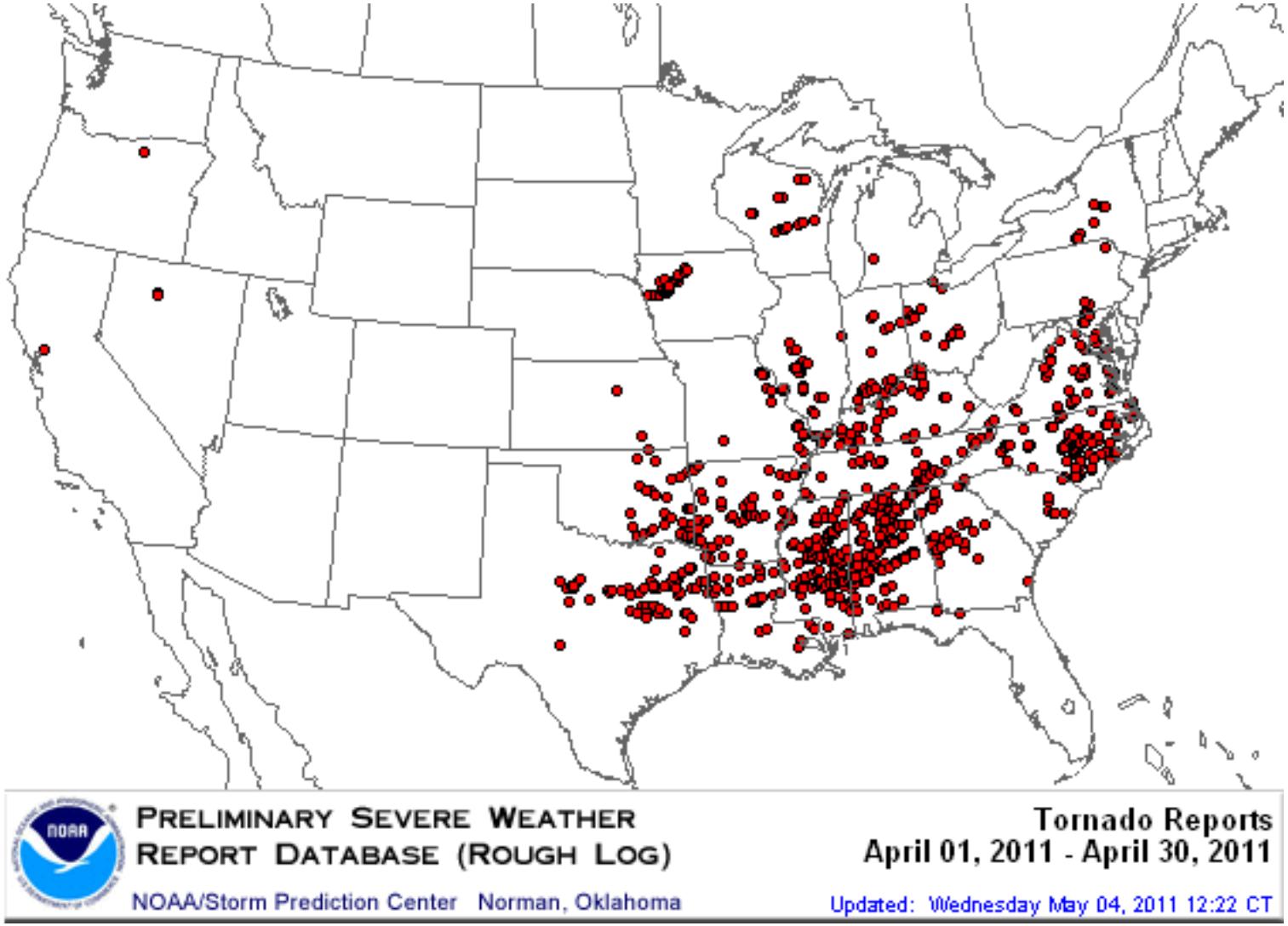
Association of U.S. tornado counts with the large-scale environment on monthly time-scales

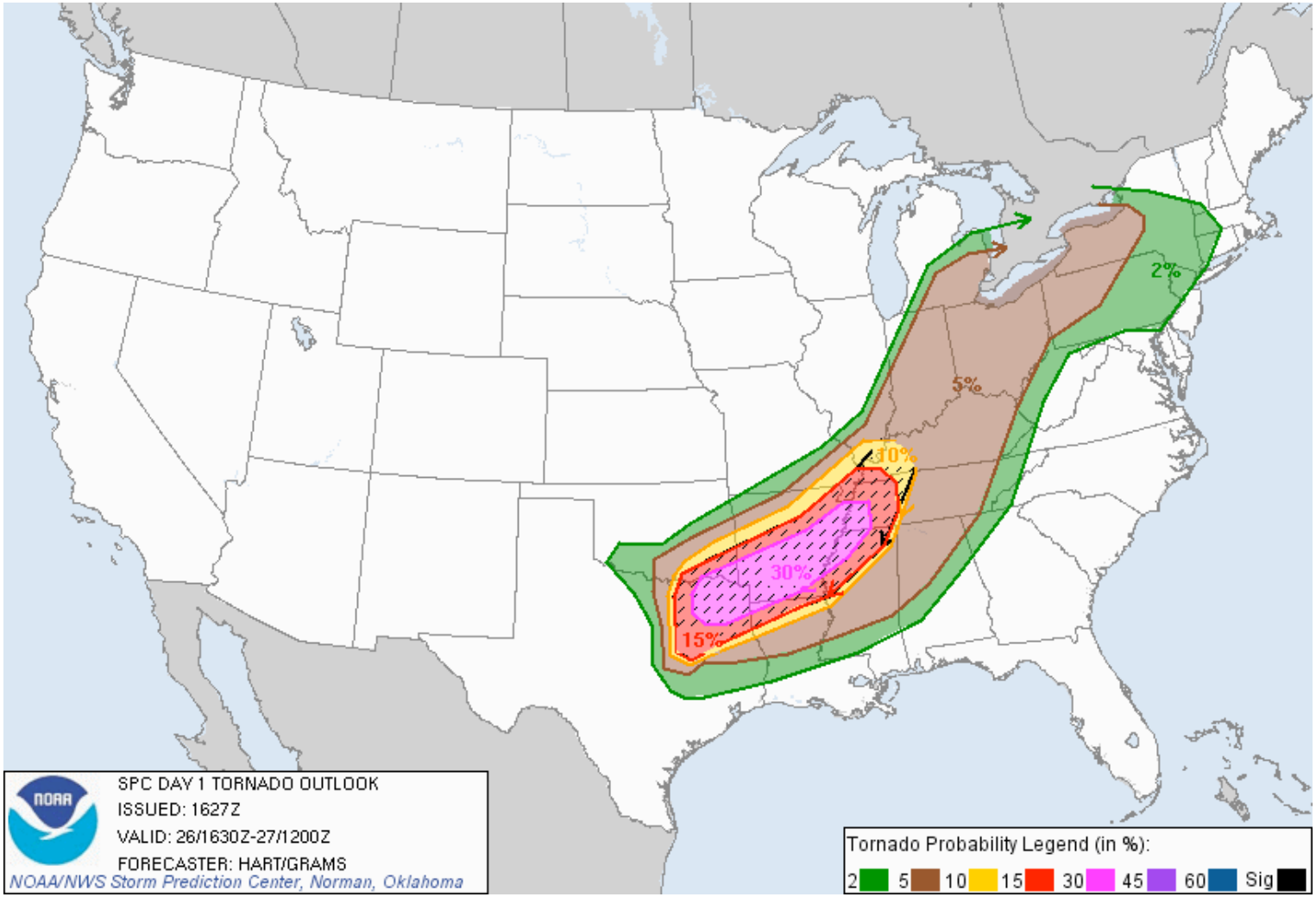
Michael K. Tippett[1], Adam H. Sobel[2,3] and Suzana J. Camargo[3]

[1] International Research Institute for Climate and Society, Columbia University, Palisades, NY
[2] Department of Applied Physics and Applied Mathematics and Department of Earth and Environmental Sciences, Columbia University, New York, NY
[3] Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY

Motivation


PRELIMINARY SEVERE WEATHER
REPORT DATABASE (ROUGH LOG)
NOAA/Storm Prediction Center Norman, Oklahoma
Tornado Reports
April 01, 2011 - April 30, 2011
Updated: Wednesday May 04, 2011 12:22 CT

Useful knowledge of the relations between large-scale environmental parameters and tornado activity



April 26, 2011 16:30Z

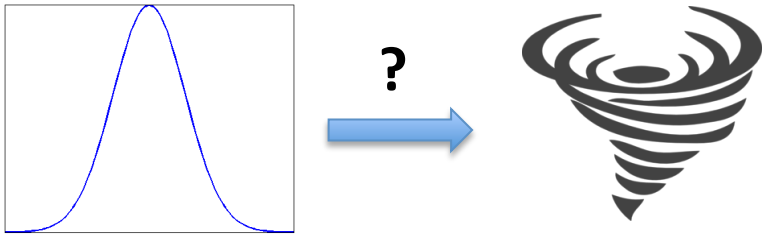
Many questions about the connection between climate and tornadoes

- "Tornado Season Intensifies, Without Clear Scientific Consensus on Why" -- NY Times, April 25, 2011.
- *"The co-variability of 20 severe spring (March-May) tornado outbreaks over the contiguous US and phases of the El Niño/Southern Oscillation (ENSO) during the past 100 years presents a complicated picture of the historical relationships."* -- NOAA/ERSL Climate Attribution Rapid Response Team
- outside the work of Harold Brooks … , *"Not much research has been done on climate change effects on middle latitude severe weather*." -- Kerry Emanuel

Basic Questions

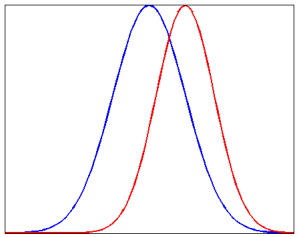
- To what extent do environmental parameters explain tornado activity?

Does the distribution of environmental parameters during a month determine tornado activity?



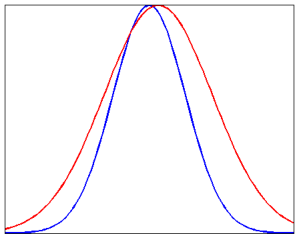
- What makes one month more active than another?

Changes in mean?



Easier?

Changes in spread?



Harder?

Outline

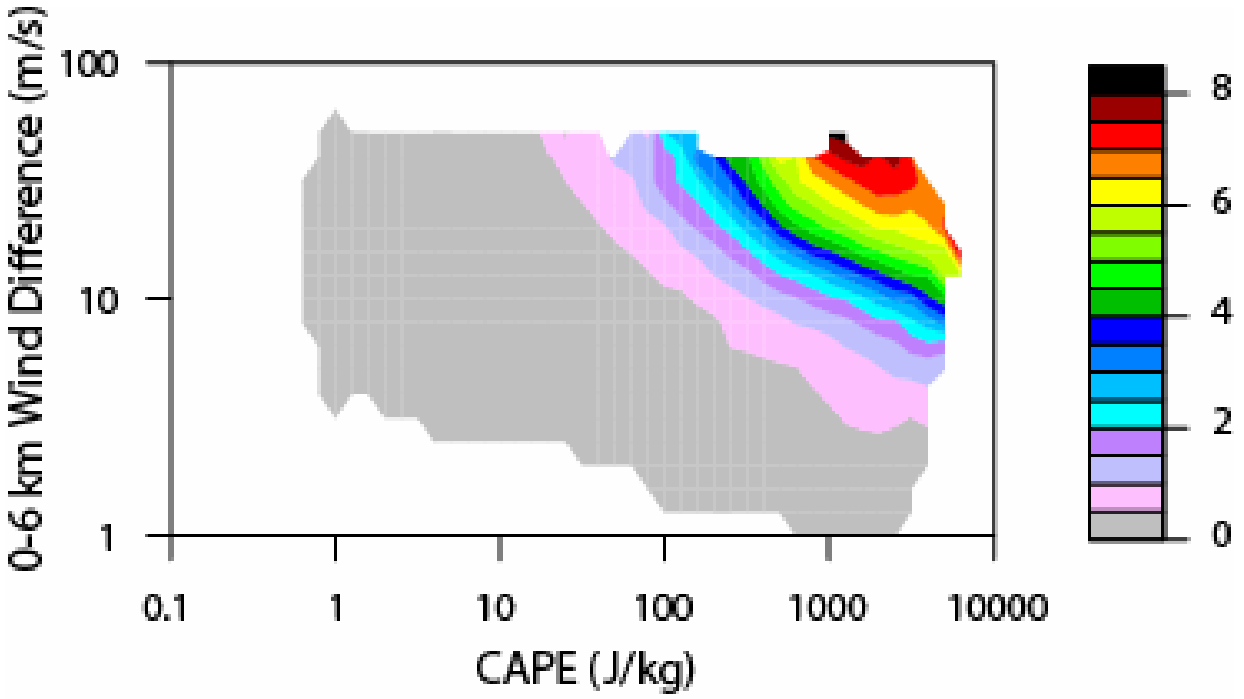
- Tornadoes and local environment
  - Daily/hourly
    - Soundings
    - Reanalysis
  - Monthly time-scales
- Tropical cyclone genesis index methodology
- Preliminary results with a tornado index

What are the important environmental conditions?

- Instability, updrafts
- Shear

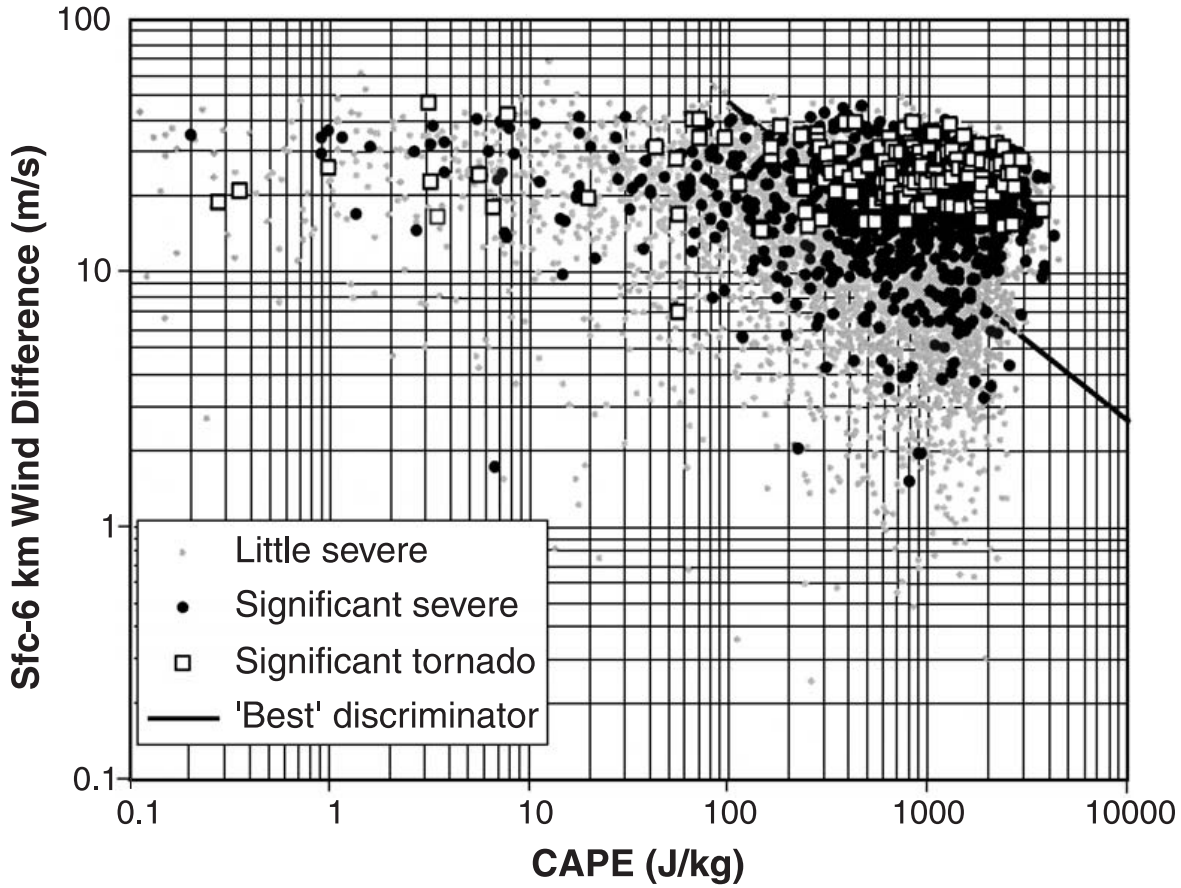
Many potential parameters.

Probability of severe thunderstorm with F2 tornado, 5cm hail, or 120 km/h wind gusts



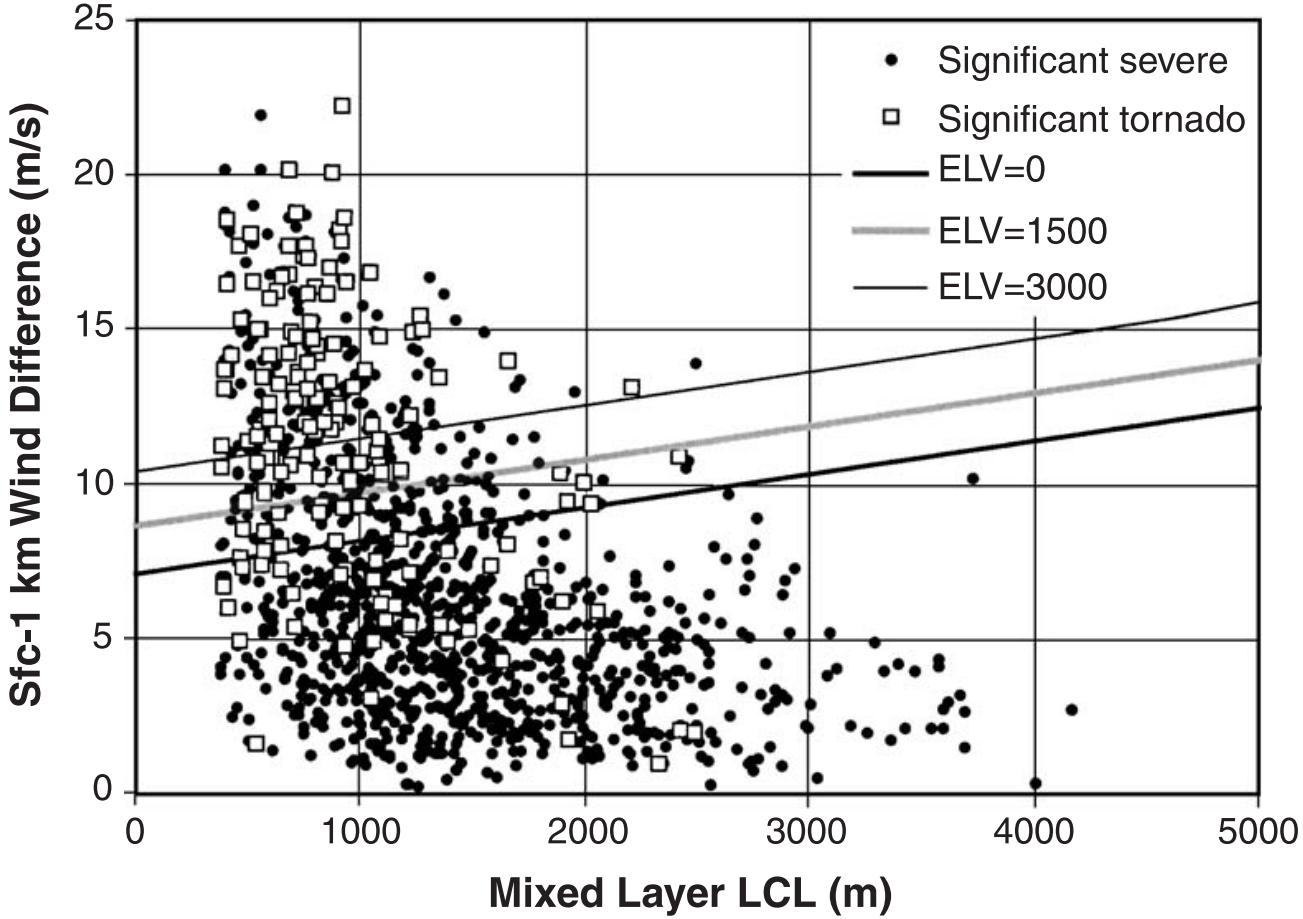
Significant severe parameter (Craven and Brooks, 2004)
CAPE x 0-6 km Shear > 10,000 $m^3 s^{-3}$
Figure from Brooks and Dotzek (2008)

NCEP/NCAR 6-h reanalysis environmental parameters near severe thunderstorms 1997-1999



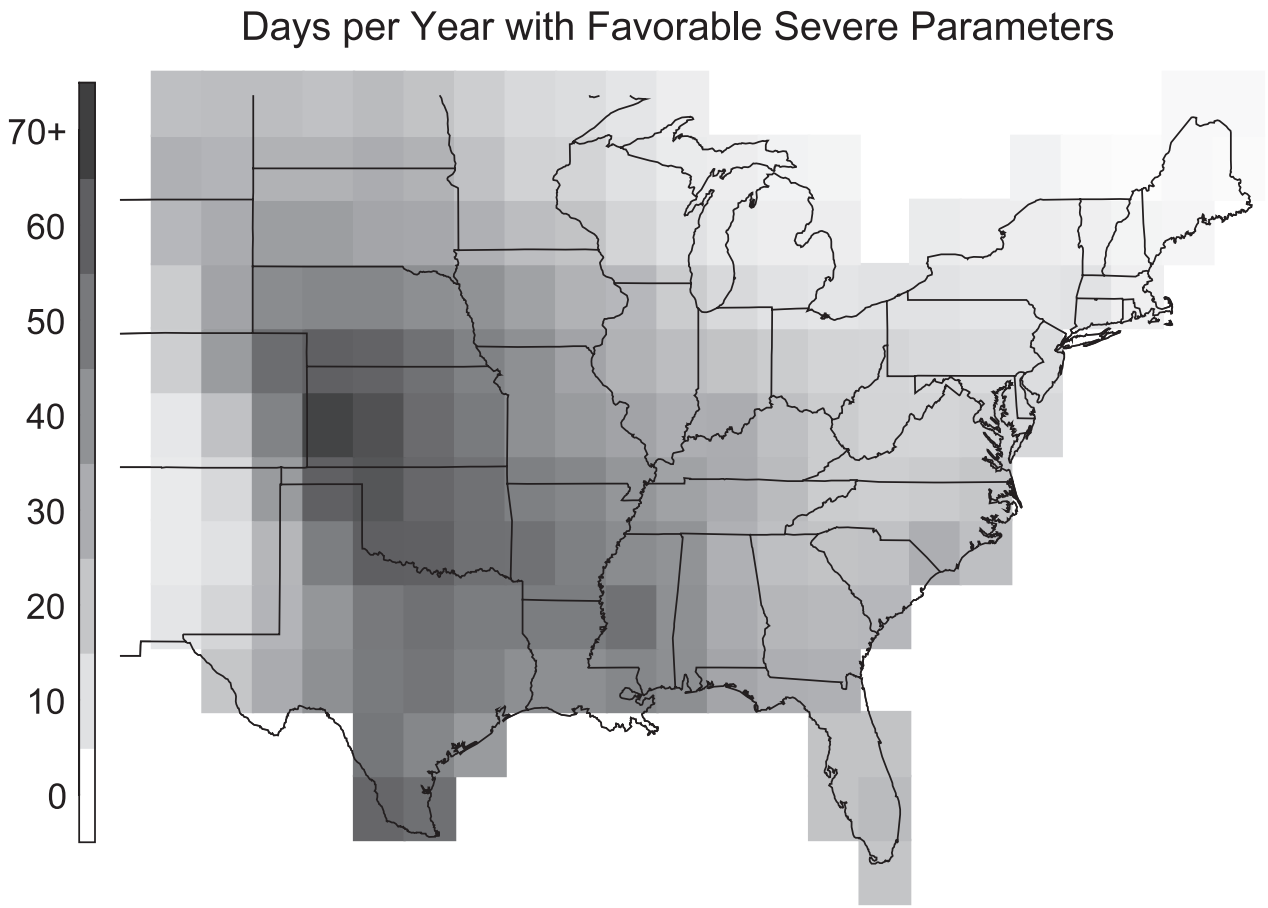
(Brooks et al. 2003)

Sfc-1 km shear and mixed layer lifted condensation layer distinguish between significant tornadic and non-tornadic



(Brooks et al 2003)

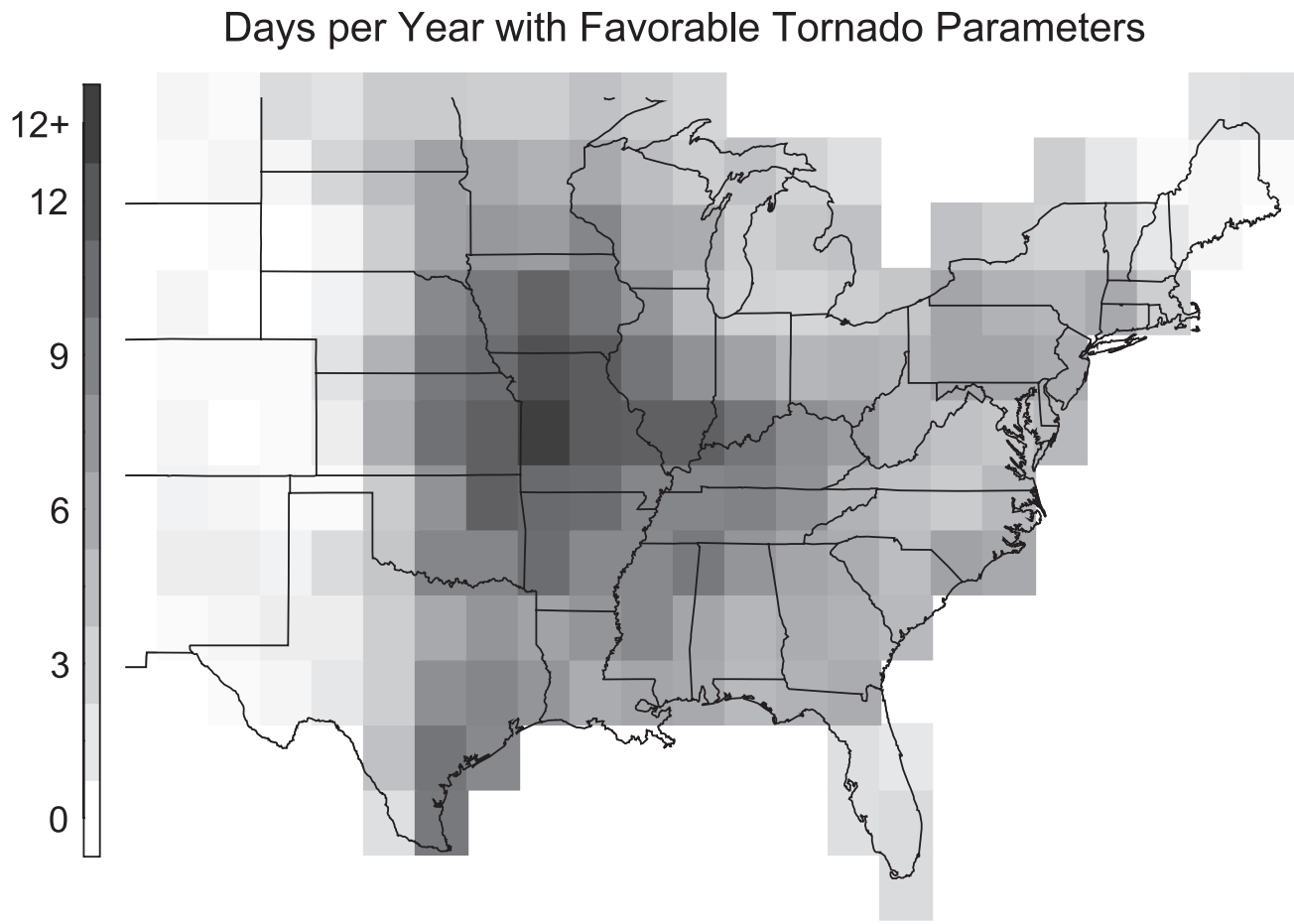
CAPE + Shear(deep, lower) + LCL



6-hourly reanalysis

(Brooks et al 2003)

CAPE + Shear(deep, lower) + LCL



6-hourly reanalysis

(Brooks et al 2003)

Monthly time-scales

- Are *monthly means* of environmental parameters related to monthly tornado activity?
- Large-scale climate phenomena likely to modulate monthly means.
- Path to extended-range prediction.

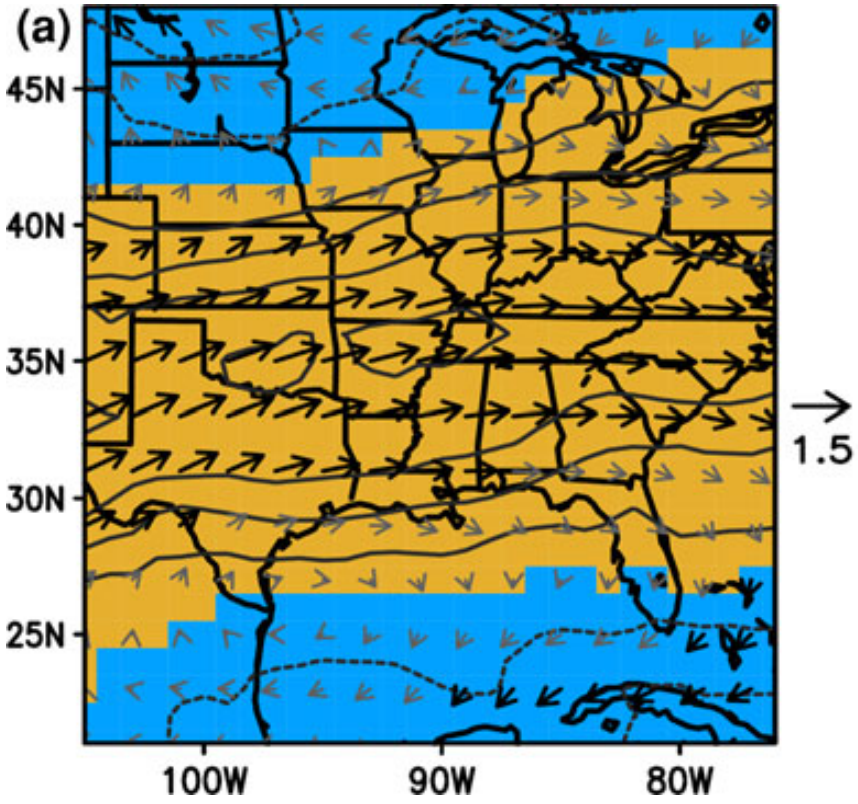
Large-scale climate phenomena potentially modulating monthly tornado activity

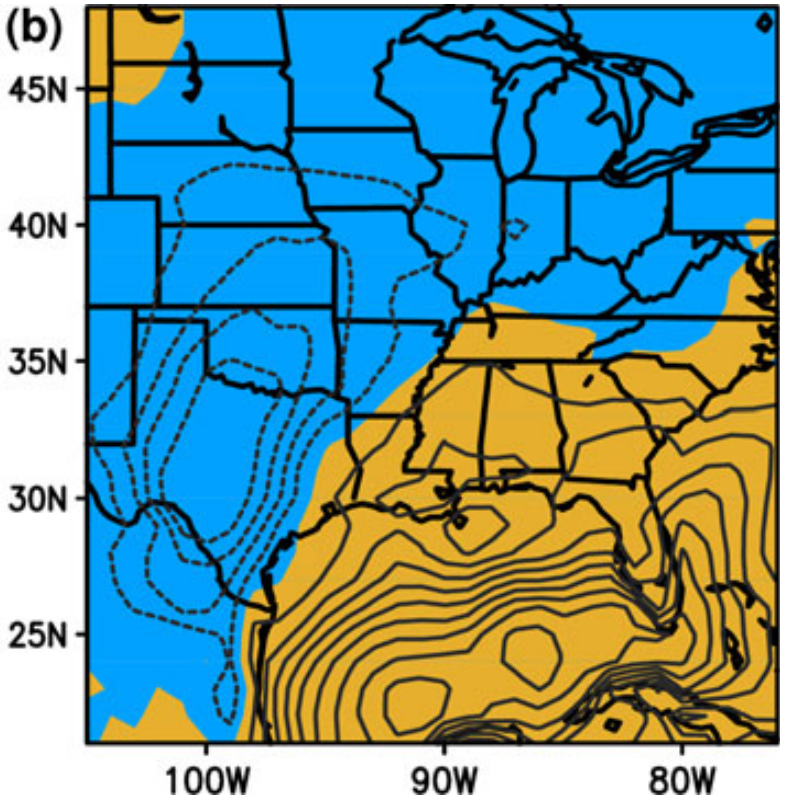
- Precipitation (Galway, 1979)
- Greenhouse gas forcing (Trapp et al., 2007)
- ENSO in winter. (Cook & Schaefer, 2008)
- Antecedent drought (Shepherd et al., 2009)
- IAS April-May (Muñoz et al., 2011)

Regression of shear and CAPE onto an April-May tornado index (1979-2006)

Shear

CAPE

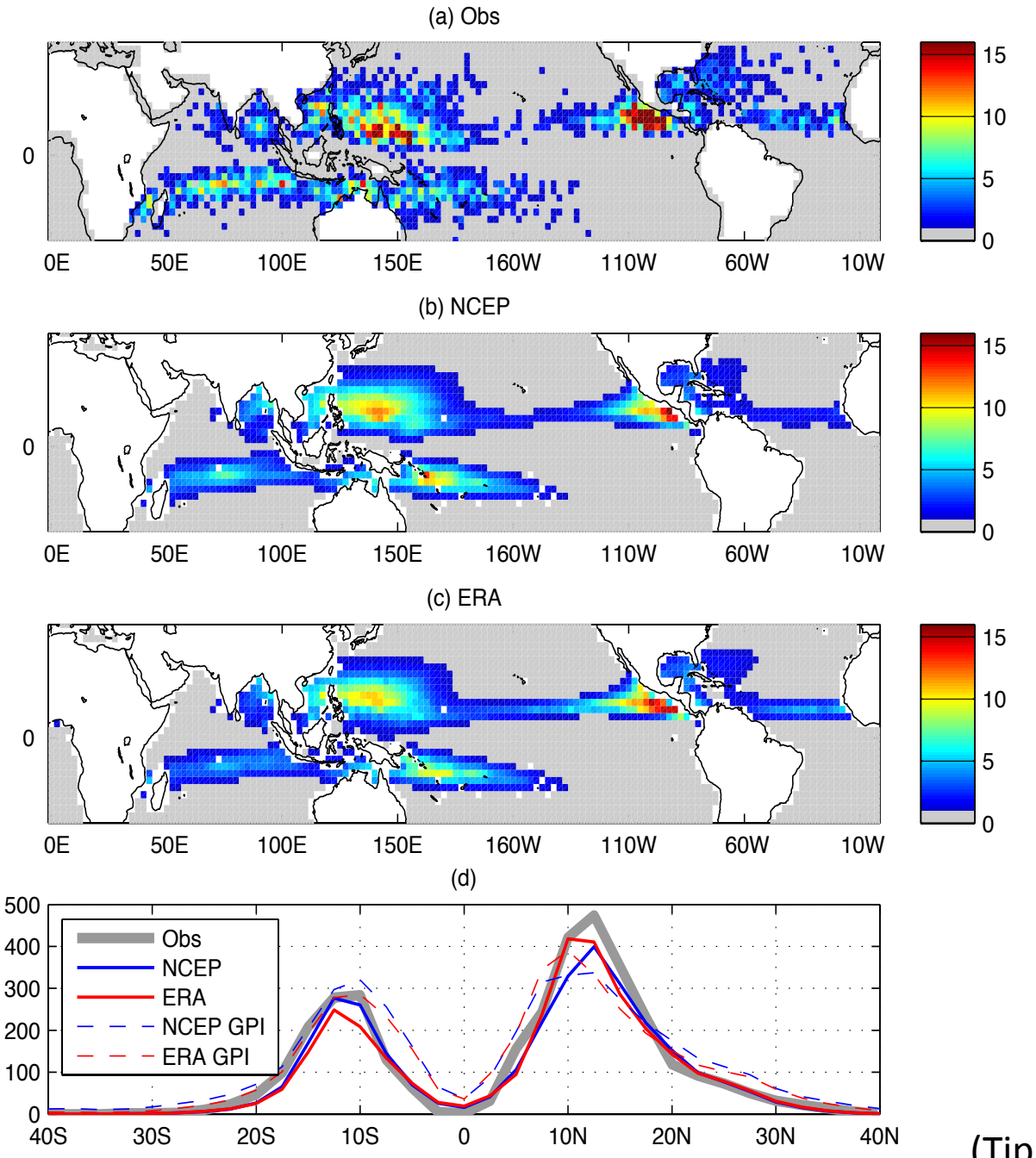




Muñoz et. al 2011

Methodology from tropical cyclones

- TC genesis index (Gray 1979).
- Genesis index = function of the local environment
  - Monthly values of
    - SST
    - Shear
    - Humidity
    - Vorticity
- Climatological distributions, interannual variability, climate projections.



(Tippett et al., 2011)

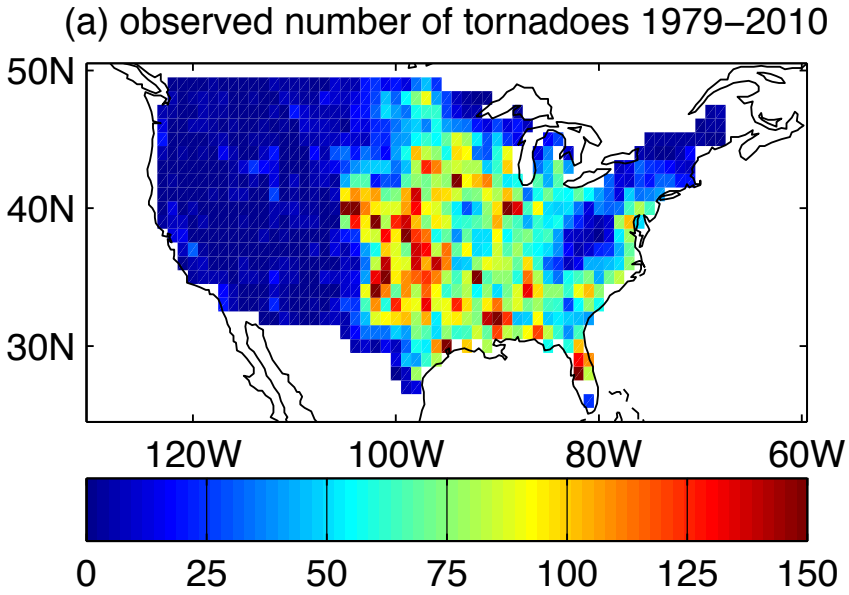
Apply TC index methodology to monthly tornado counts

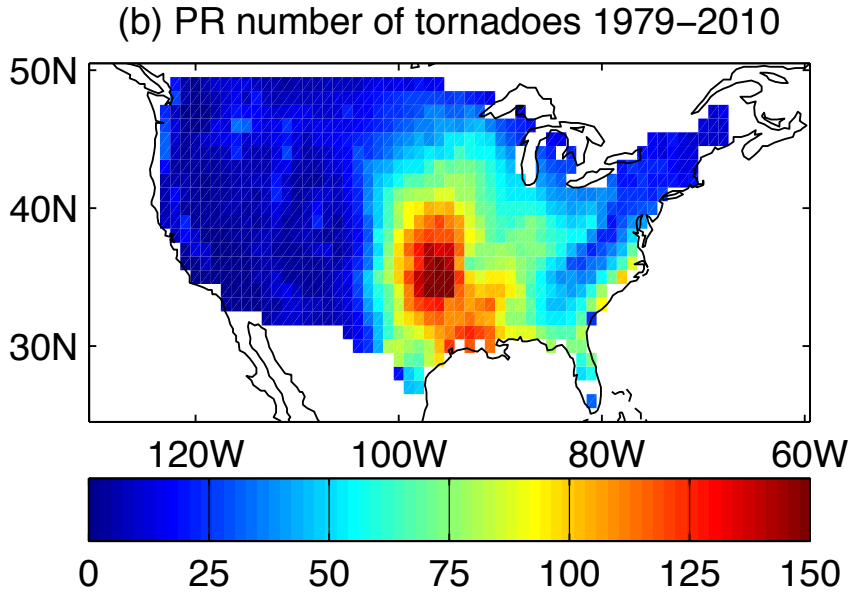
- Index = function(constants x environmental parameters)
- Parameters = CAPE, CIN, lifted index, lapse rate, mixing ratio, SRH, vertical shear, precipitation, convective precipitation and elevation
- Estimate constants from observed *climatology*
  - Same index at all (U.S.) locations, all months of year
  - NARR data 1x1 degree grid
  - SPC Tornado, Hail, and Wind Database. 1979-2010.
  - ***All*** tornadoes (>F0).

How well does the index capture the climatology?

Observations

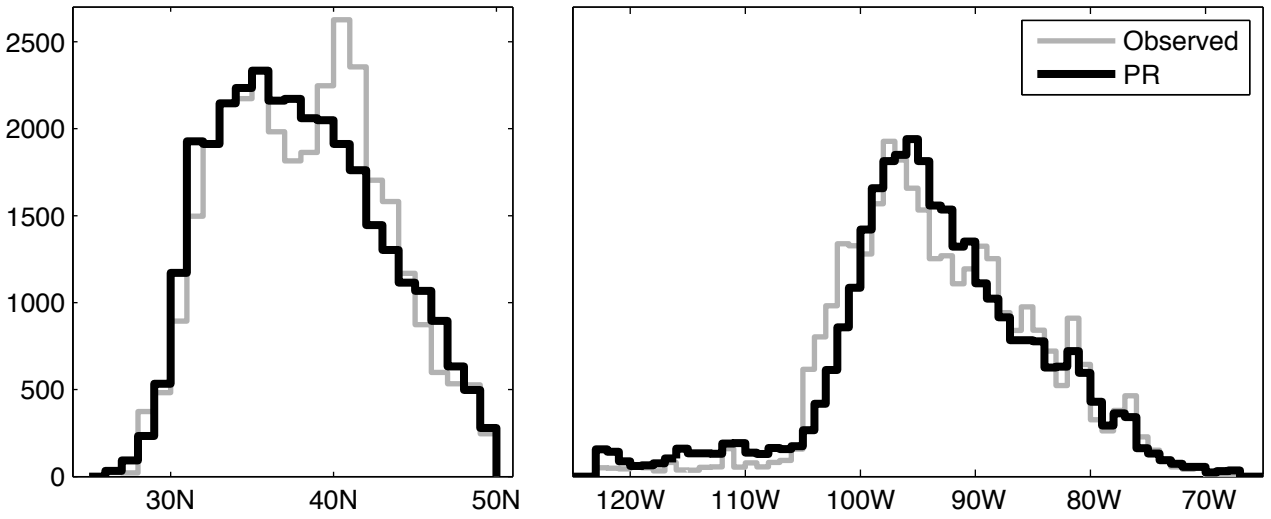
Index





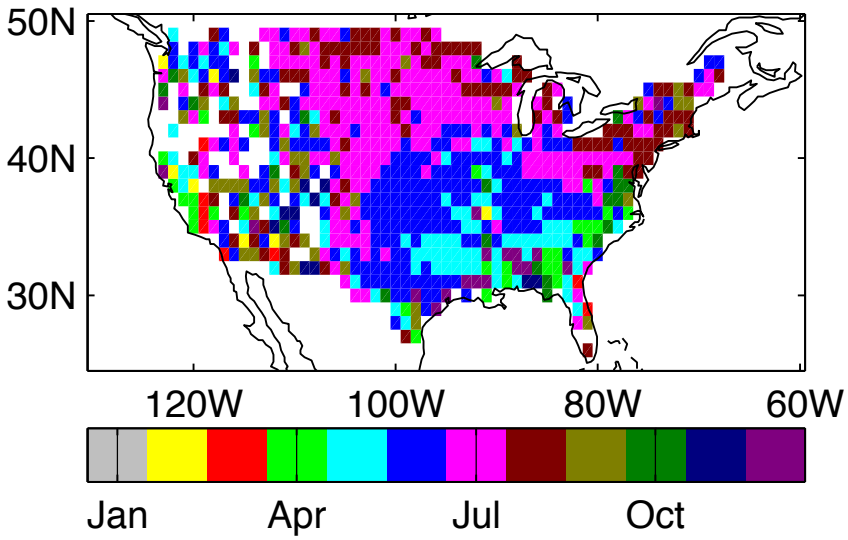
Obs.

Index

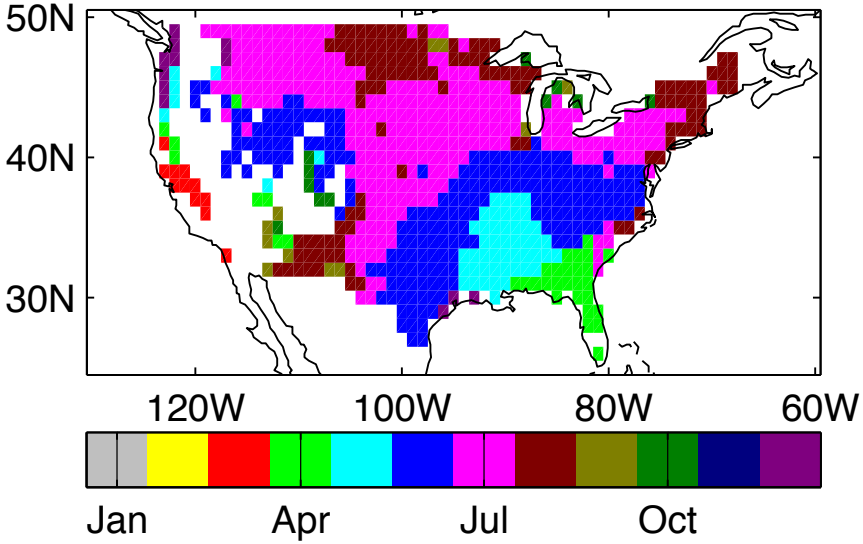


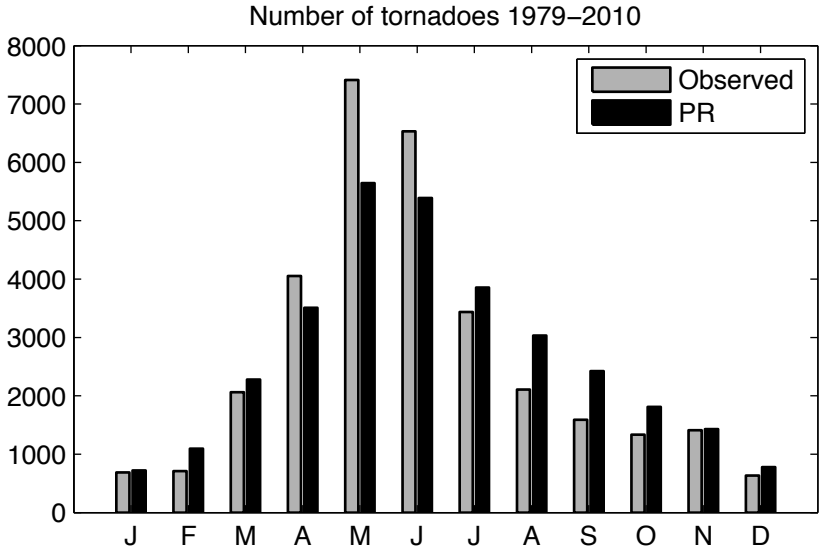
Month of Maximum Activity

Observations



Index





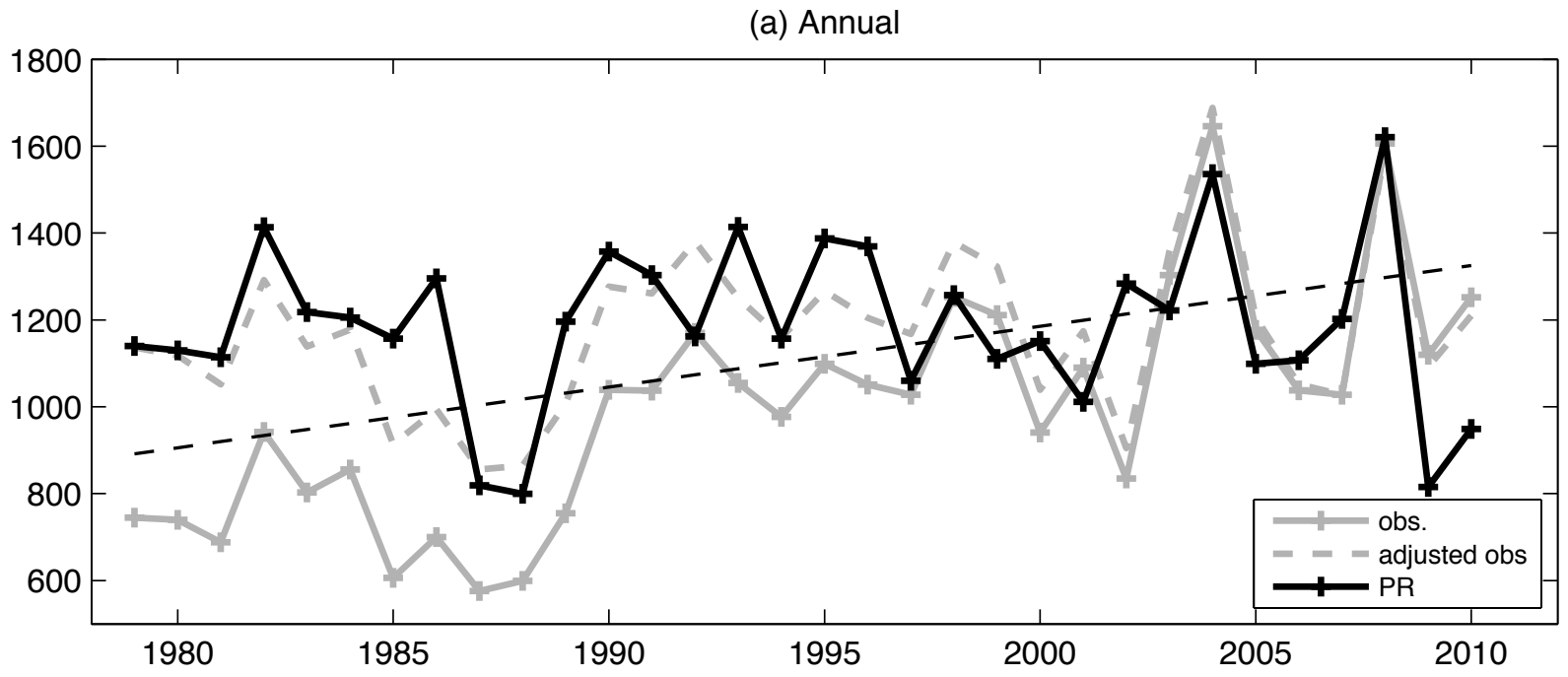
Annual Cycle

Does the index capture interannual variability?

Interannual variability

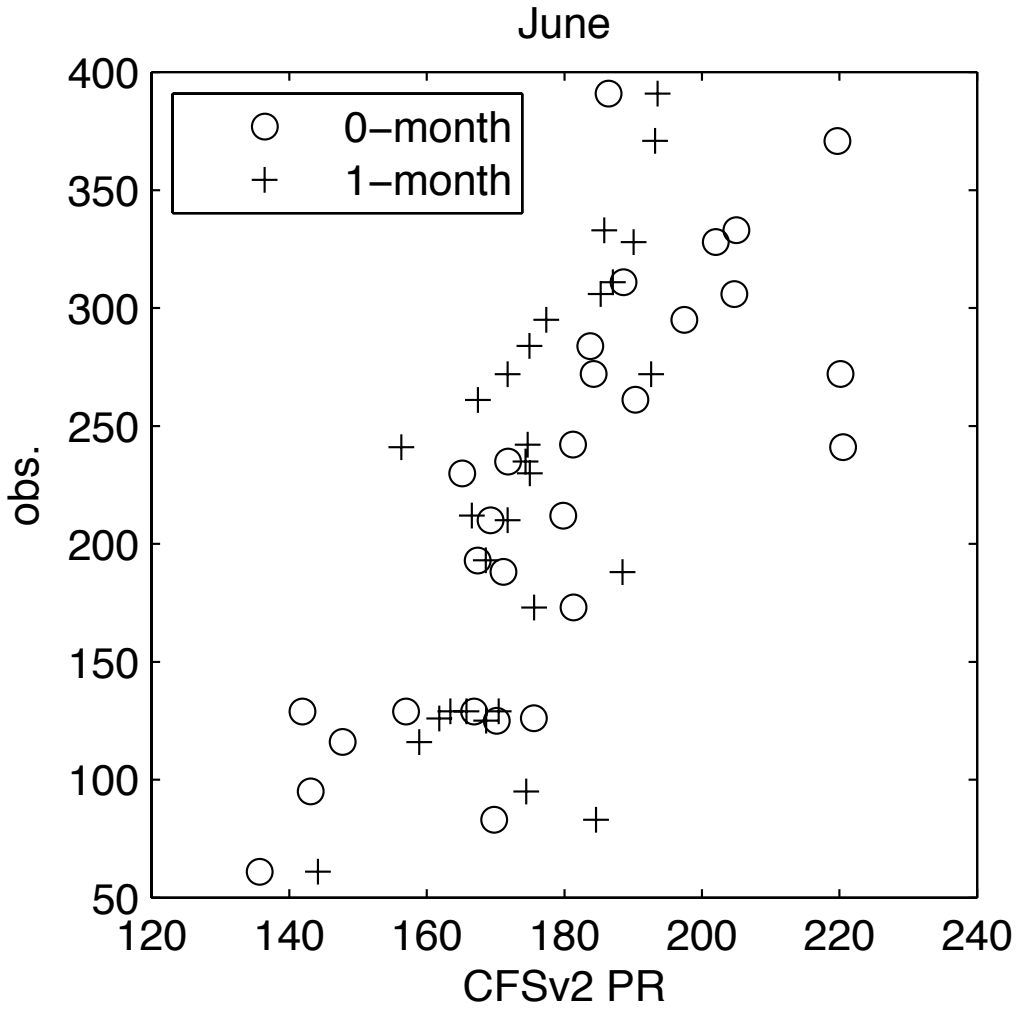
Correlation between index and observed number

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.75	0.64	0.54	0.50	0.60	0.67	0.75	0.40	0.15	0.25	0.48	0.74



Conclusions

- Some association between environmental parameters and tornado activity on monthly time-scales.
  - Climatological variability
  - Interannual variability
- Tornado “index” is a potential useful tool for:
  - Attributing observed variability
  - Extended-range prediction
  - Climate projections


June
0–month
1–month
obs.
CFSv2 PR
400
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