# Attribution of interannual variations in tornado occurrence to regional atmospheric circulations

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## Motivating questions

- What is the regional variation in interannual tornado occurrence?
- How do these variations in occurrence relate to variations in the atmospheric state?
  - explanations for 2011 tornadic activity
  - explicit consideration of "local," rather than "remote" forcing

## Tornado occurrence: Temporal

- Derives from local storm reports
  - Caveats (population bias, reporting procedures, etc.)
- Interannual variations presented through total reports/yr in U.S.



#### Tornado occurrence: Temporal

- Interannual variations presented through total days/yr over the U.S.
  - not always the same perspective...
- What is the *regional* manifestations of these variations?



## Tornado occurrence: Spatial

## Following Brooks et al. (2003, *WAF*)

- consider tornado days within grid boxes
  - NARR (221) grid (~32 km)
  - 1980-2009 (*N*=30)
- apply temporal and spatial smoothing (Gaussian Kernel)

#### Mean annual tornado



#### Tornado occurrence <u>anomalies</u>

- Compute anomalies:  $x' = x_{yr} - x_{mean}$ 
  - for *yr* = 2011
  - mean from 1980-2009
    (N=30)





## Tornado occurrence <u>anomalies</u>

- for *yr* = 1987
- 30-yr mean excludes year of analysis

Anomaly for 1987



#### Tornado occurrence <u>anomalies</u>

- for *yr* = 2004
- The distribution is different
- Take-home-point #1
  - the regional contributions to the total activity varies from year to year...

#### Anomaly for 2004





#### Relation to anomalies in atmospheric state variables

- Determine monthly anomalies in relevant state variables and associated parameters
  - not a synoptic composite associated with individual events
  - Data source: NARR (North American Regional Reanalysis)
    - mean from 1980-2009, 2011 anomalies
- Quantify cross-correlation over regions, with focus here on southeast U.S.











*Take-home-point #2* 

Anomalies in regional atmospheric state correlate well with regional tornado occurrence anomalies in the U.S. in the case of April 2011...

#### Multiple linear regression model, preliminary results: 2011

Period/Region	Coefficient of determination (R <sup>2</sup> )
Apr/SE	0.64

predictor variables: soil, MSLP,  $q_{850}$ ,  $Z_{500}$ ,  $u_{300}$ ,  $v_{850}$ , SRH, CAPE

#### Seasonal outlooks?

 Consider the use of a global dynamical modeling system + statistical modeling
 NOAA Climate Prediction Center's CFS



Mean 850 mb v, from 1-month CFS (re) forecast, valid April 2011

#### Comments, issues, future work

- No explicit consideration of internal climate variability (e.g., ENSO)
  - We seek to understand "local" before "remote" forcing
  - However, knowledge/quantification of occurrence and atmospheric anomalies allows application of attribution techniques
    - internal climate variability as well as humaninfluenced radiative forcing...



#### Simulated Frequency of July Temperature Extremes

#### ACE (Attribution of Climate-related Extremes)

Use of ensemble of climate models run with different radiative forcings, perturbed SSTs, etc.

#### Comments, issues, future work

In principle, the methodology can be applied to other convective hazards

- Iocalized flooding, hail
- need sufficient data record

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