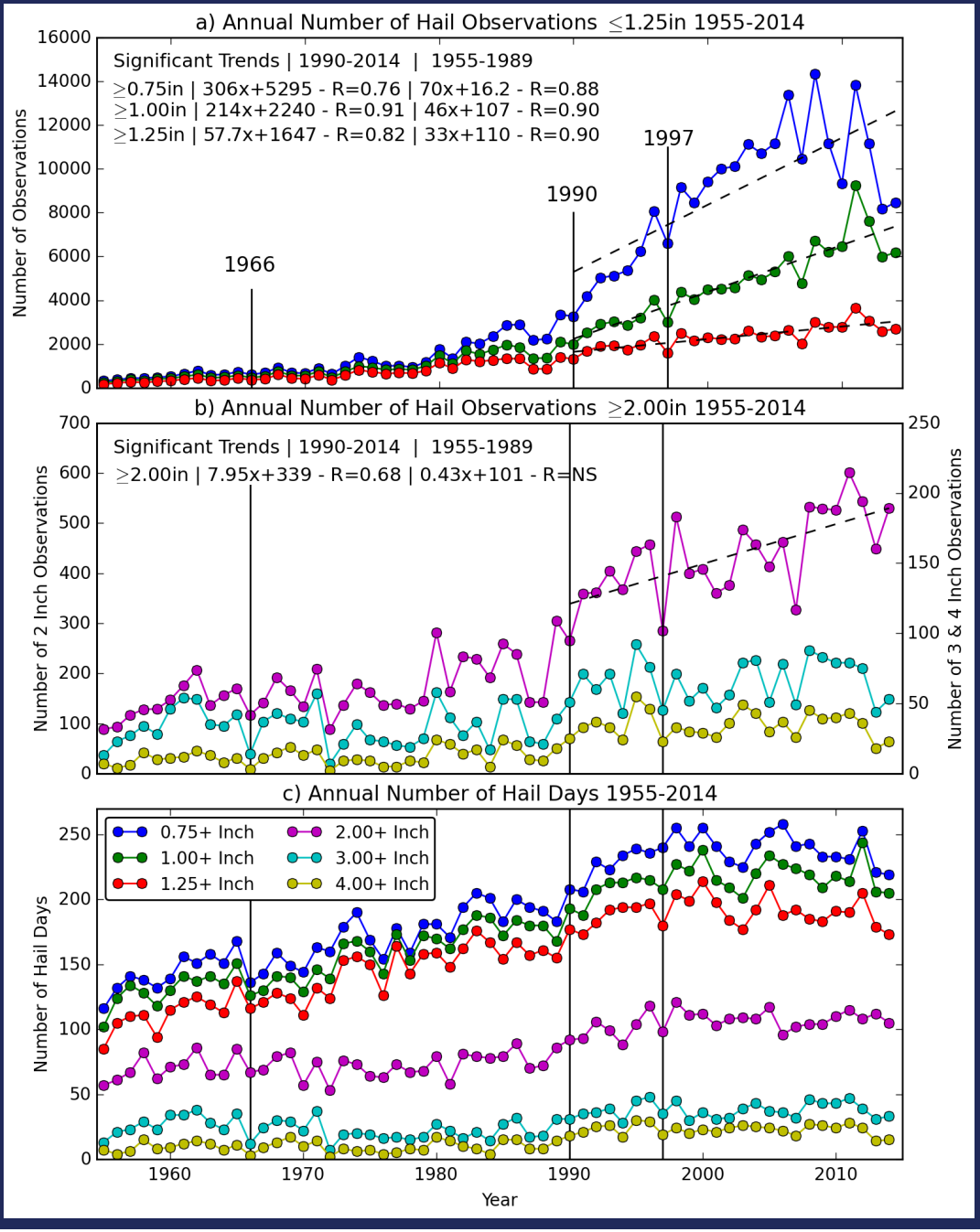
All Measures of Severity and Reference Objects are 'Value-added'!

2016 Forecast (Based on Ensemble Predicted Nino 3.4 SST)



Relies only on ENSO state (so what can we do with no ENSO?), hopes for no outbreaks, and is a below normal forecast really that useful?

US Hail Reports Increase, but not Hail Days US Wide

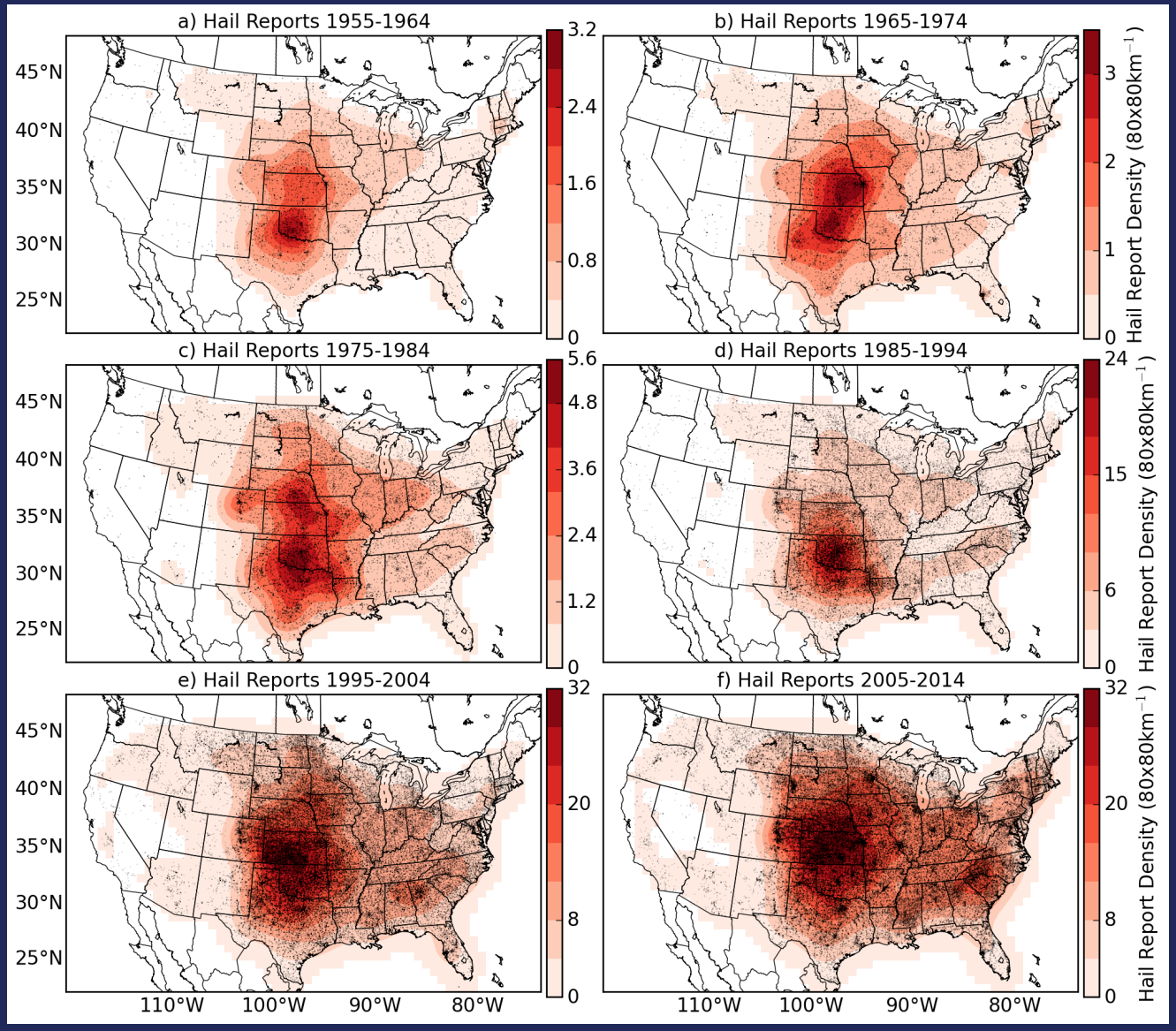


Top and Middle:
Trends in observed hail reports stratified by size for the period 1955-2014. Only significant trends shown.

Bottom:
Trends in number of days in which at least 1 hail event is reported somewhere in the US. (on a regional scale hail days are also less stable)

Allen & Tippett 2015 (EJSSM)

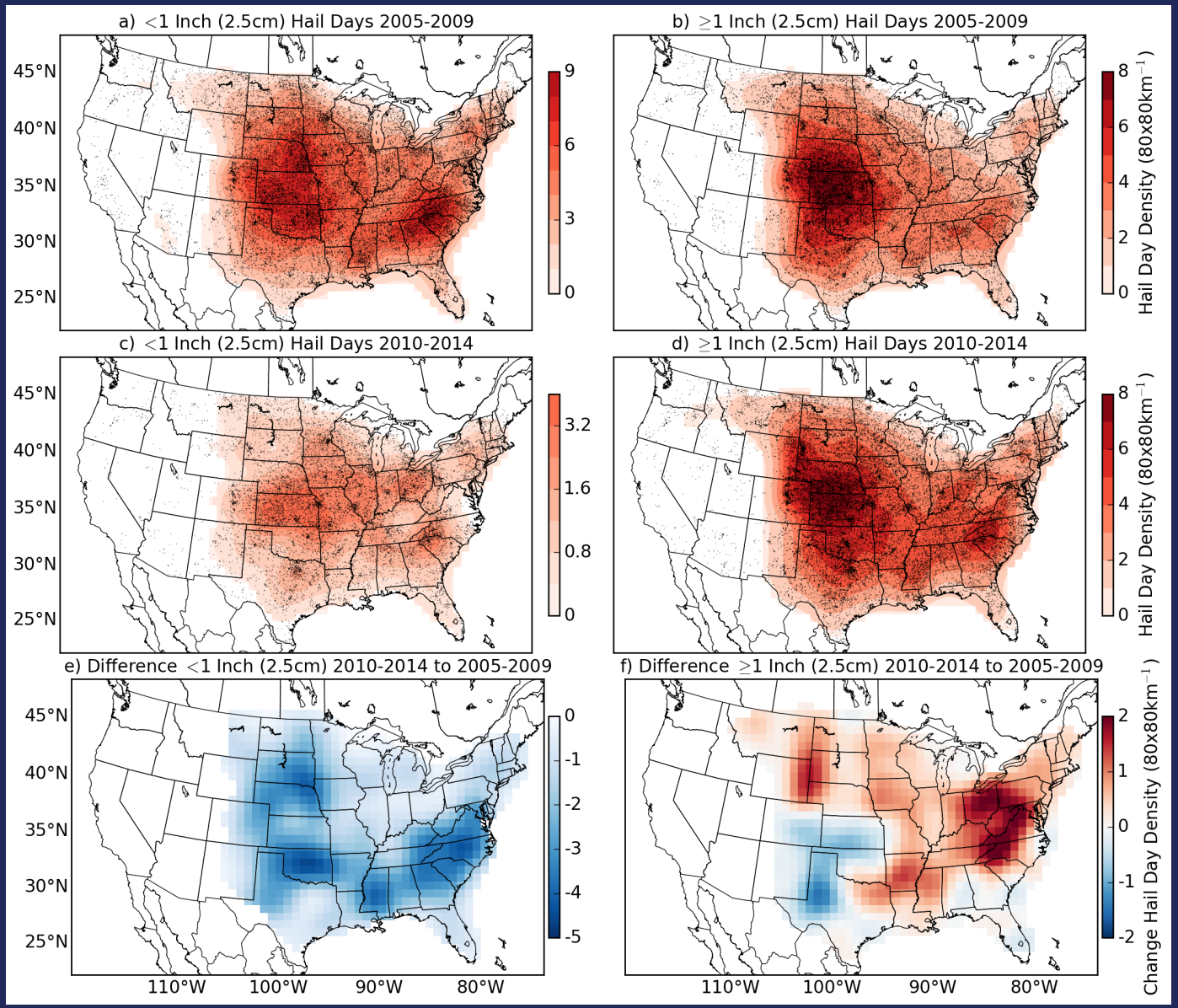
Temporal Changes not Spatially Uniform



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

Allen & Tippett 2015 (EJSSM)

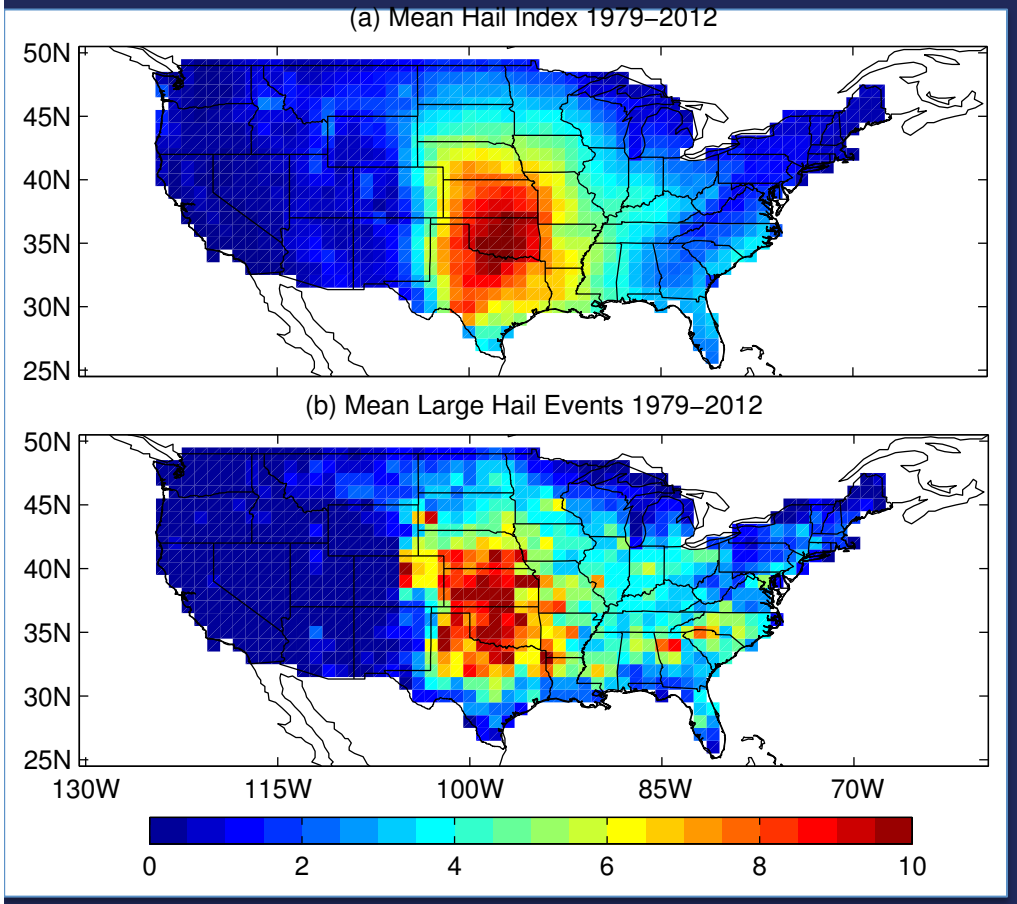
Non-Meteorological Bias: Arbitrary Change – Arbitrary Result

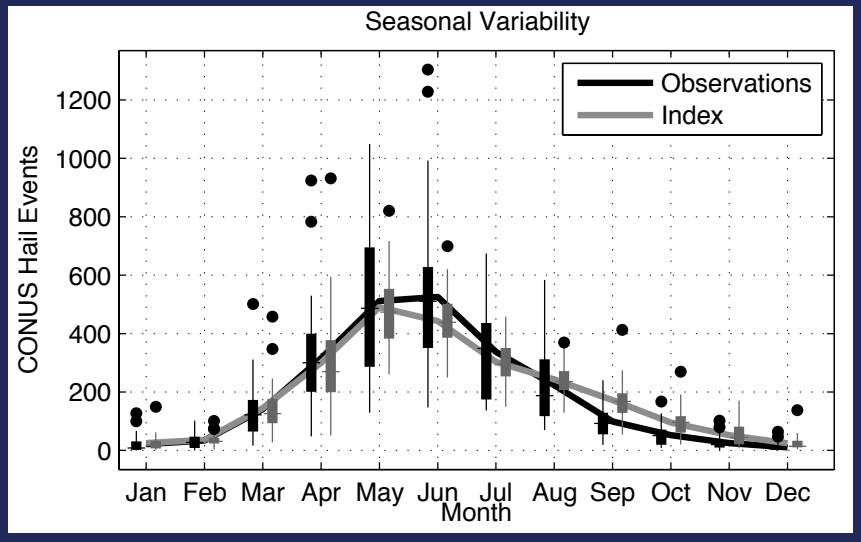


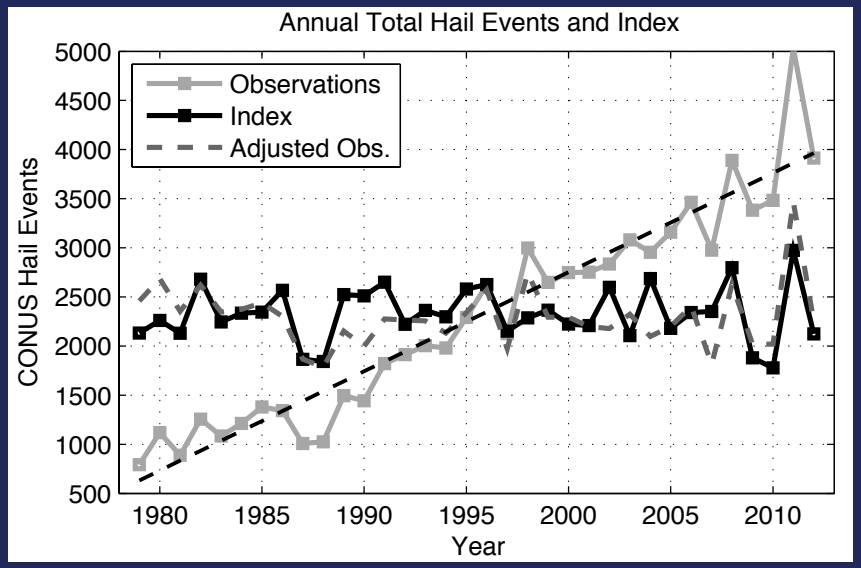
The influence of the severe hail criteria change in 2010.

Allen & Tippett 2015 (EJSSM)

‘Cleaning Up’ - An Environmental Index for Hail Occurrence





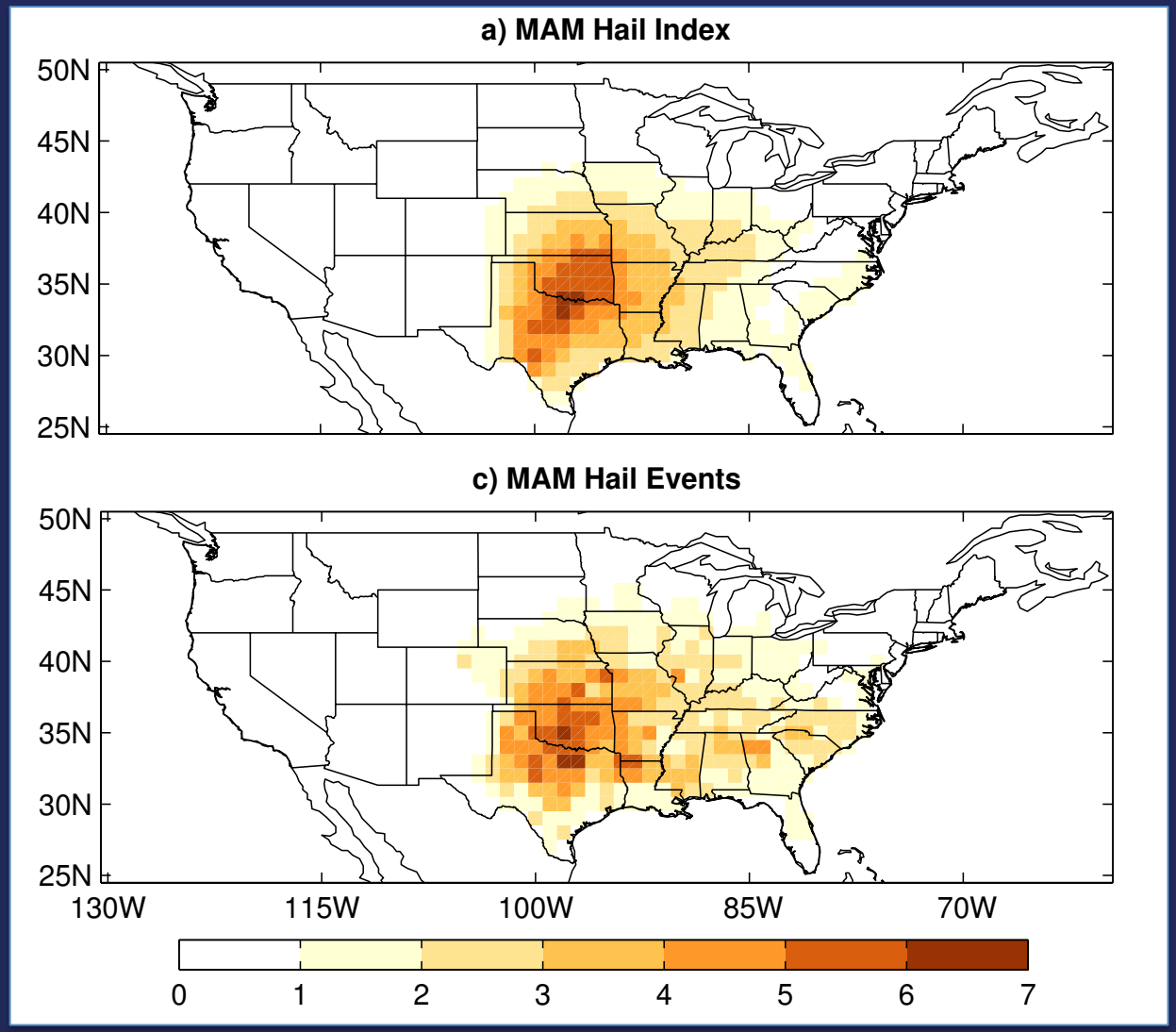


$$\mu(\mathbf{x}) = \exp(-10.18 + 0.97\log(\mathbf{cPrcp}) + 1.13\log(\mathbf{SRH}) + 1.00\log(\mathbf{MLCAPE}) - 0.31\mathbf{Q}_{\mathbf{mean}} + \mathbf{offset})\,.$$

Hail Environmental Index (NARR reanalysis) compared to Observed Hail Days Period: 1979-2012.

Allen et al. 2015 (JAMES)

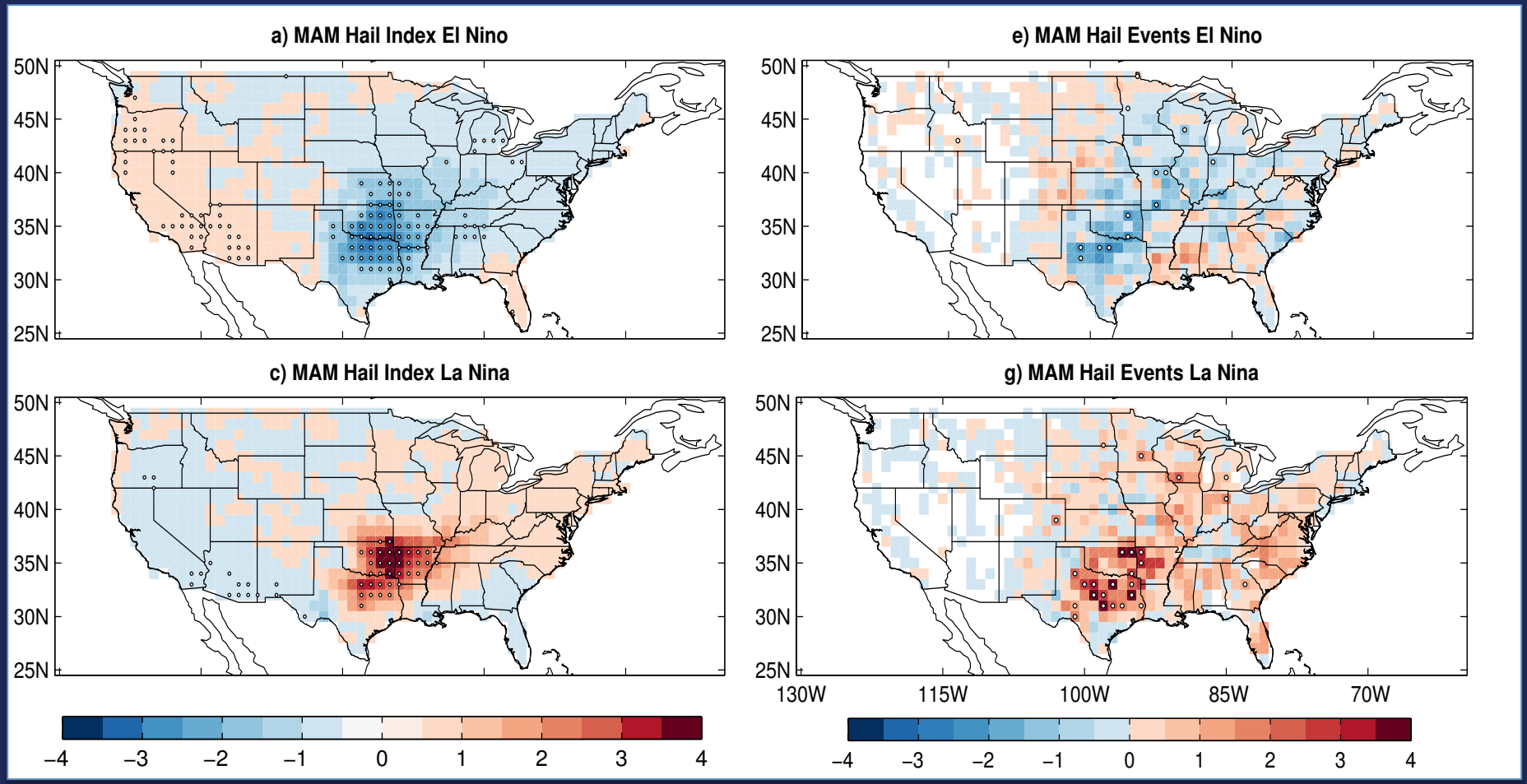
MAM Climatology of Hail (Obs. & Index)



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

Allen et al. 2015 (Nat. Geoscience)

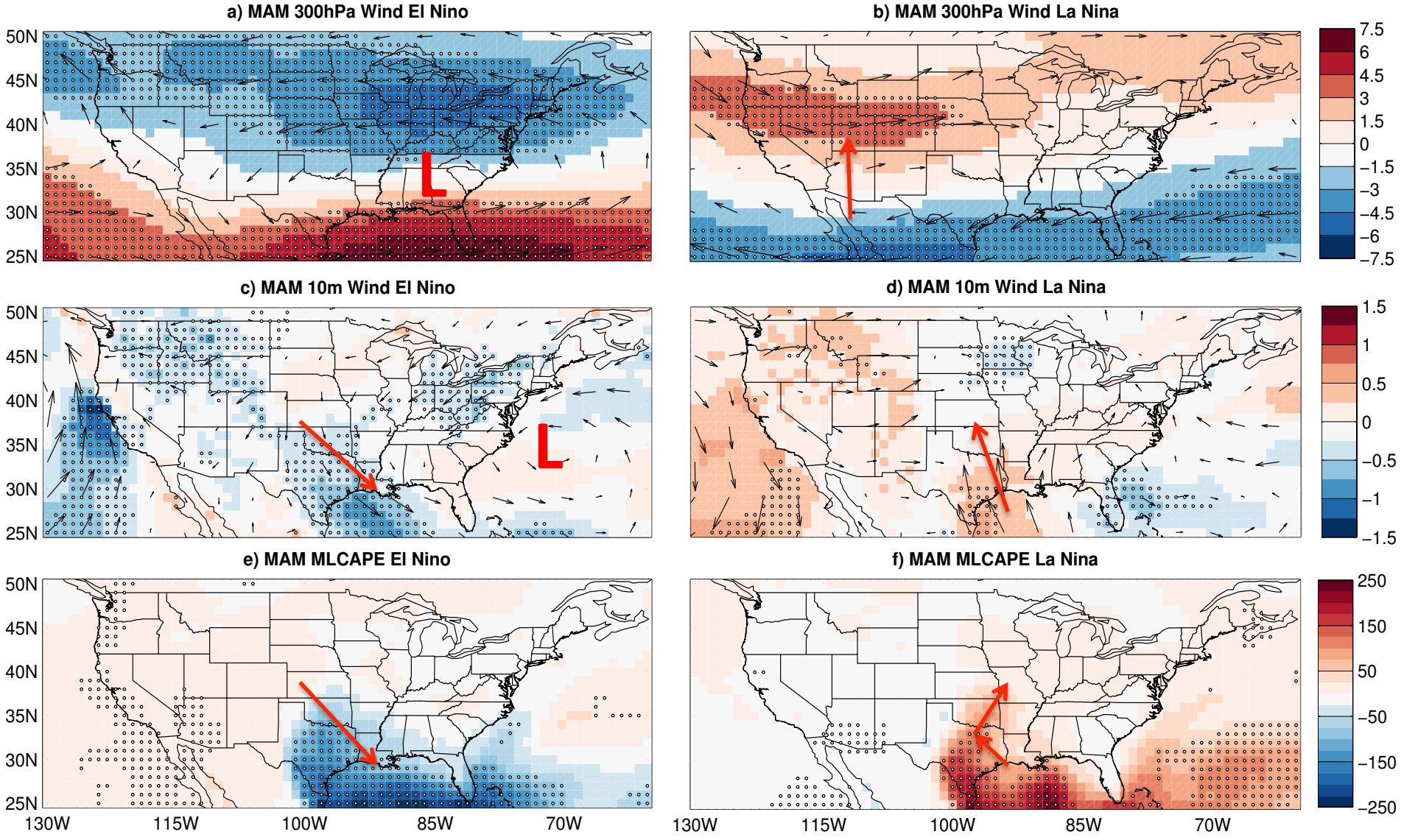
Modulation of Hail by ENSO Teleconnection - MAM



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 (Nat. Geoscience)

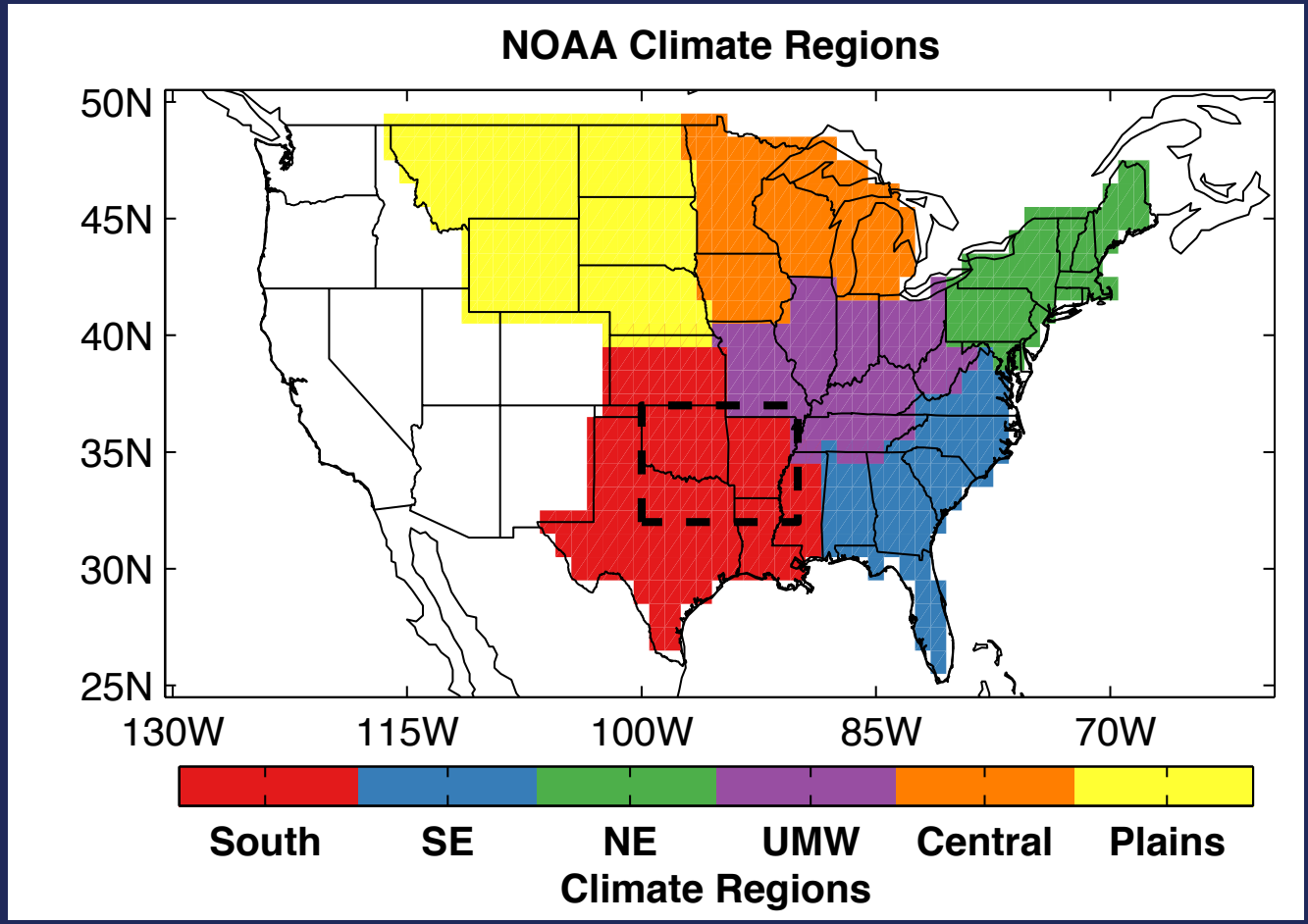
ENSO Teleconnection MAM – Synoptic and Environment



MAM Composites of Environmental variables for El Niño and La Niña

Allen et al. 2015 (Nat. Geoscience)

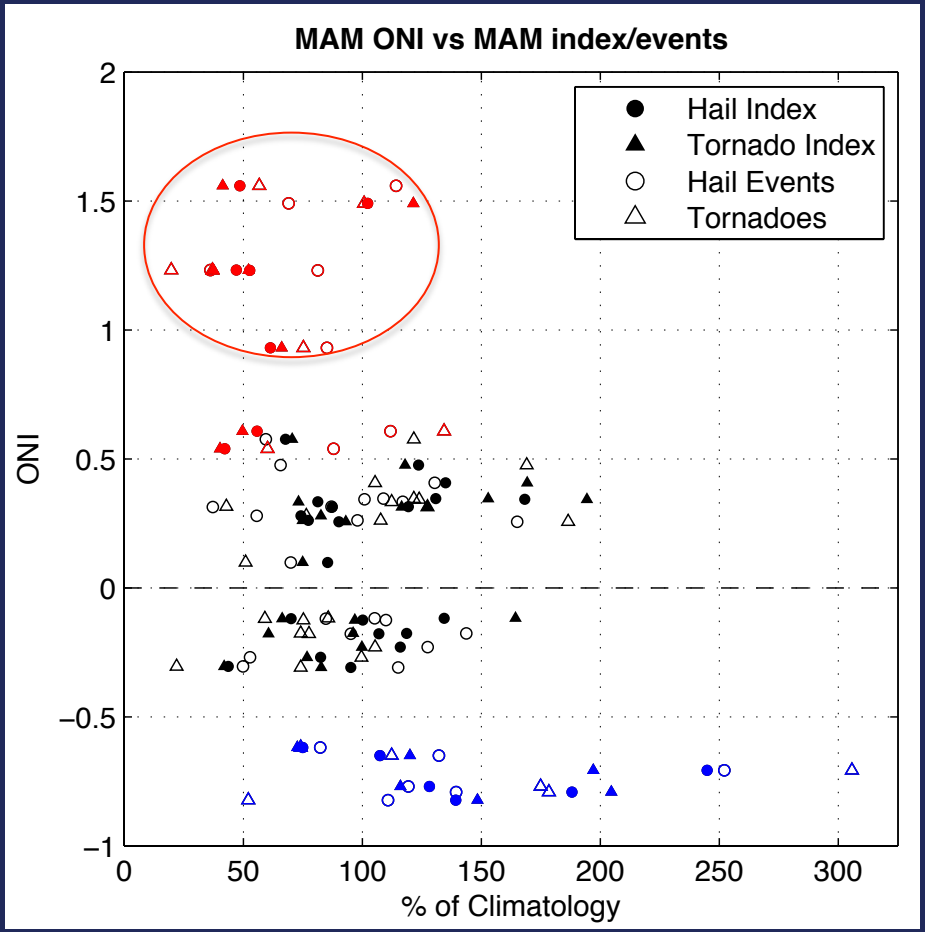
Application – Seasonal Predictability: DJF forecasting MAM

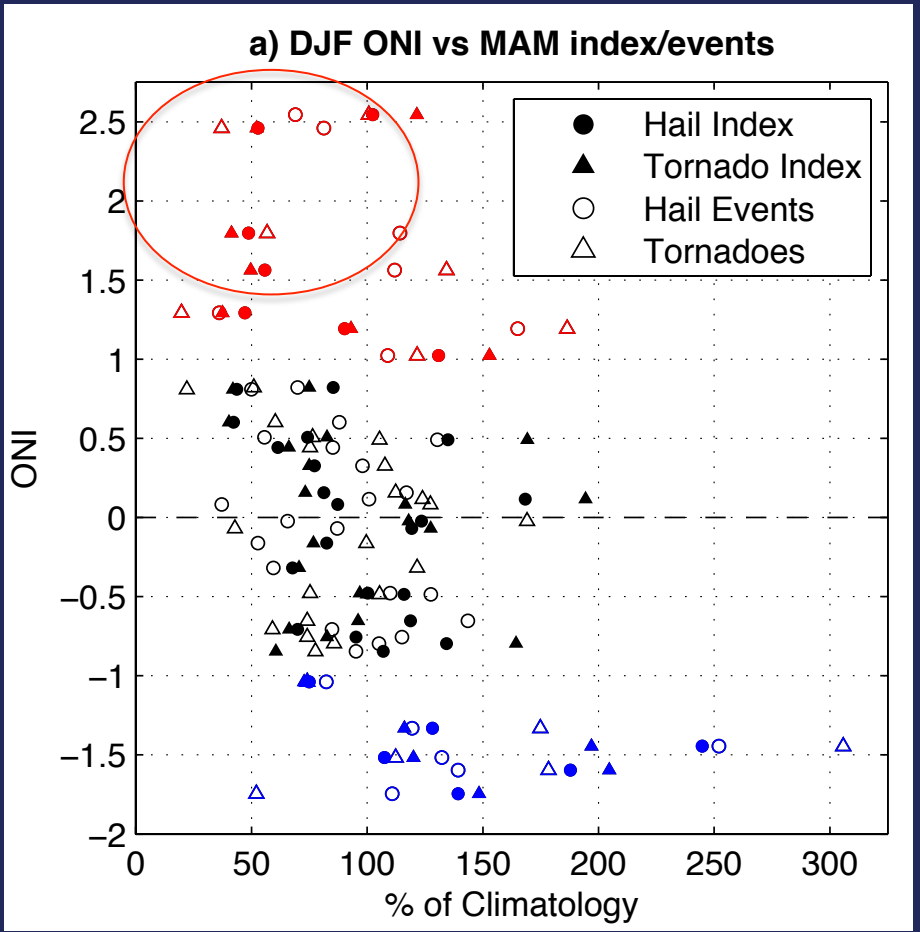


Define a box around area with most noticeable signal bounded by 100-90°W and 31-36°N – what does frequency look like compared to climatology for each year?

Allen et al. 2015 (Nat. Geoscience)

ENSO Signal – Seasonal Predictability: DJF forecasting MAM

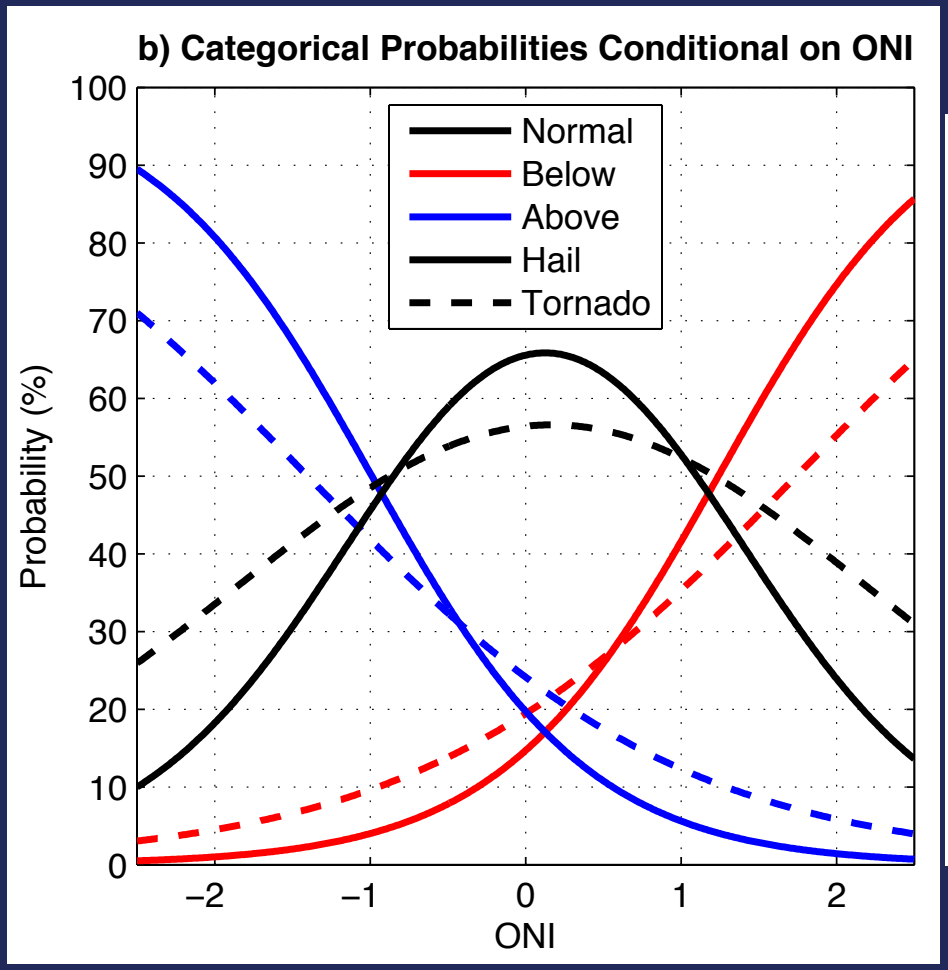


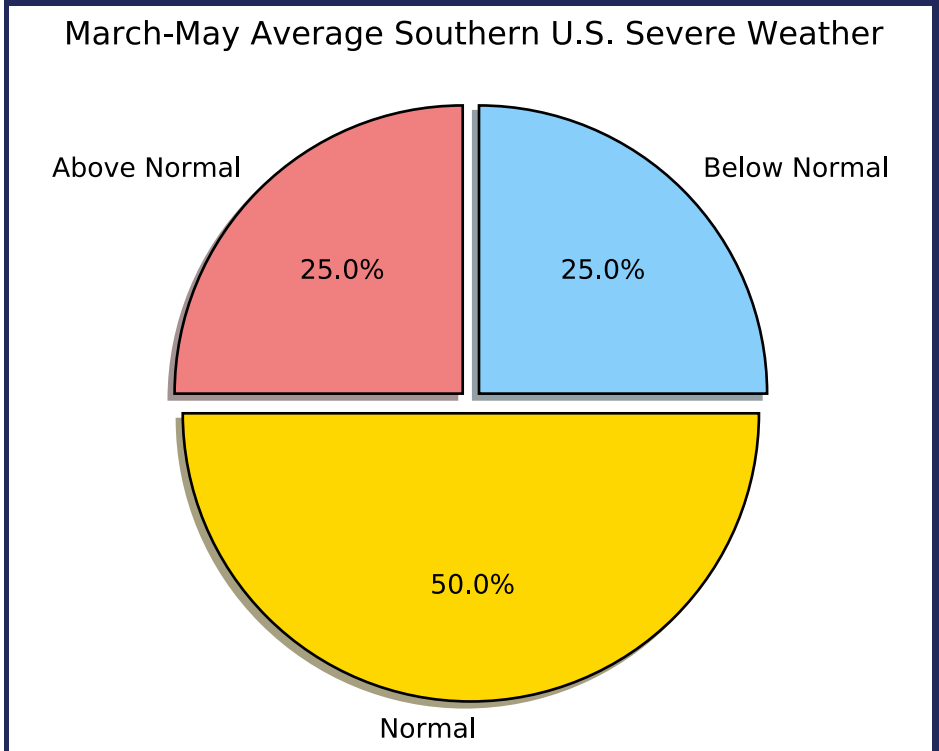


Scatter of box (bounded by 100-90°W and 31-36°N) total index for hail and observed hail events against seasonal ONI for a) MAM ONI b) Preceding DJF ONI. Shapes are as indicated in the legend. Red shapes correspond to the 7 El Niño seasons and blue icons correspond to the 6 La Niña seasons used in the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

Allen et al. 2015 (Nat. Geoscience)

ENSO Signal – Seasonal Predictability: DJF forecasting MAM





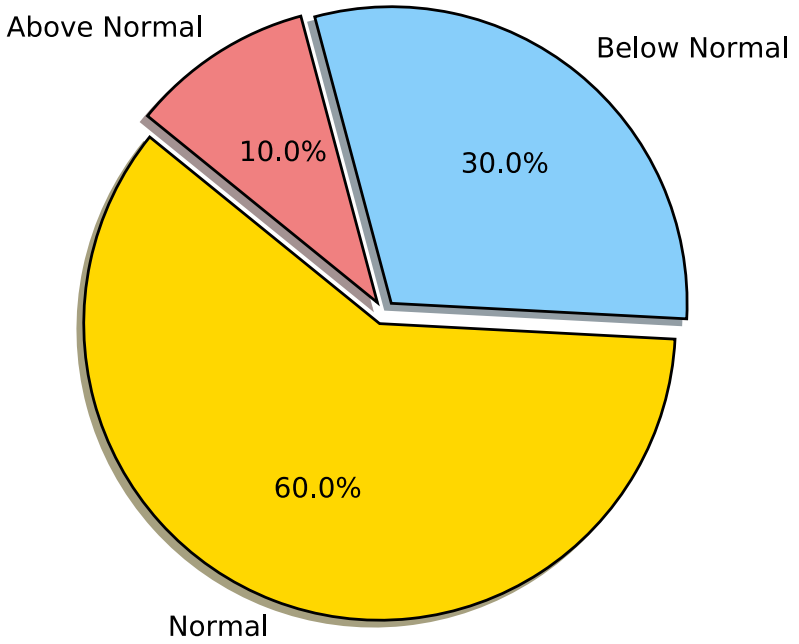
Extended Logistic Regression for MAM tornado and hail index probability conditional on the ONI state of the prior DJF for the defined area – Note these aren't your ordinary terciles (25%/50%/25%)

Allen et al. 2015 (Nat. Geoscience)

ENSO Derived Seasonal Predictability: DJF forecasting MAM

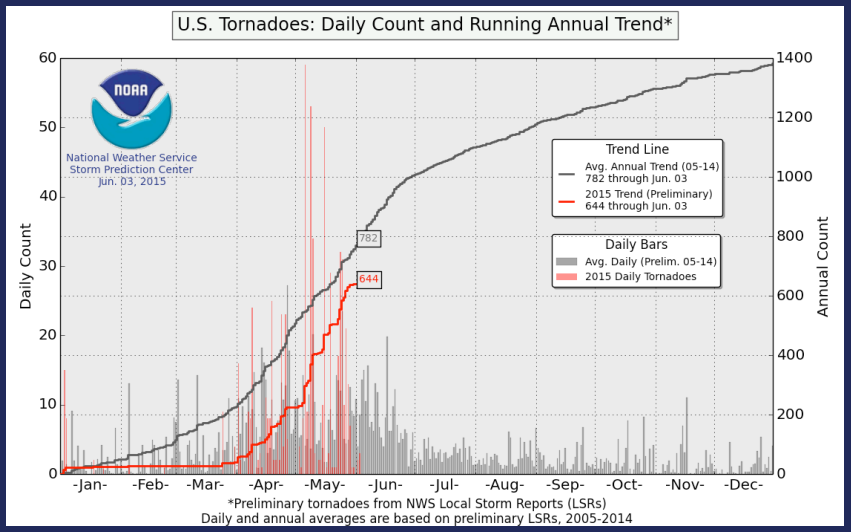
Forecast (March Issued)

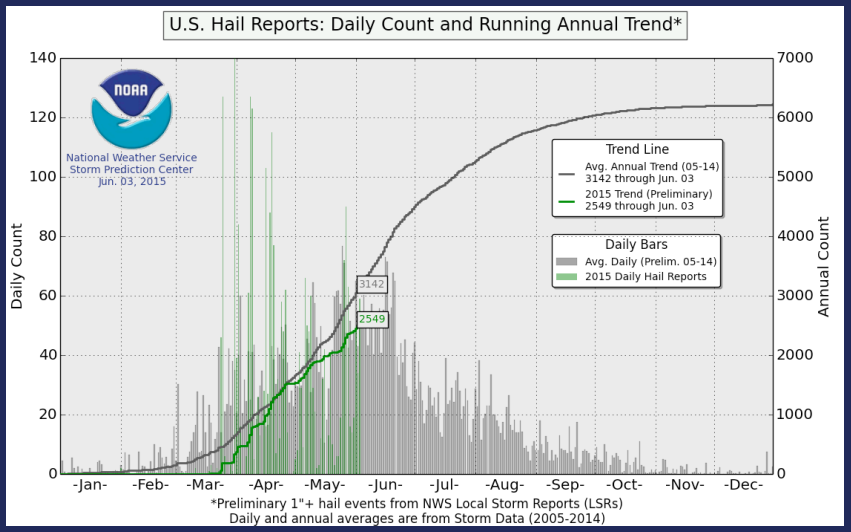
March-May 2015 Southern U.S. Severe Weather Forecast



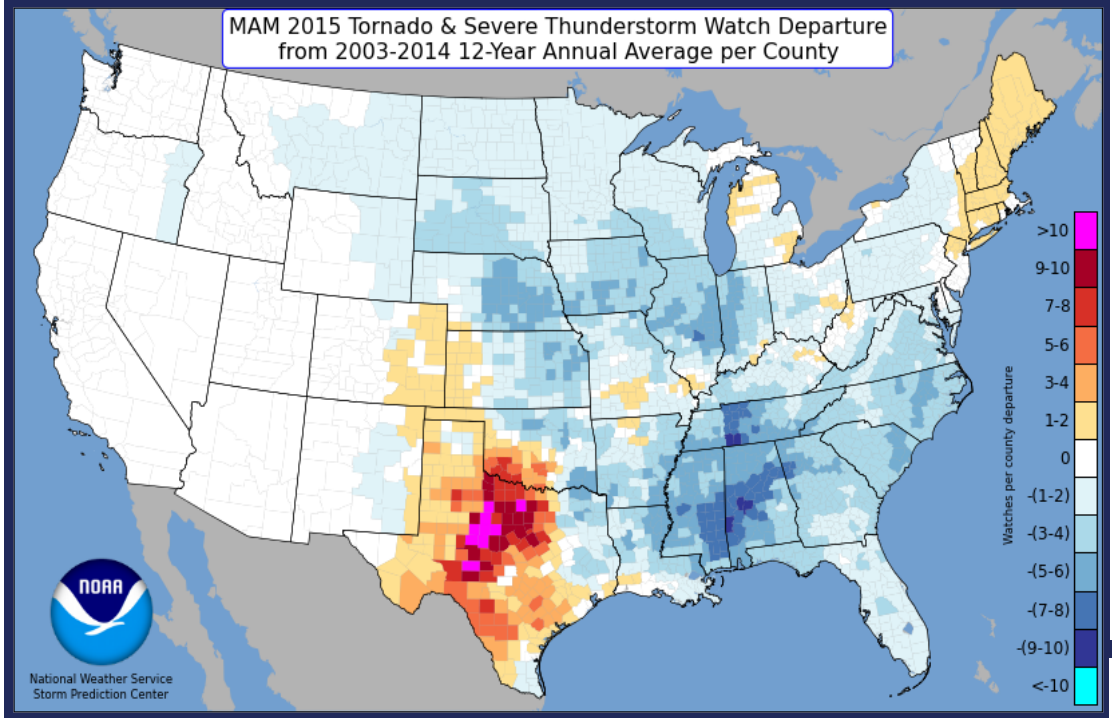
Probabilistic forecast of severe weather occurrence based on DJF ONI data for the 2015 spring severe weather season.

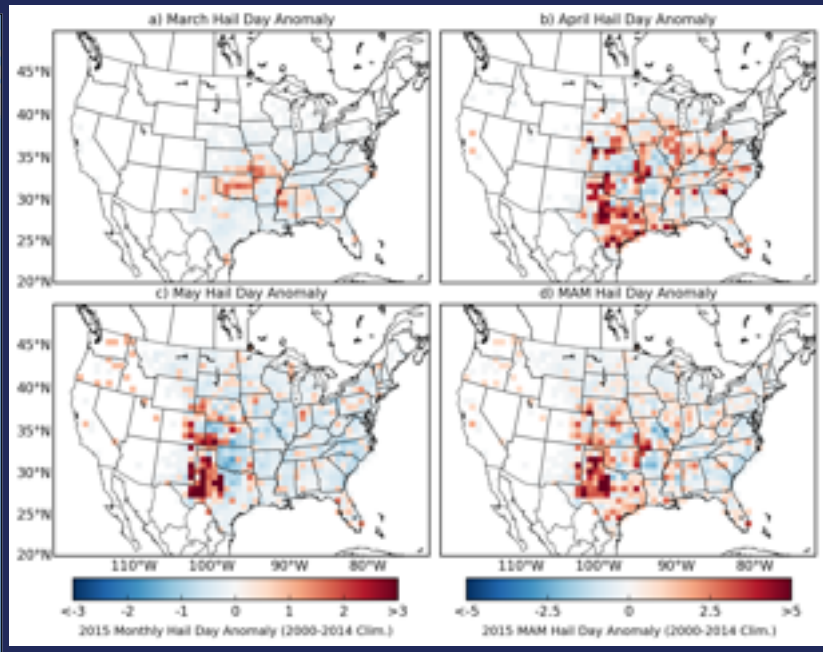
Verification?

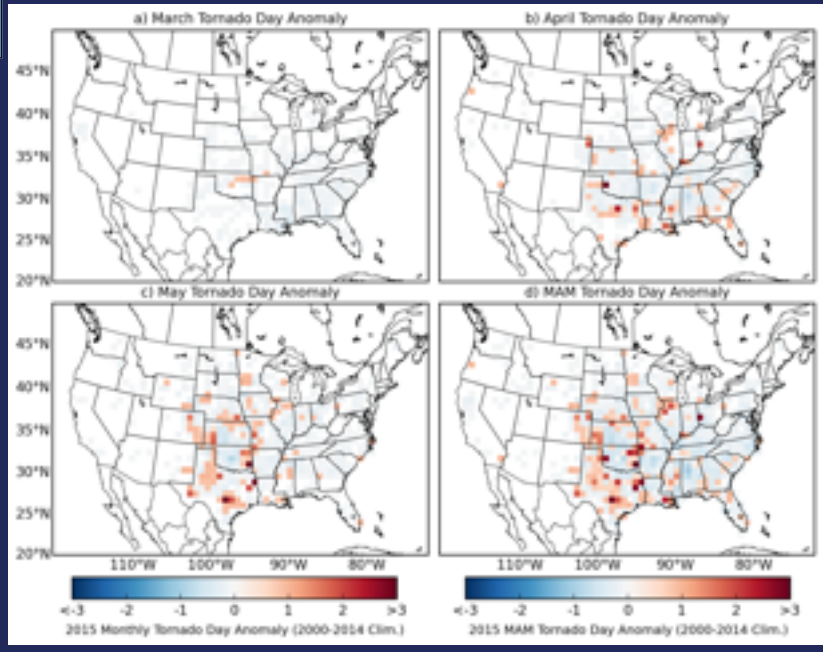




ENSO Derived Seasonal Predictability: DJF forecasting MAM



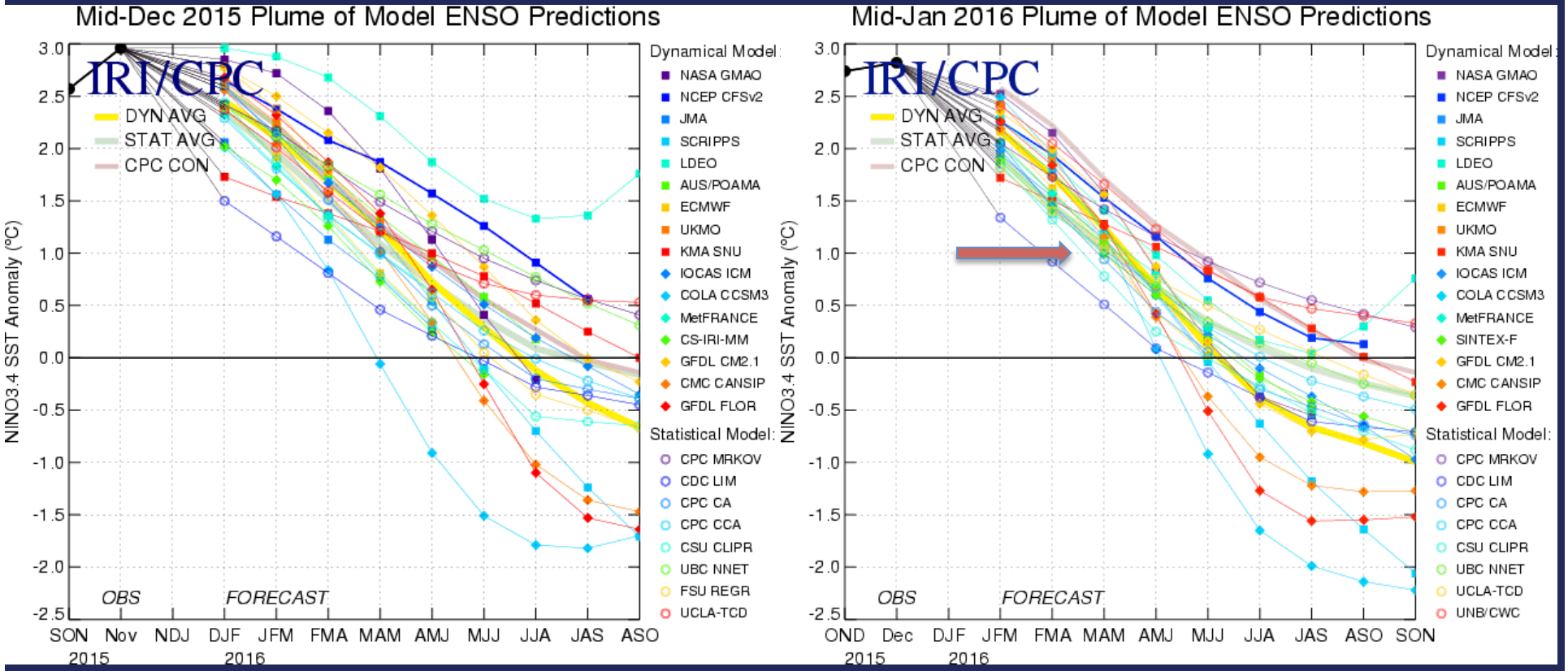




Lessons so far:

- Hail and Tornado don't necessarily match.
- According to official figures in this box 107% tornadoes, 121% hail. (EF1+ tornado, 1 Inch Hail).
- Forecasting for marginal ENSO conditions requires other predictors.

2015/2016 El Niño – Forecast Plume Evolution NMME



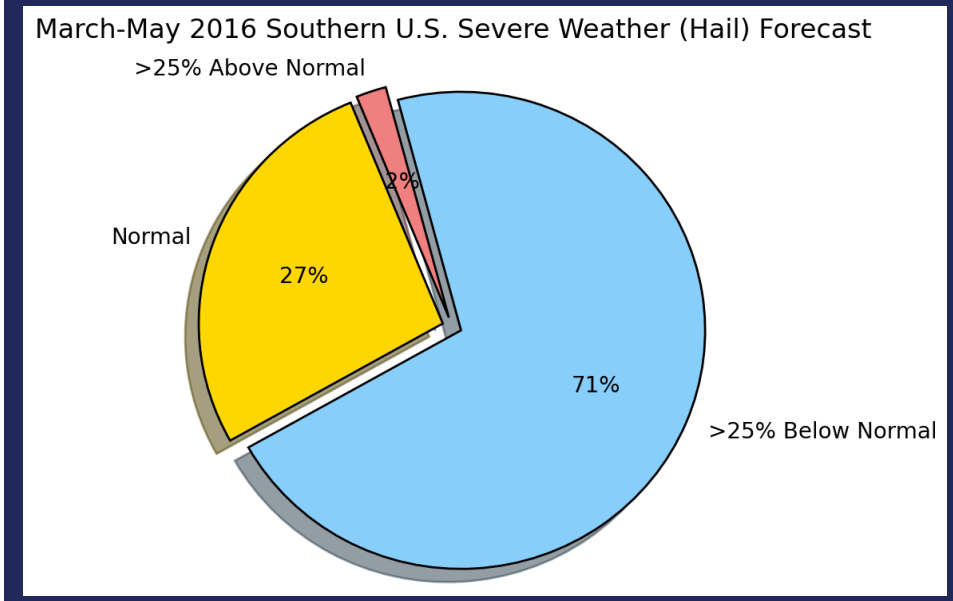
Forecast Plume NMME for ENSO State – Spring Season:

- Forecast to be ~1.0C anomaly Dynamic Average and Statistical Average
- Ranks Mid-High Range for El Nino events in MAM period (Relative Anomaly Matters)

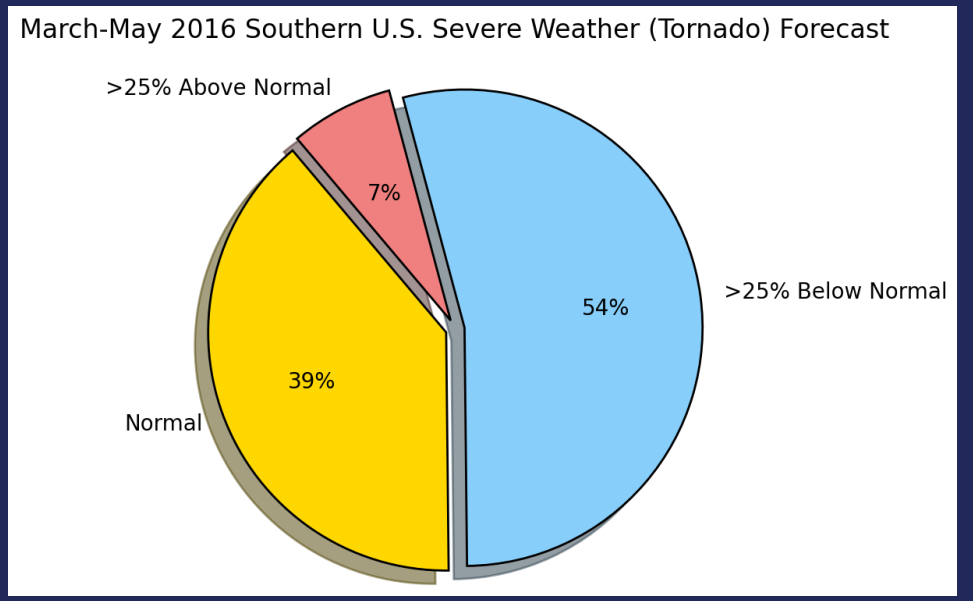
2016 MAM – Simple Probabilistic Forecast

Seasonal Forecast: 2016 Severe Weather Season (Southern US)

Hail



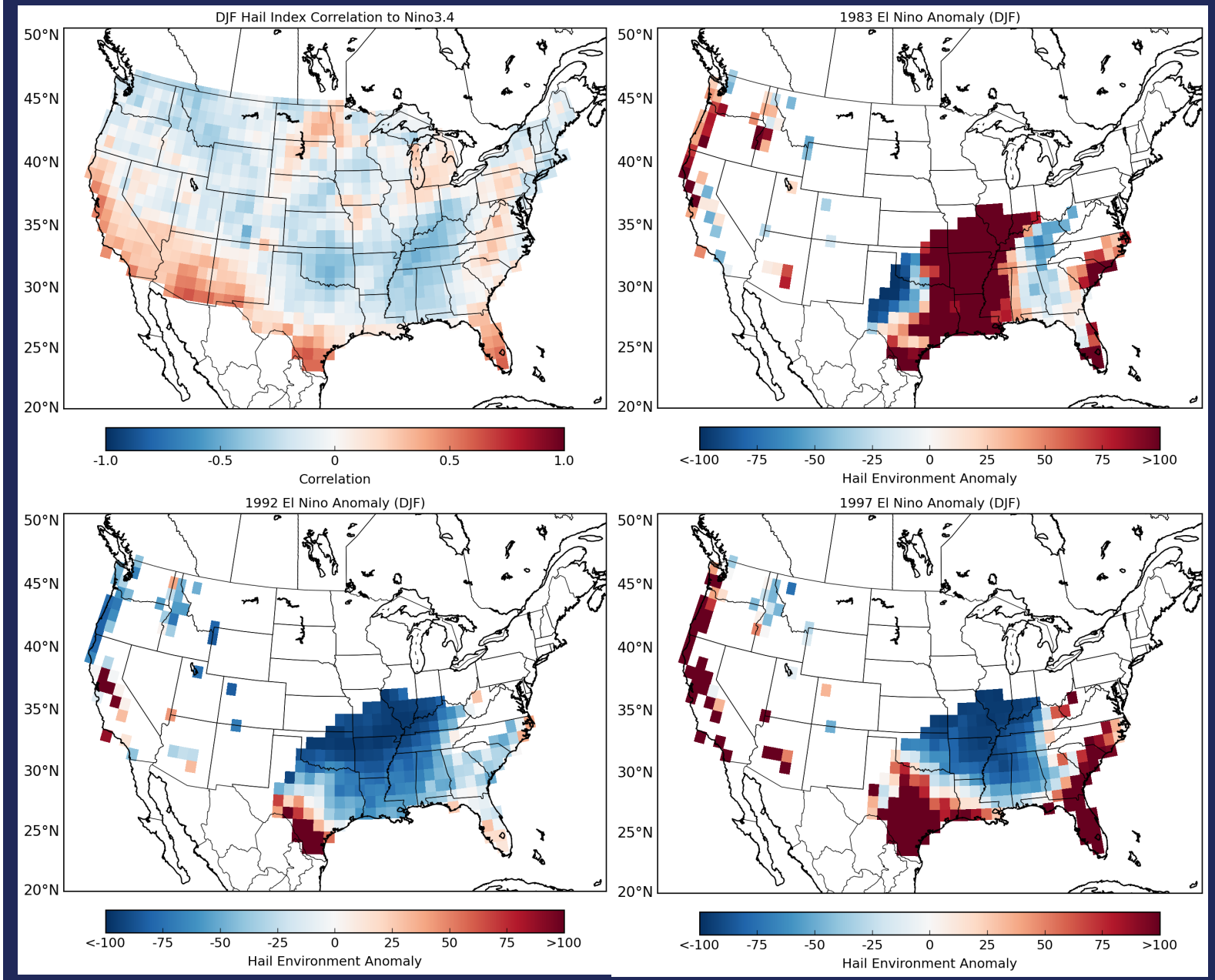
Tornado



CAVEATS:

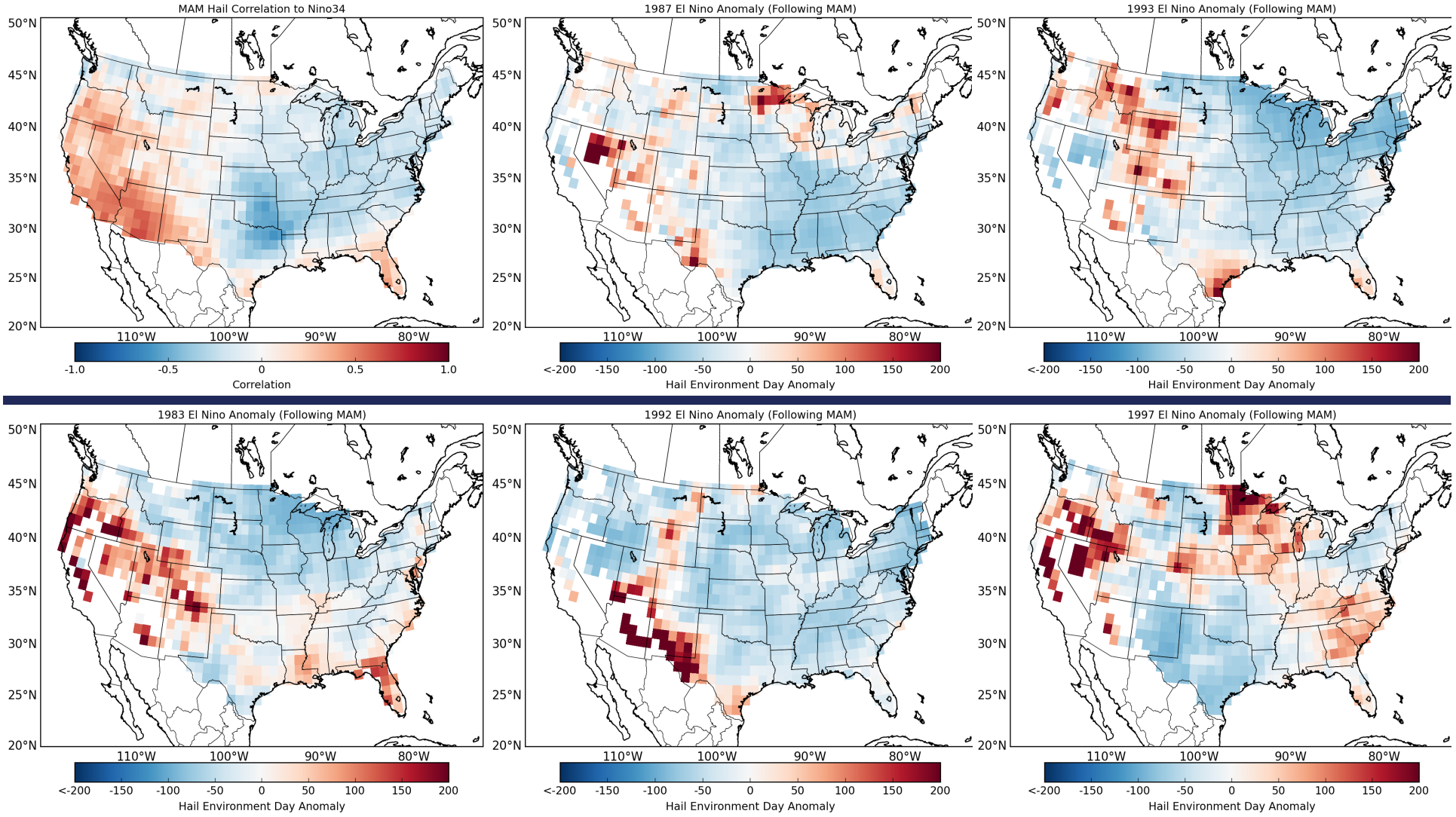
- Assumes we don't see synoptically-driven outbreak events that oppose the climatological signal (which are less likely in strong El Niño – but certainly not unprecedented).
- Uses DJF Niño 3.4 (in this case forecast from the mean ensemble NMME) as the sole predictor for the ELR.

DJF Hail – Comparable Years (Analog forecast NMME Nino3.4)



% Anomaly (Relative to 1979-2014 Climatology) Hail index proxy days

MAM Hail – Comparable Years (Analog NMME Nino3.4)



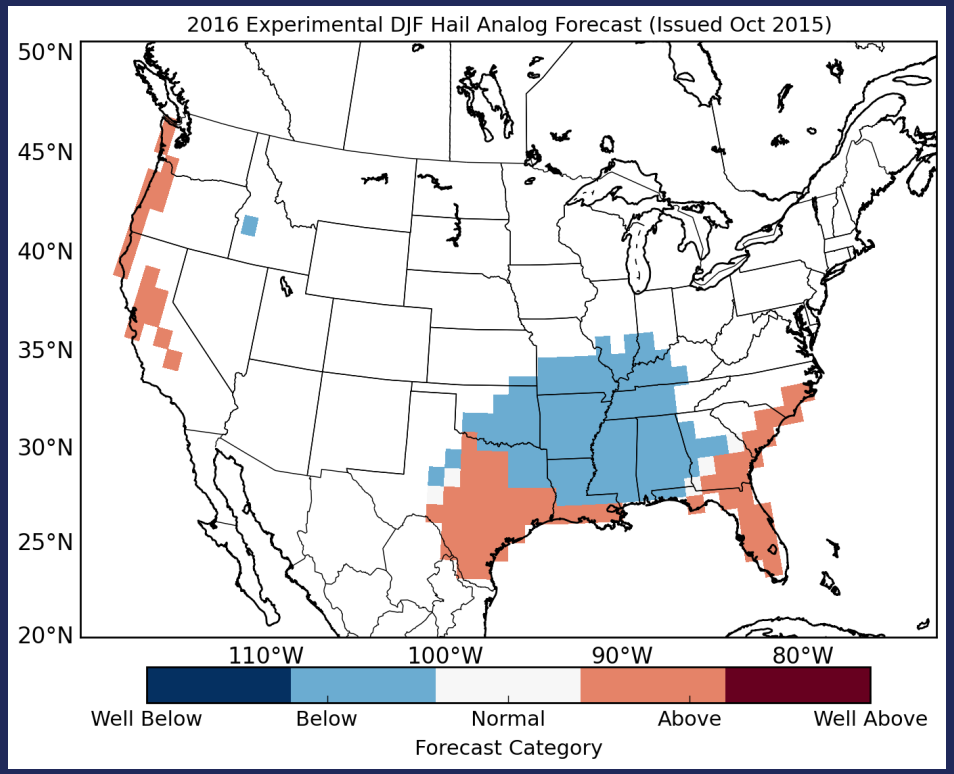
% Anomaly (Relative to 1979-2014 Climatology) Hail index proxy days

2016 – Analog Map Forecast

Spatial Hail Seasonal Forecast: 2015/2016 DJF & 2016 MAM

Based on NMME ONI forecast analogs for both Winter and Spring.

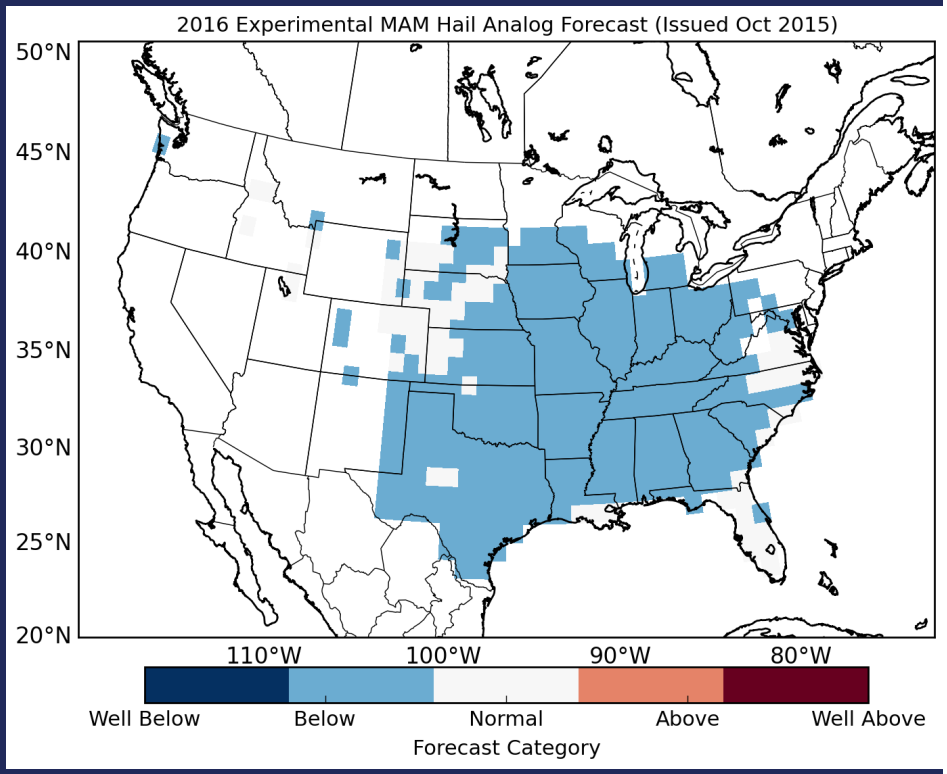
DJF Outlook



82/83, 91/92, 97/98

>=2 seasons with signal off category

MAM Outlook

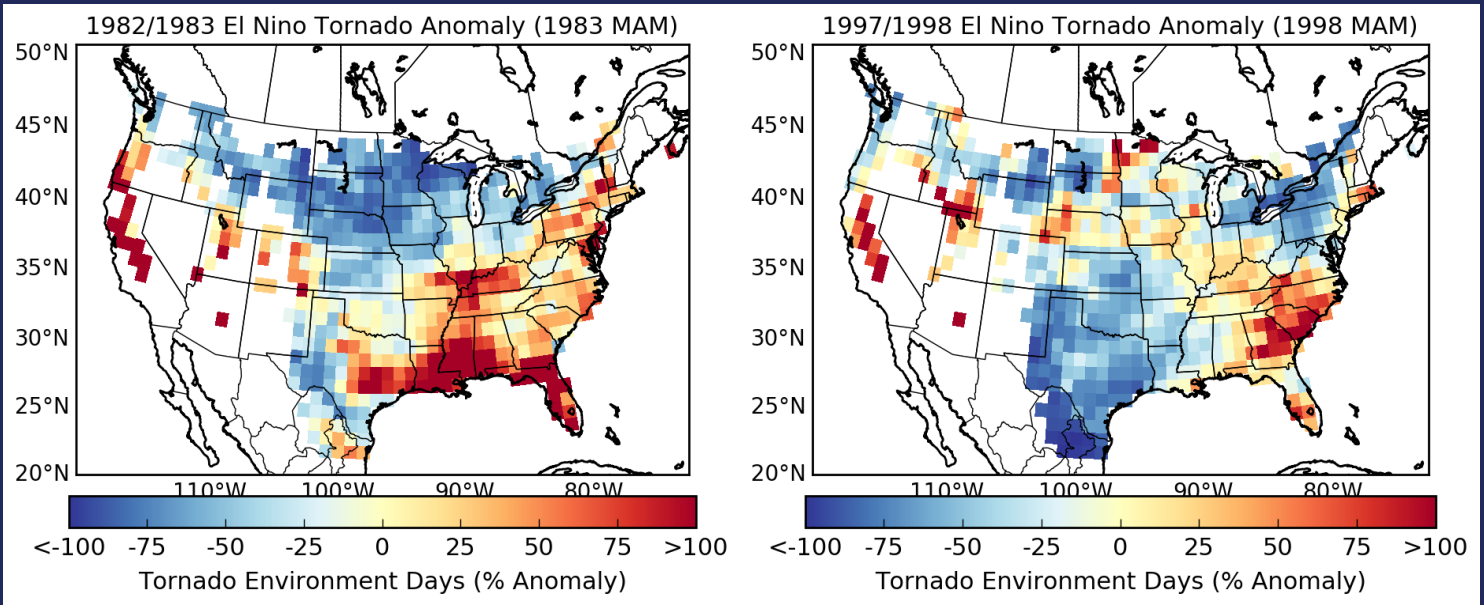


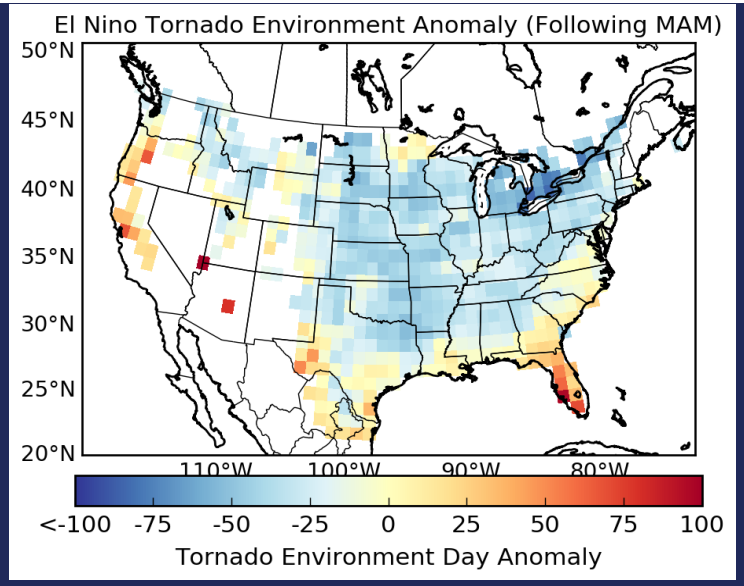
1983, 1987, 1992, 1993, 1997

>=3 seasons with signal off category

Categories: Well >=+50% of Normal, Above/Below >=+25% of Normal, -25% < N <+25%

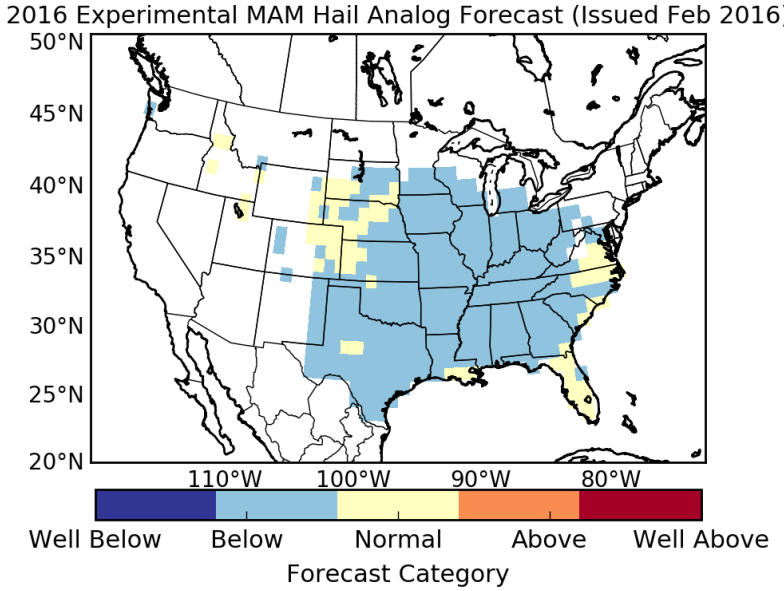
TEI Analogs 1982/1983 & 1997/1998 (Proxy for all Tornadoes)

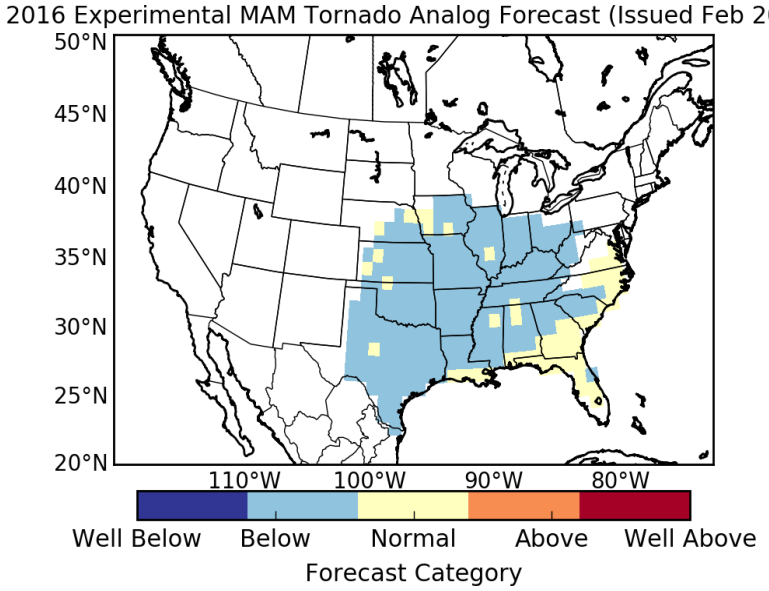


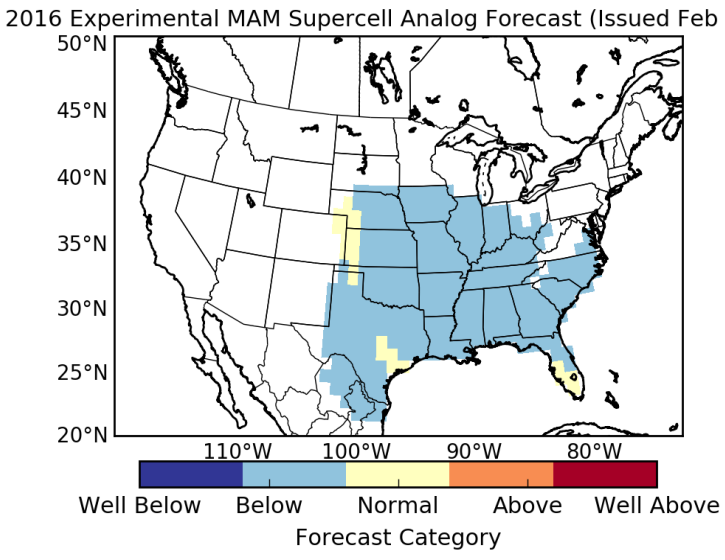


Anomaly Seasonal TEI (Relative to 1979-2014 Climatology)

2016 Spatial Forecast (SST Analog 'Informed Climatology')







Consensus forecast is for a below normal over the entire season – but that doesn't help you if your house is hit by a tornado.

Summary

- Observations of hail cannot be taken at face value for climate problems (but sample size is bigger than tornadoes). Caution – check the meteorological environment is the driving signal, and that the climate signal can influence it.

- ENSO (ONI) relationship for strong ENSO signal is statistically robust – not necessarily transitions (but there are flavors and transitions which explain a smaller fraction). El Niño produces significant negative anomalies (25-50%). La Nina has strong positive anomalies (50-150%)

- Is there really a use for a below normal forecast? The one tornado problem.

- 2016 Seasonal Prediction is for below normal activity for MAM (25-50% below normal compared to 1979-2014 Climatology).