Associating Hail Occurrence and Large Scale Environment for the Continental United States 1979-2012

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The Challenge

- How do we extend forecasts of severe weather phenomena (e.g. hail, tornadoes) to periods outside a week?

Our Approach

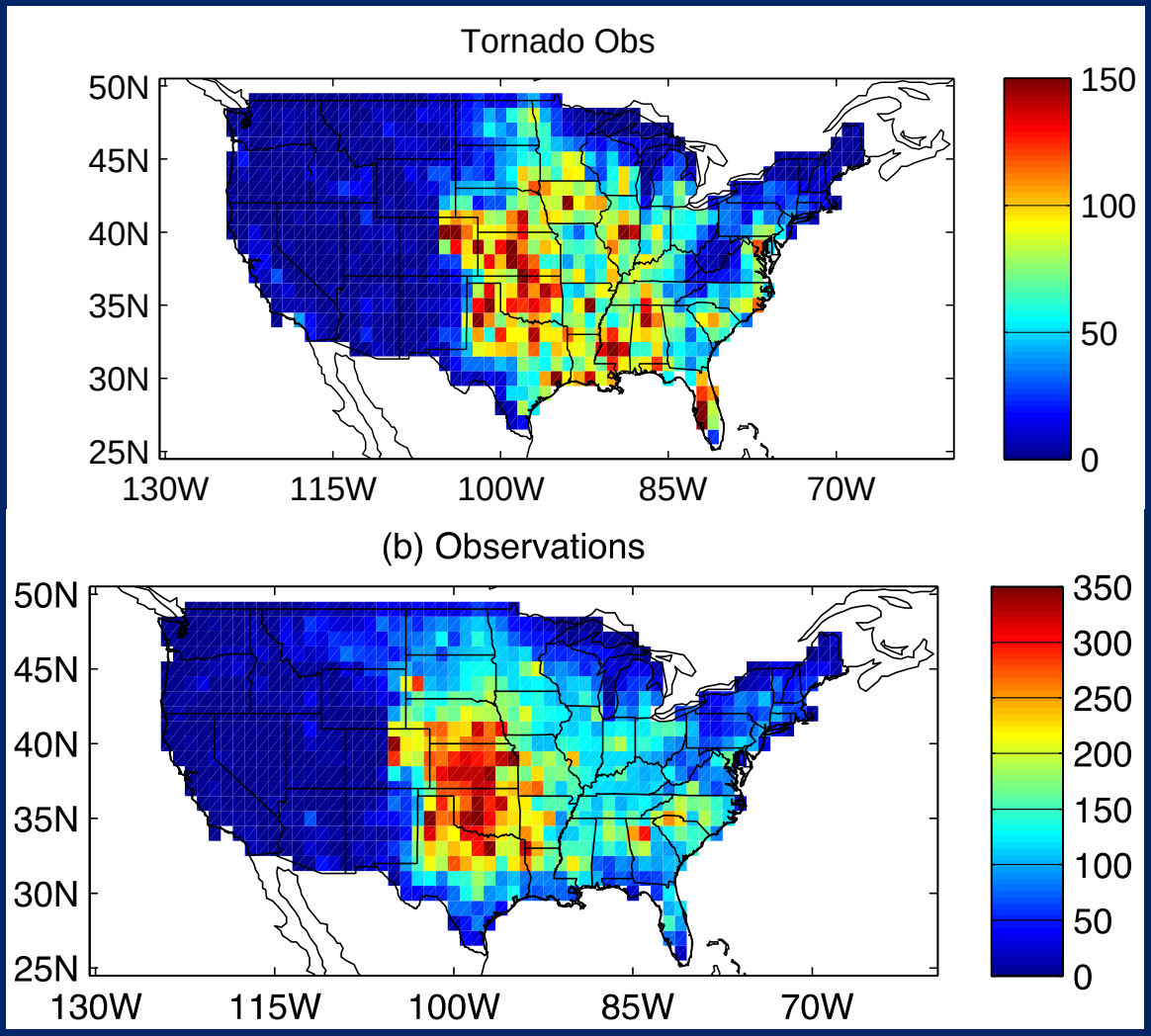
- Severe thunderstorm likelihood can be related to the environmental conditions that precede it – but linking this to the climate can be difficult.

- Choice between Dynamical or Statistical approaches.

- Can we define a statistical relationship that describes the occurrence of hail and is it different from that for tornadoes on a monthly basis?

- How does this relationship 'index' compare to climatology and inter-annual variability?

Tornado and Hail Observational Climatologies Don't Look the Same



a) Mean annual NCDC tornado observations, all tornadoes 1979-2012.

b) Mean annual NCDC observed hail events for hail between one and two inches 1979-2012.

Apply a Poisson Regression

- Use parameters than can be observed/modeled to develop a relationship.

- Assume a relationship of Index = exp(constants x parameters)

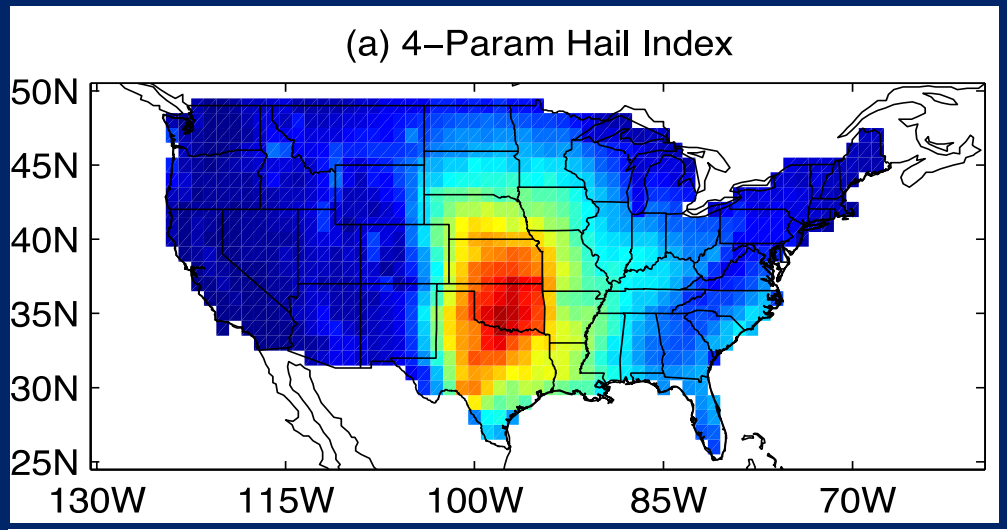
- 20 potential parameters:
  Thermodynamic: (CAPE, CIN, Convective Precip., Lifted Condensation Level, Surface Theta-E, Surface to Freezing level relative humidity)
  Kinematic: (Bulk Layer Shears, SRH)
  Simple: (Qmean, SoilM01, Temperature at 500mb)

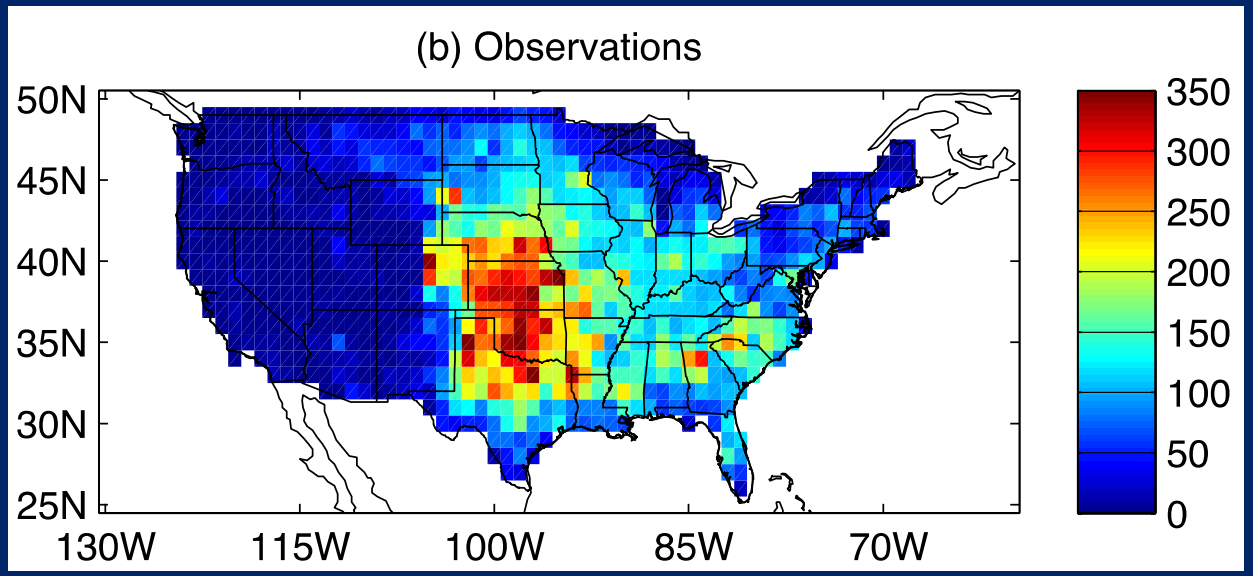
- Estimate constants using Poisson Regression from observed climatology of hail for the entire U.S. – avoids issues with changing technology and reporting.

- **Data**: Monthly mean NARR parameters on 1°x1° grid, NCDC/SPC hail between 1 and 2 inches 1979-2012.

A New Hail Index

'Best' Deviance/RMSE 4-param Index cPrcp, SRH, MLCAPE, Q_{mean}

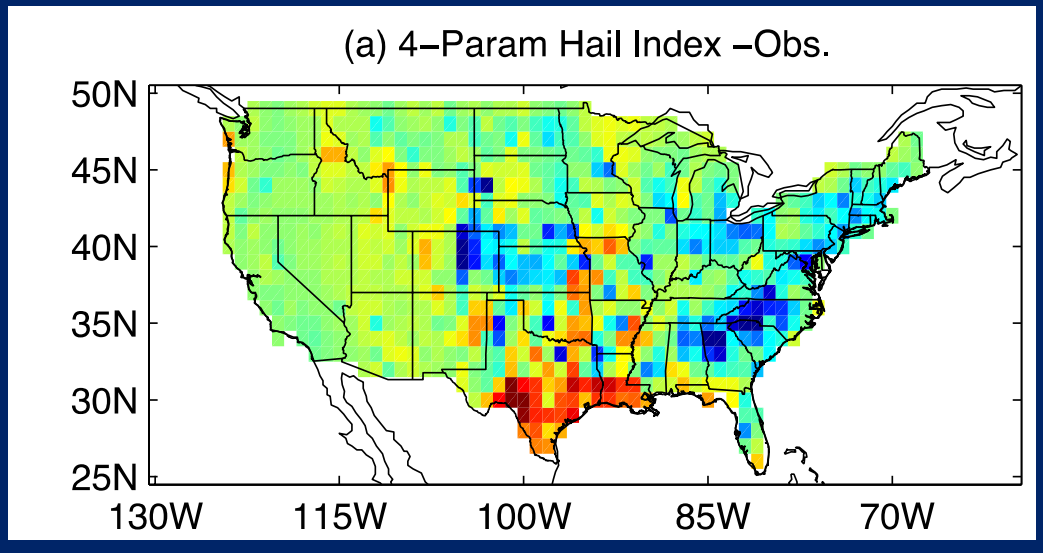


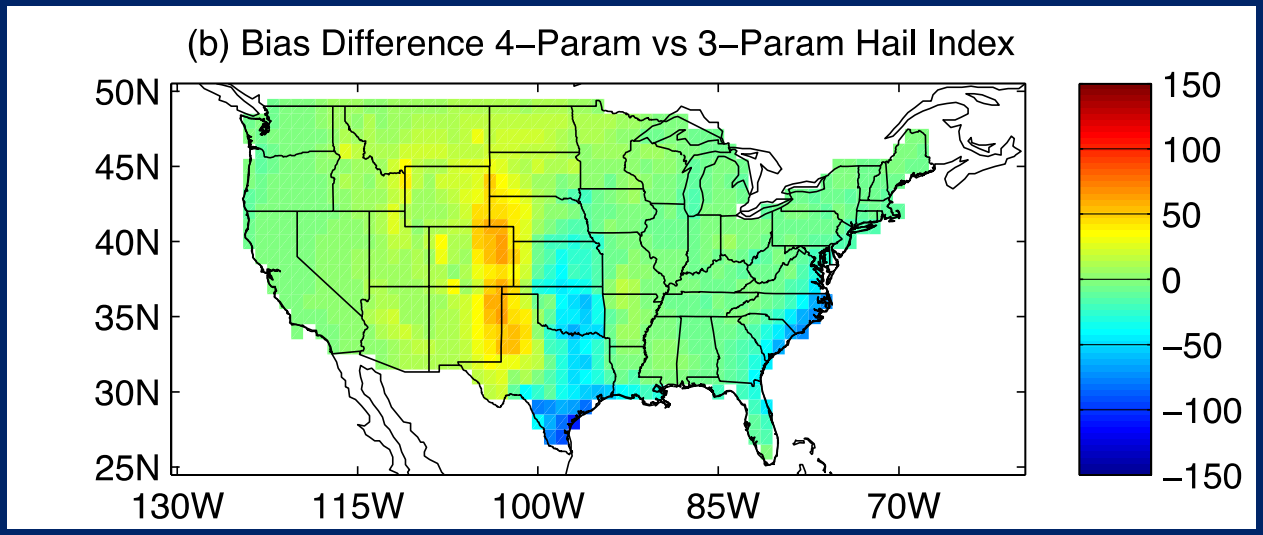


a) Mean annual 4-parameter Hail index for hail between one and two inches 1979-2012.

b) Mean annual observed hail events for hail between one and two inches 1979-2012.

Parameter Biases

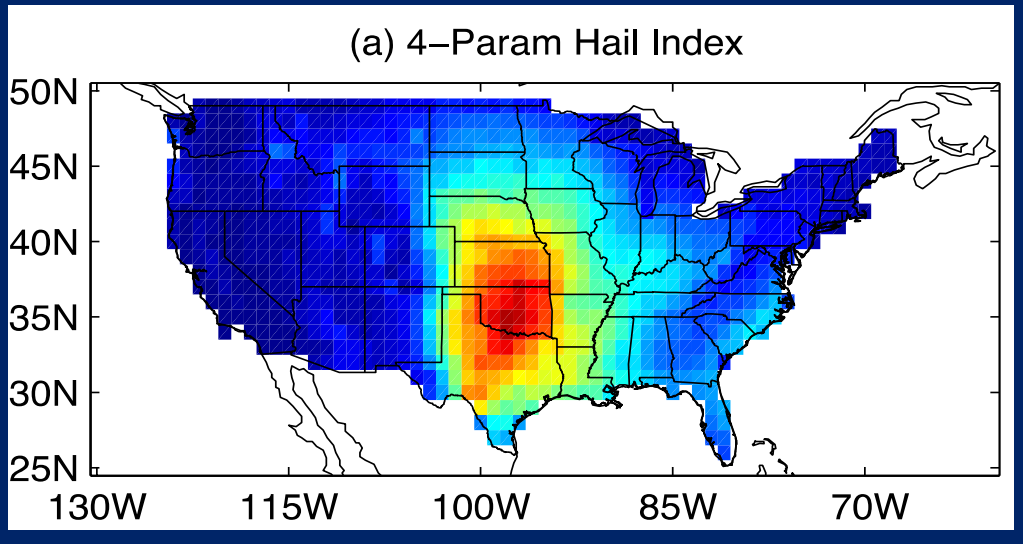


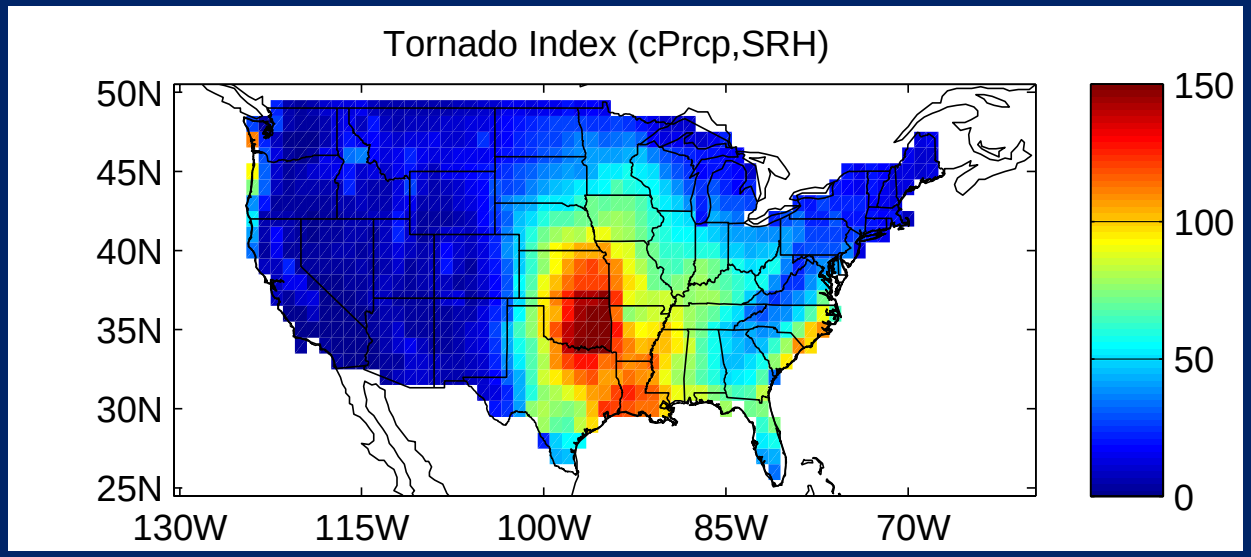


a) Difference between 4-parameter Hail Index and Observations.
b) Difference between the 3 and 4 parameter hail index showing the influence of the Q_{mean} parameter.

Comparison to Tornado Index

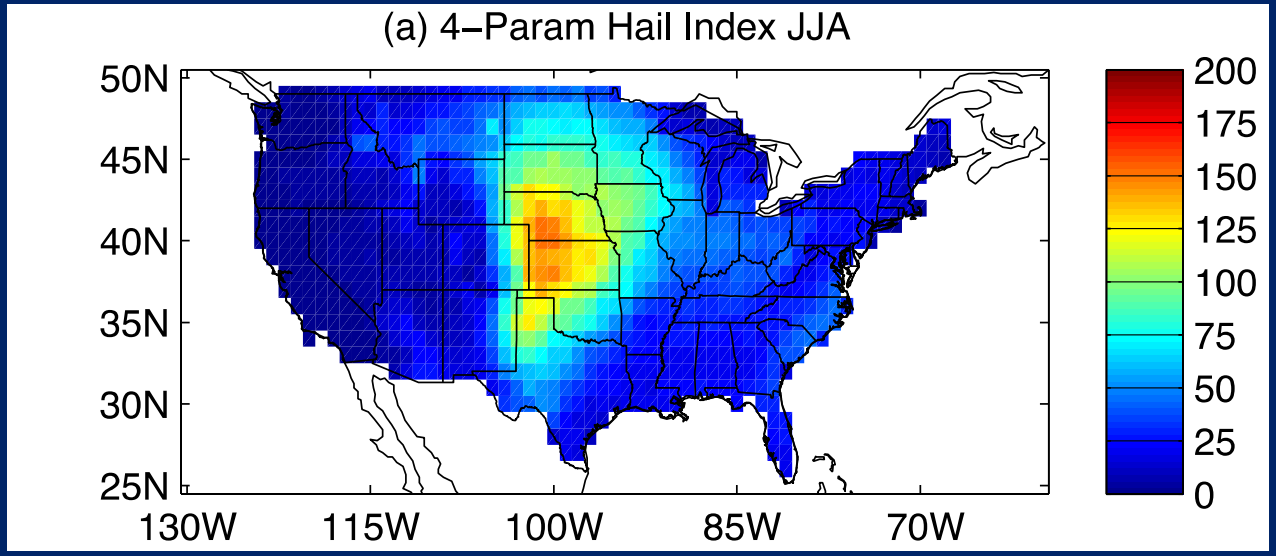
'Best' Deviance/RMSE 4-param Index cPrcp, SRH, MLCAPE, Q_{mean}

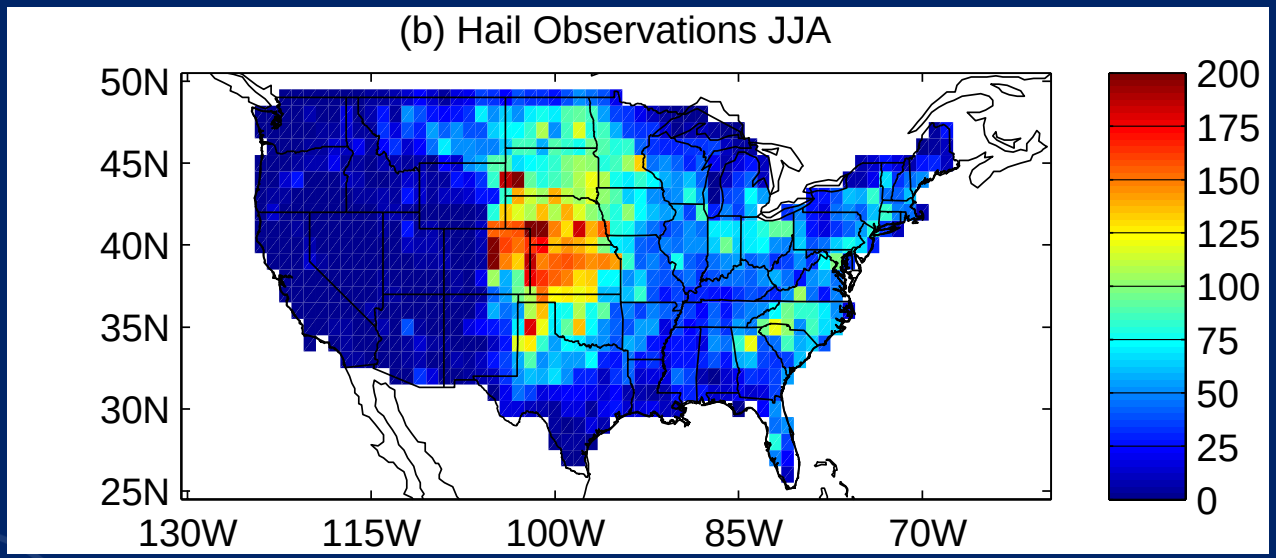




a) Mean annual 4-parameter Hail index for hail between one and two inches 1979-2012.
b) Mean annual 2-parameter Tornado index for all tornadoes F0+ 1979-2012.

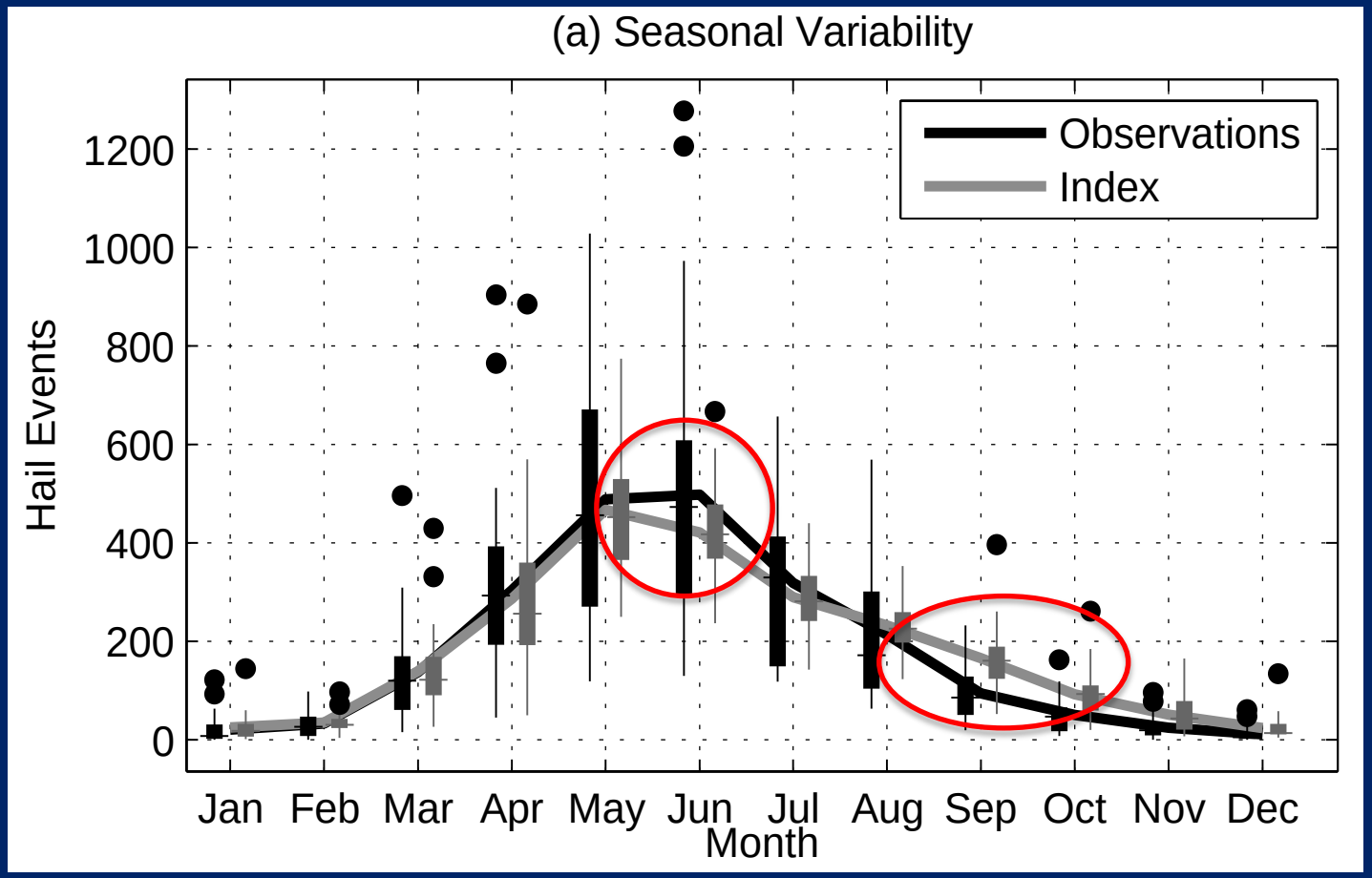
Seasonal Performance - Summer





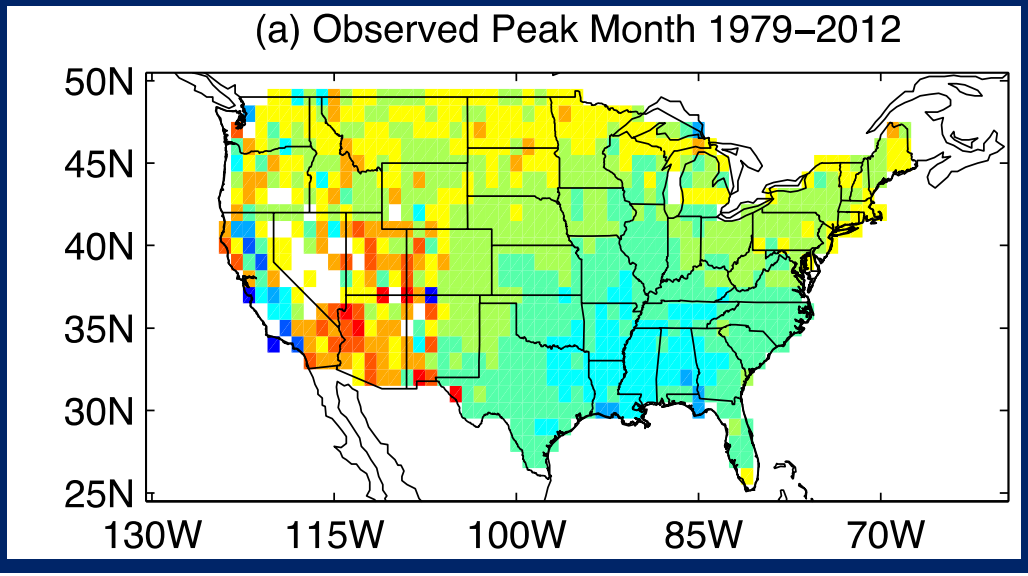
a) Mean Hail Index JJA (1979-2012)
b) Hail Observations JJA (1979-2012)

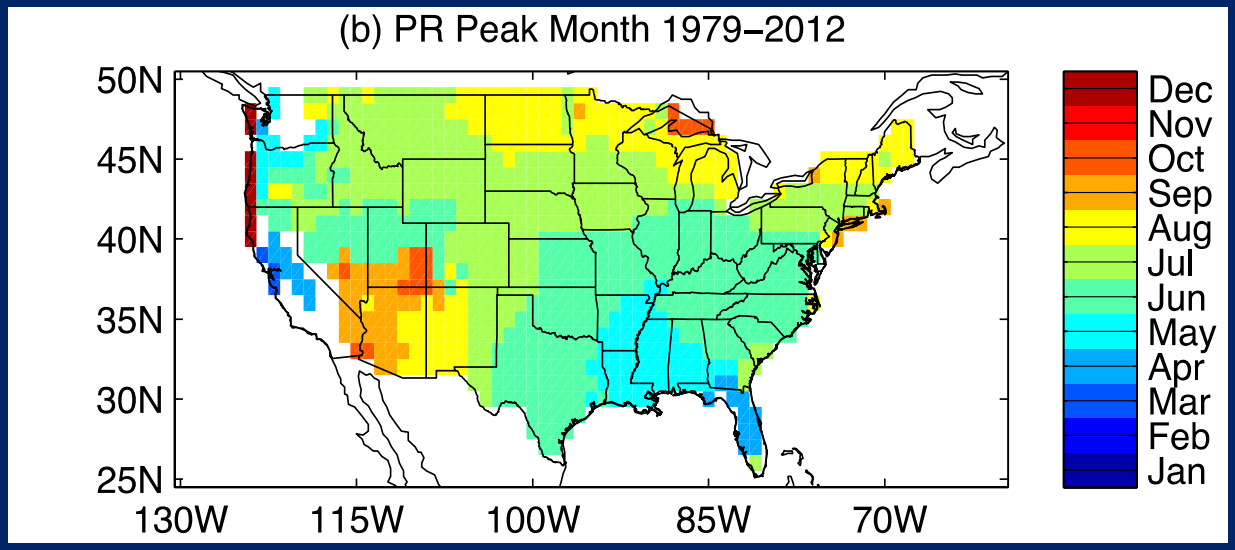
Seasonal Variability



Seasonal variability of the hail index as compared to observations. Lines are mean index (grey) and obs. (black) seasonal cycle, whiskers reflect 2.7sigma (99.3%). Dots show outlying years.

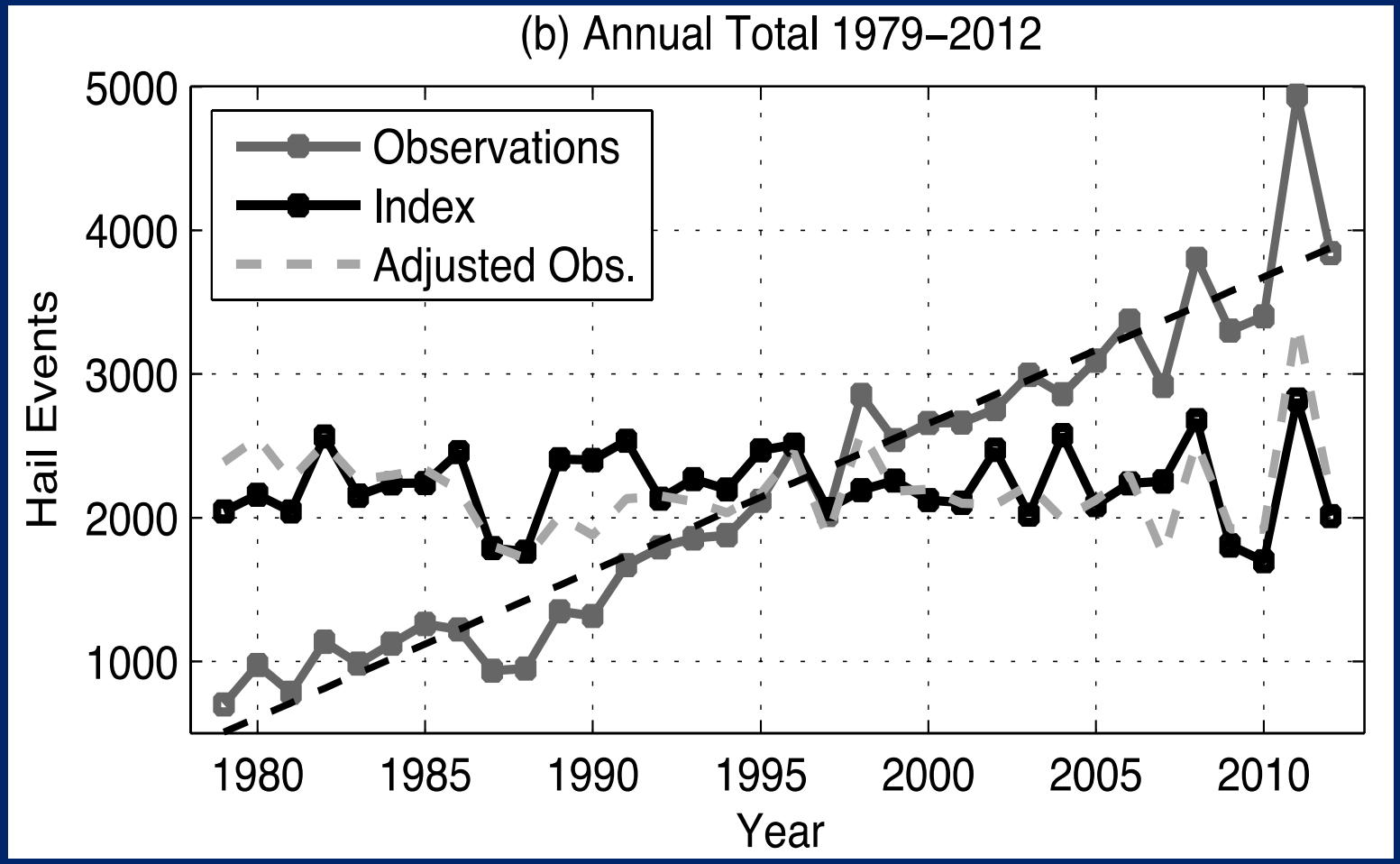
Spatial Seasonality





a) Mean observed peak month of observed hail events 1979-2012.
b) Mean observed peak month of 4-parameter Hail index 1979-2012.

Annual CONUS Total Variability



Variability in annual total of hail reports as compared to the index for the period 1979-2012. The adjusted observations have been linearly detrended.

Summary

- *A new monthly hail index has been developed* using Poisson regression to relate large-scale environment to the occurrence of hail between one and two inches, *different to the index for tornadoes*.

- The index produces a spatial distribution that while sensitive to the chosen dataset (due to the parameters), *gives a better representation than existing indices for all severe weather*.

- While monthly variability is less, the hail index gives *a more spatially consistent depiction of seasonal variability and is not influenced by the trend seen in observations*.

Caveats

- This is a good model, *not 'the' model*.

- A monthly index is *somewhat removed from the highly diurnal structure of some variables critical to the development of severe hail* (or tornadoes).

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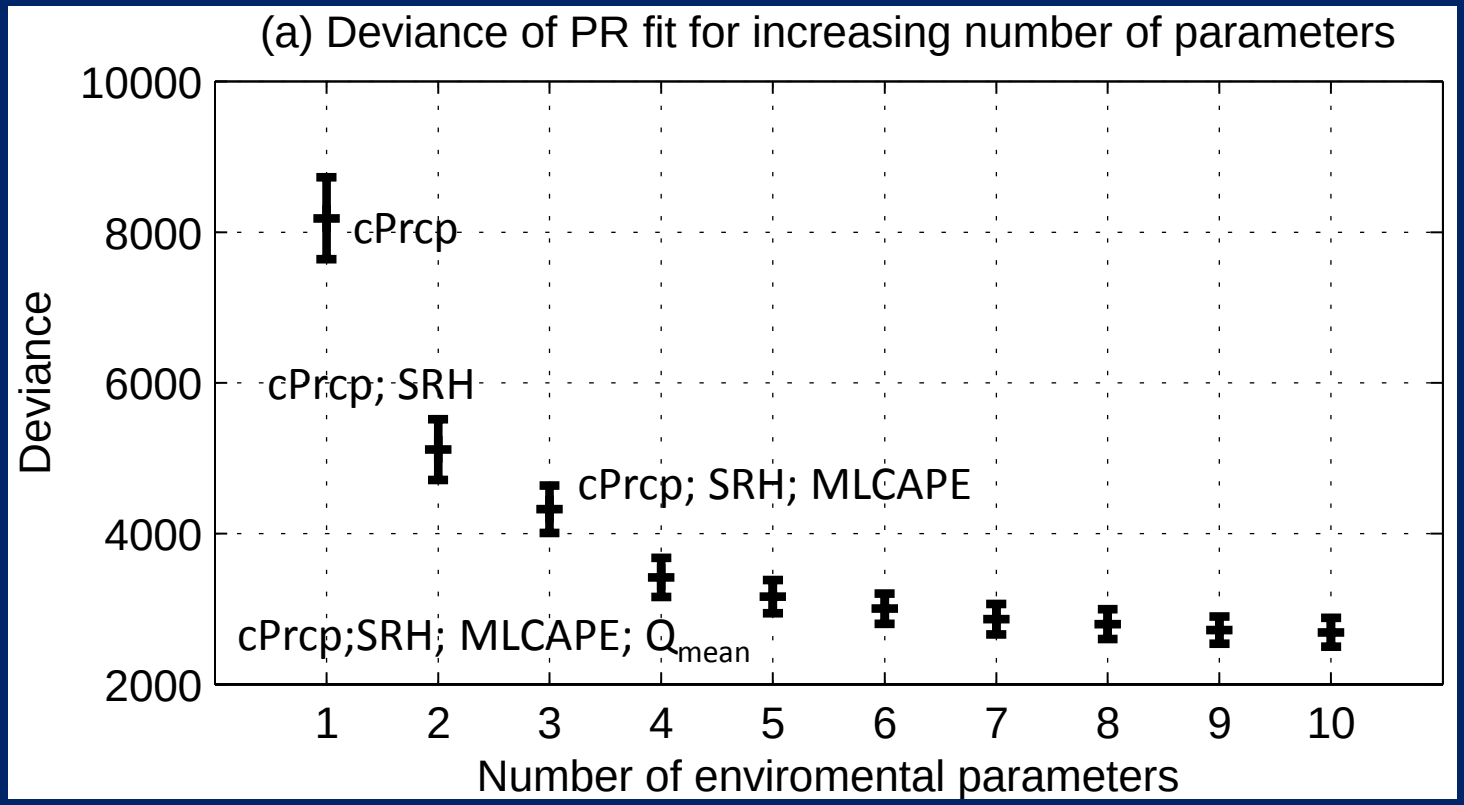
Allow the Data to Select: Deviance Minimization



Fitting Poisson Regression to the monthly climatological observations for an increasing number of environmental parameters.