

Severe Weather Within The Context of Climate Change



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Sources of information for thunderstorms and climate



- Severe thunderstorm/tornado reports/observations
- Proxy observations (hail)

- Environmental conditions (ingredients)
 - Relationships between environments and events
 - Look locally at what conditions are

- Pattern analysis
 - Large-scale background for events
 - Probably better simulated/predicted by models

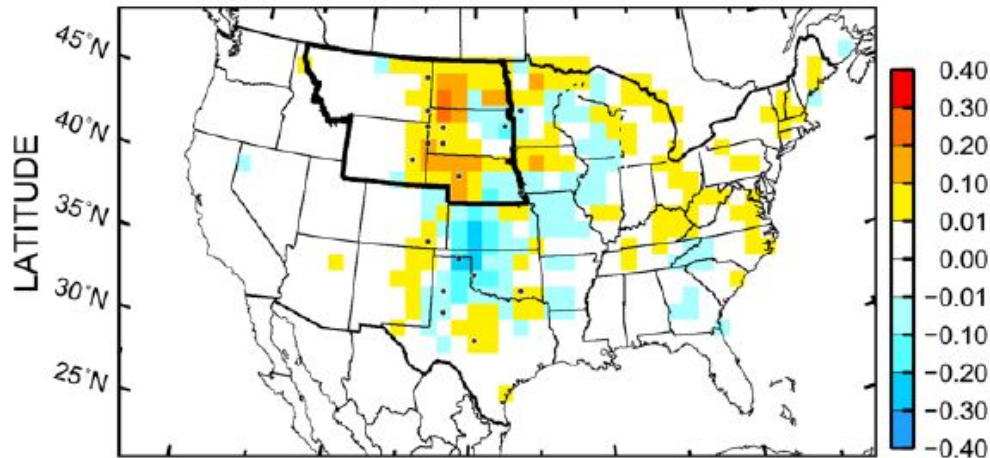
Use of environments



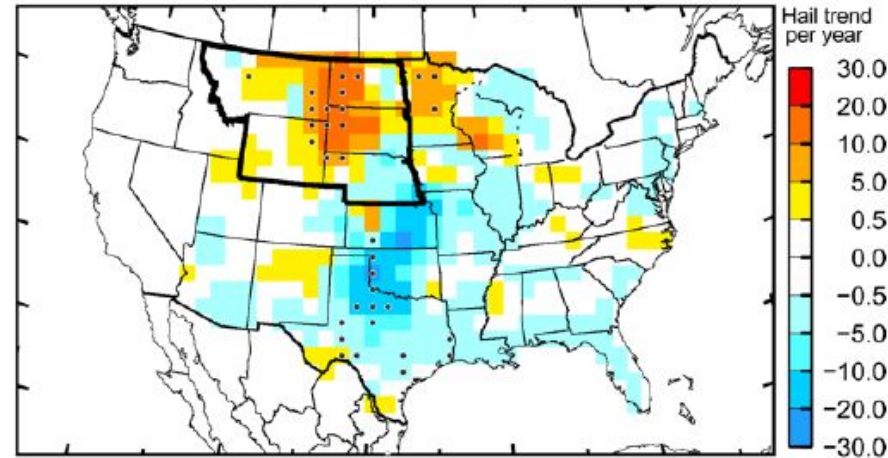
- Meteorological covariates for things we care about
 - Relationships biased to where we have reports
 - Initiation, mode?
- Soundings (proximity studies)
- Reanalysis (process into forecast model)
 - More complete coverage
 - Errors compared to observed?

Significant severe hail (2004-2016)

(a) Hail trend (hail report)

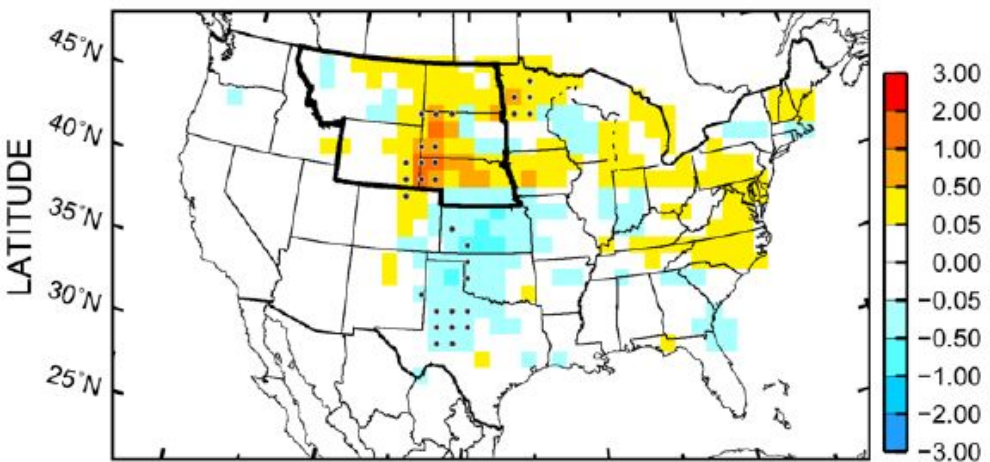


(b) Hail trend (MESH)

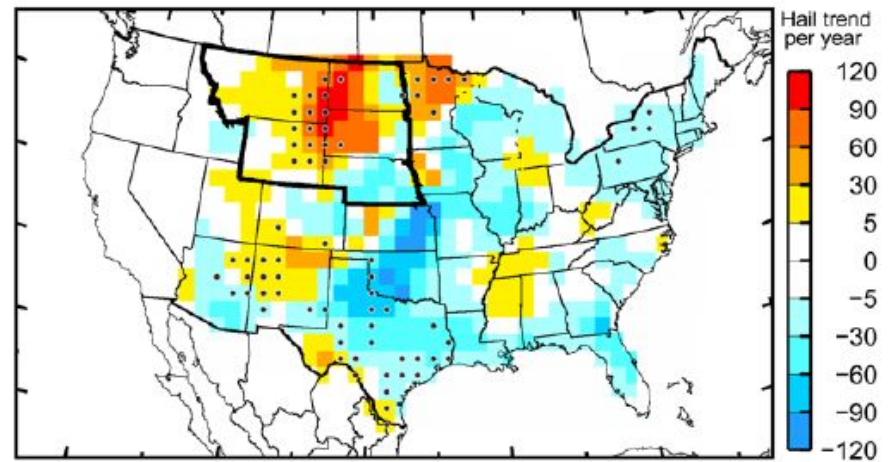


Severe hail (2004-2016)

(c) Hail trend (hail report)



(d) Hail trend (MESH)



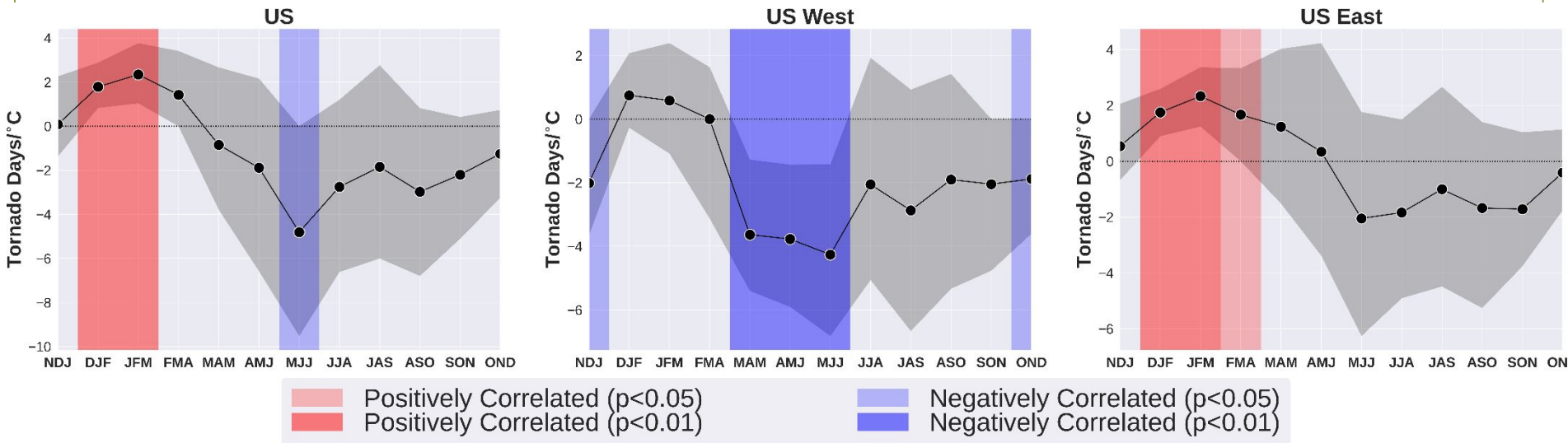
Jeong et al. (2021)

Regional Temperature Impacts on Tornadoes



- Warmer than normal (up)

- Fewer tornado days in summer, especially in west
- More tornado days in winter, especially in east



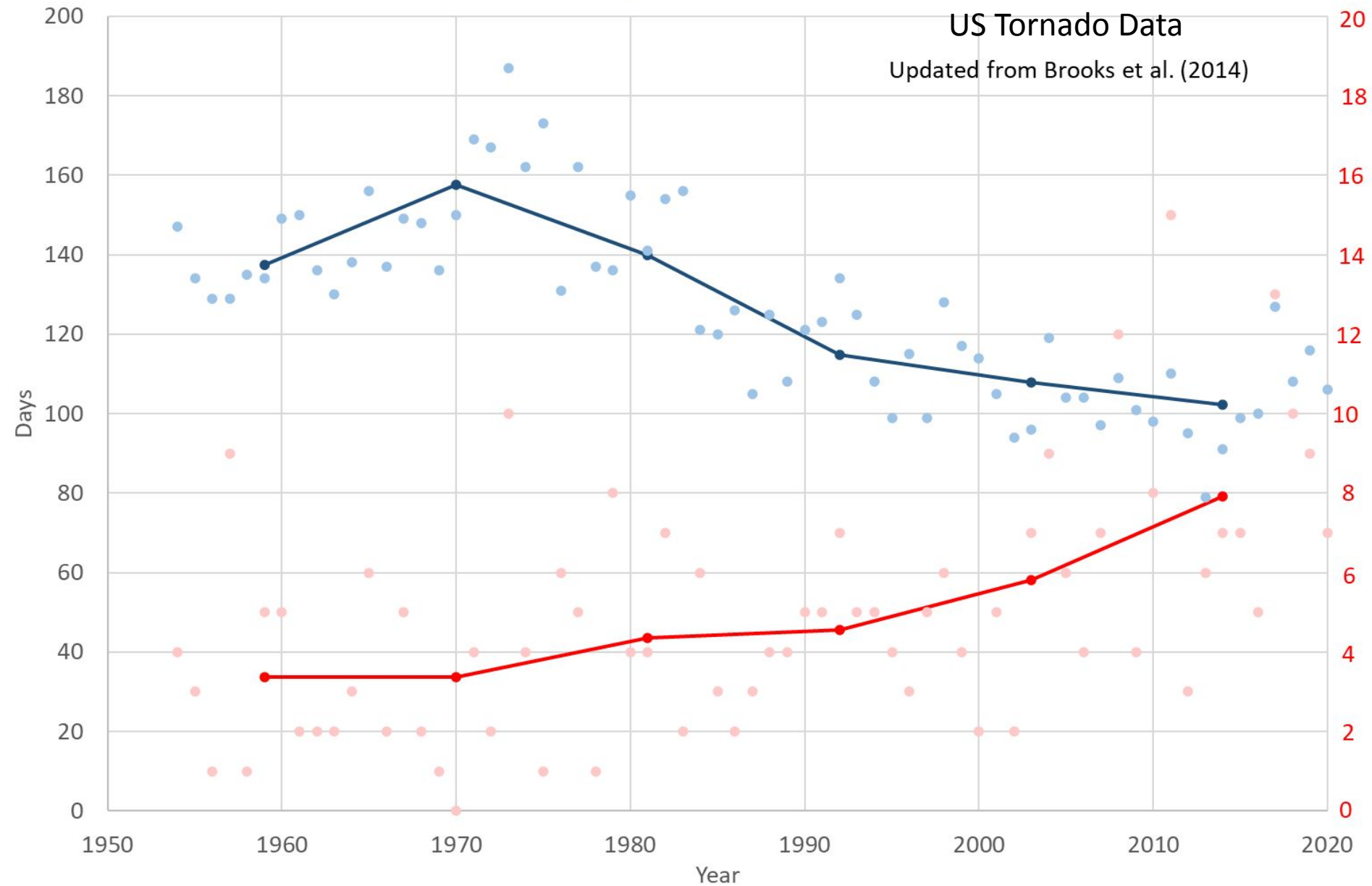
Running Three-Month Tornado Days

Days Per Year with at Least 1 (E)F1 Tornado

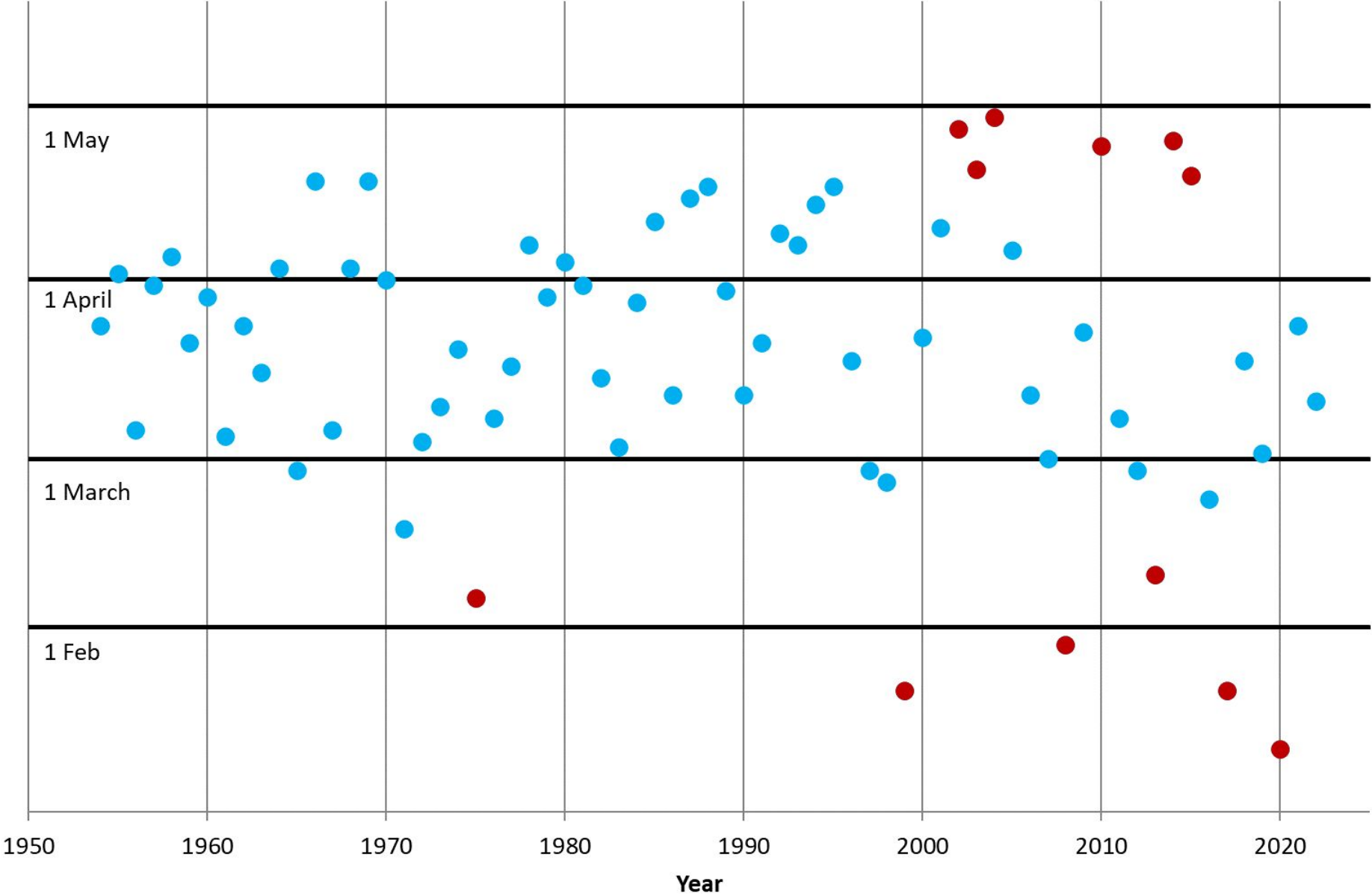
>15 (E)F1 Tornadoes

US Tornado Data

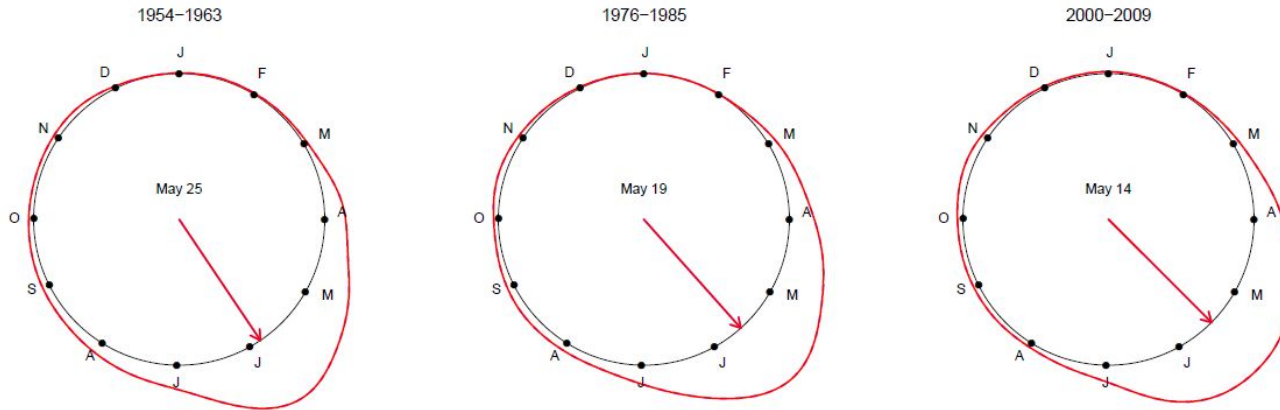
Updated from Brooks et al. (2014)



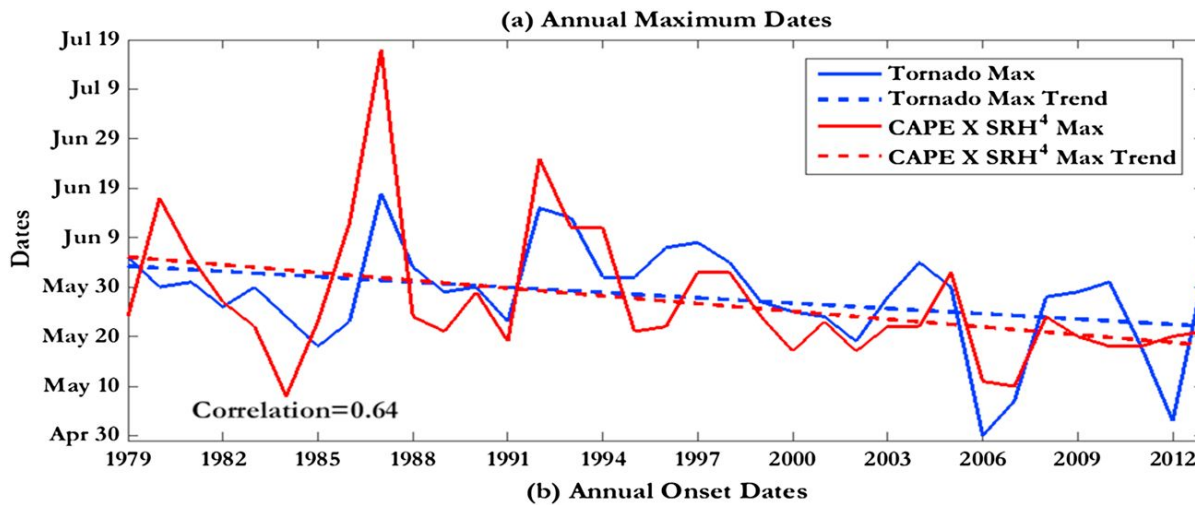
Date of 50th [E]F1+ Tornado (Red=10% earliest/latest)



Timing of tornadoes (TX-NE)



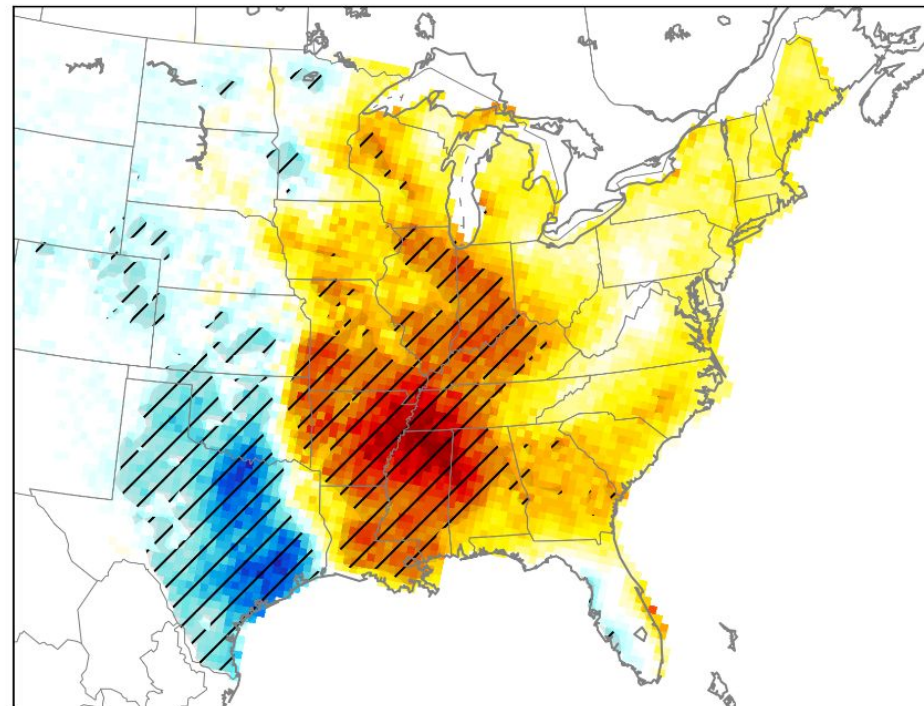
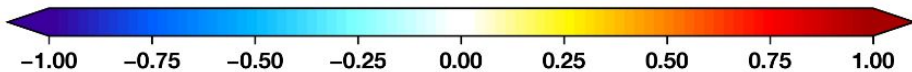
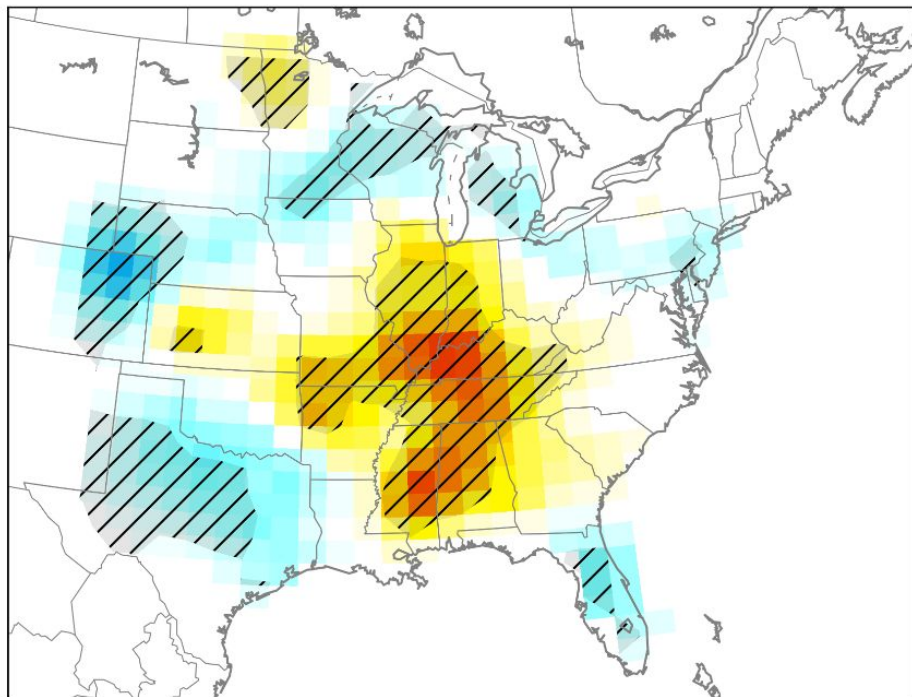
Long and Stoy (2014)



Liu et al. (2015)

Changes in tornado occurrence (1979-2016)

Reports (left) Favorable Environments (right)



Gensini and Brooks (2018)

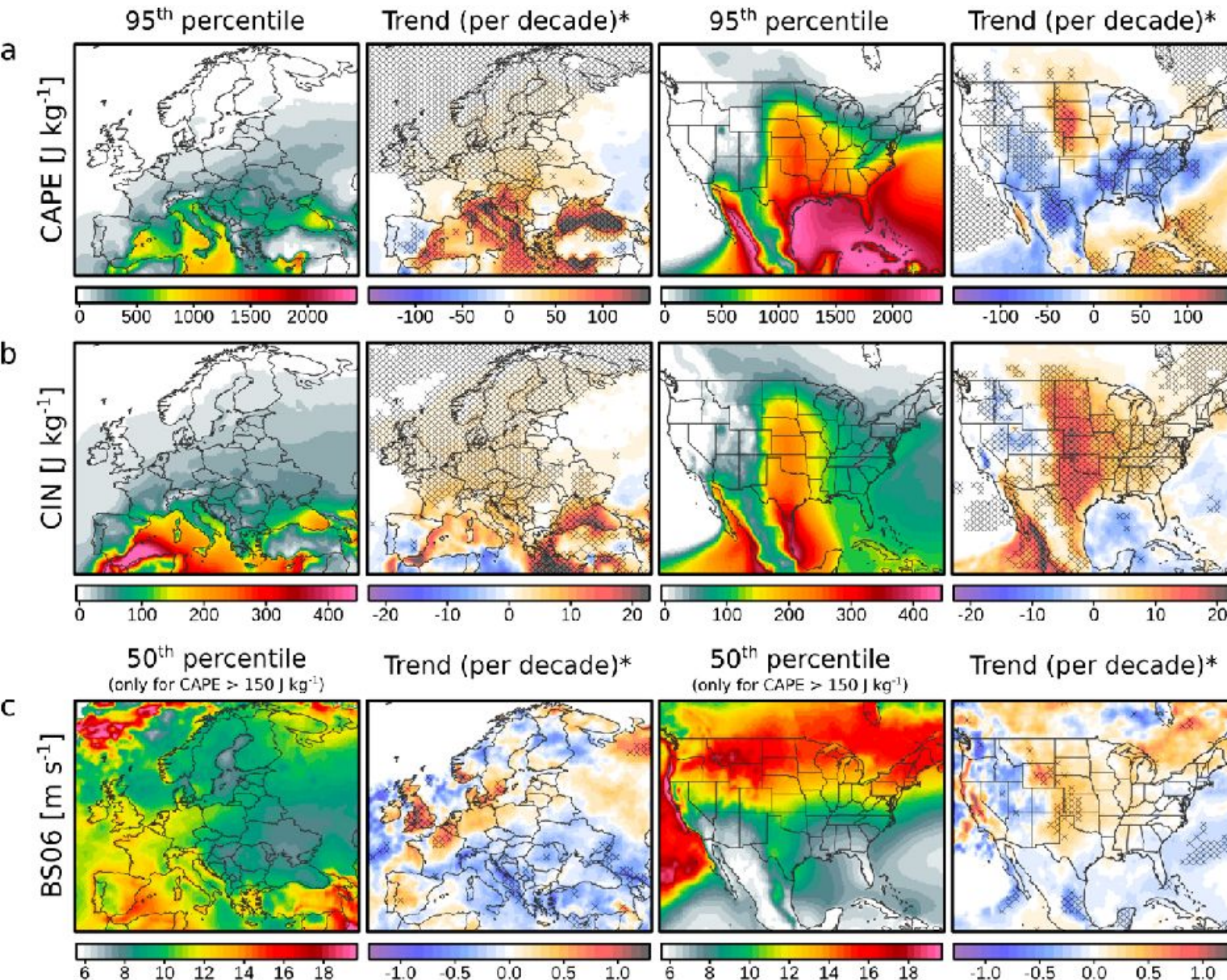
Environmental changes



- Naïve mean changes with warming
 - CAPE increase
 - Tropospheric wind shear decreases (thermal wind)
 - Initiation? (CIN, convective precip)
 - Other parameters????

- Care about combinations

ERA5 (1979-“present”)



Inhibition

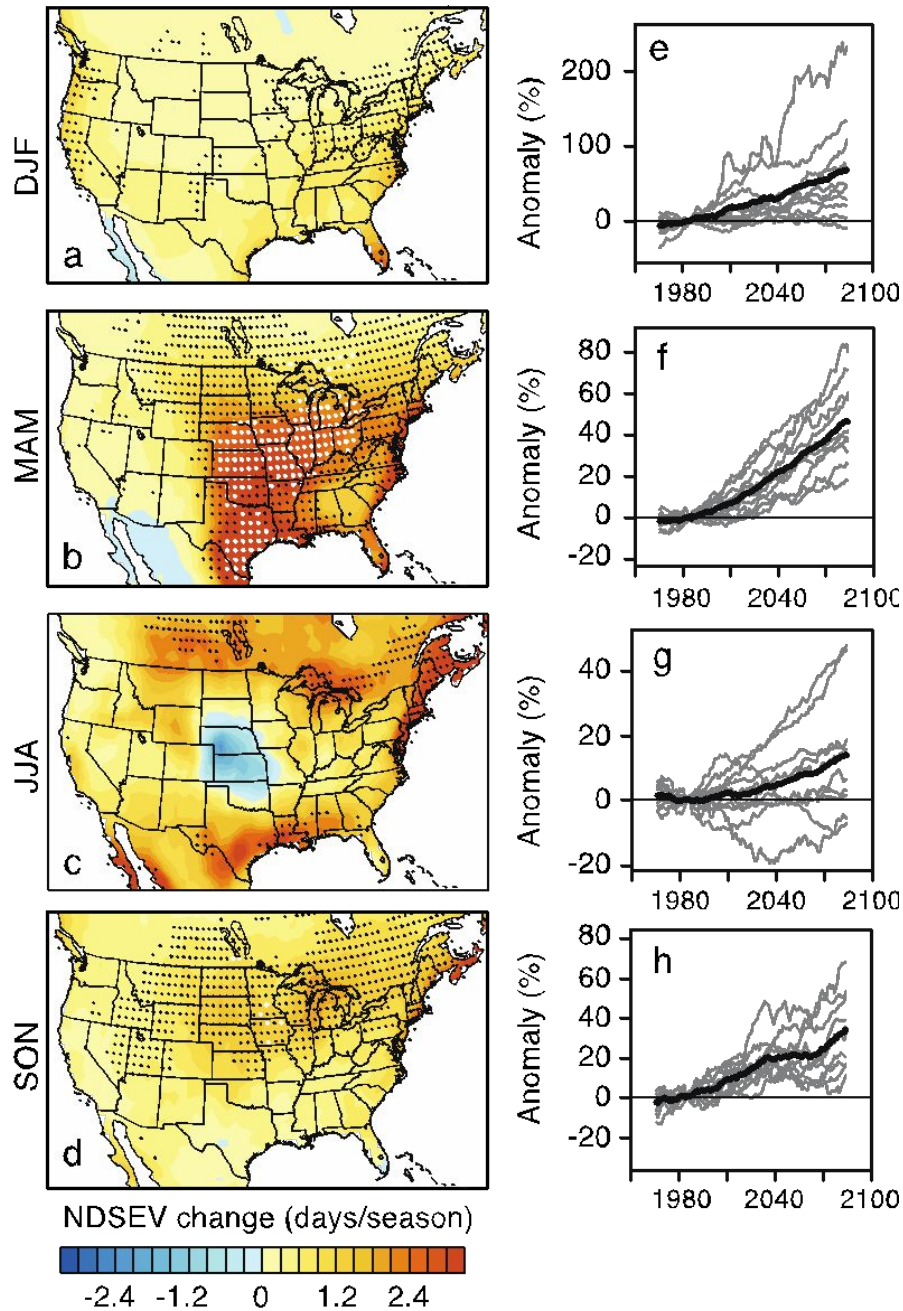
Taszarek et al
(2021)

Climate models look ahead



- Climate models
 - Environments
 - Severe storm proxies from convection-allowing models

Favorable Severe Storm Environments



Black dots:

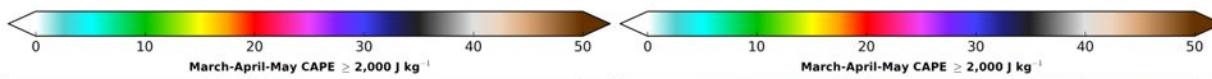
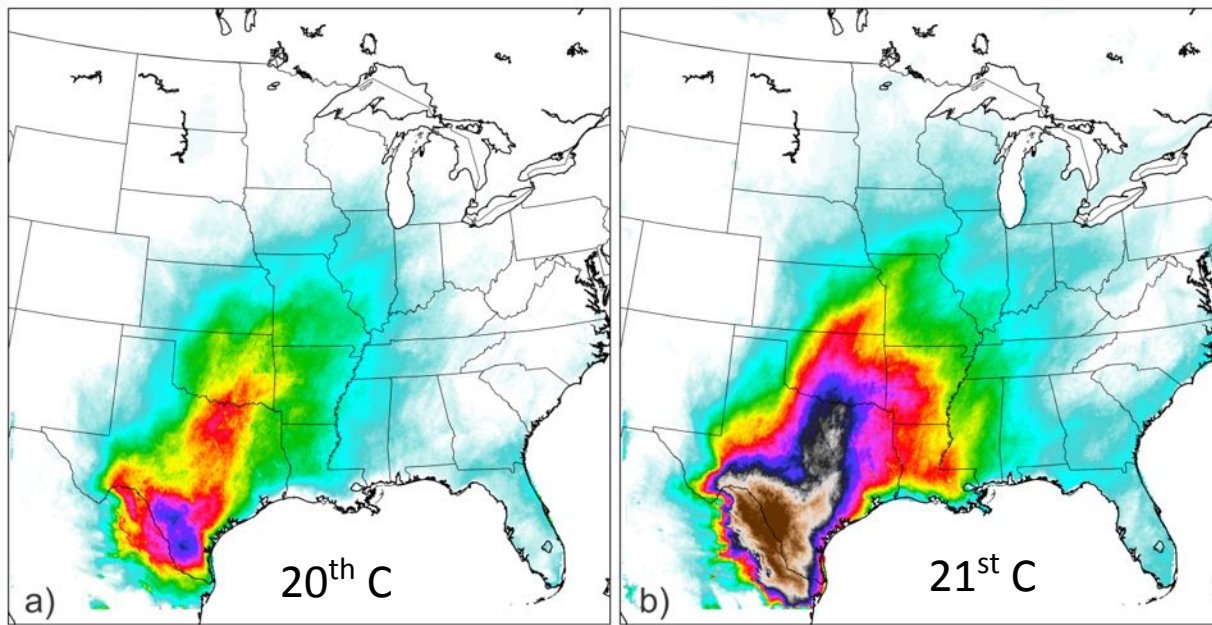
Ensemble S/N > 1

White dots:

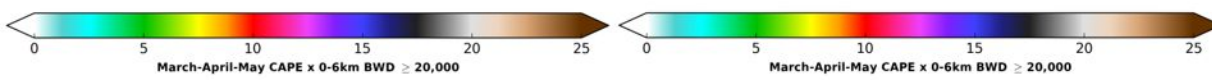
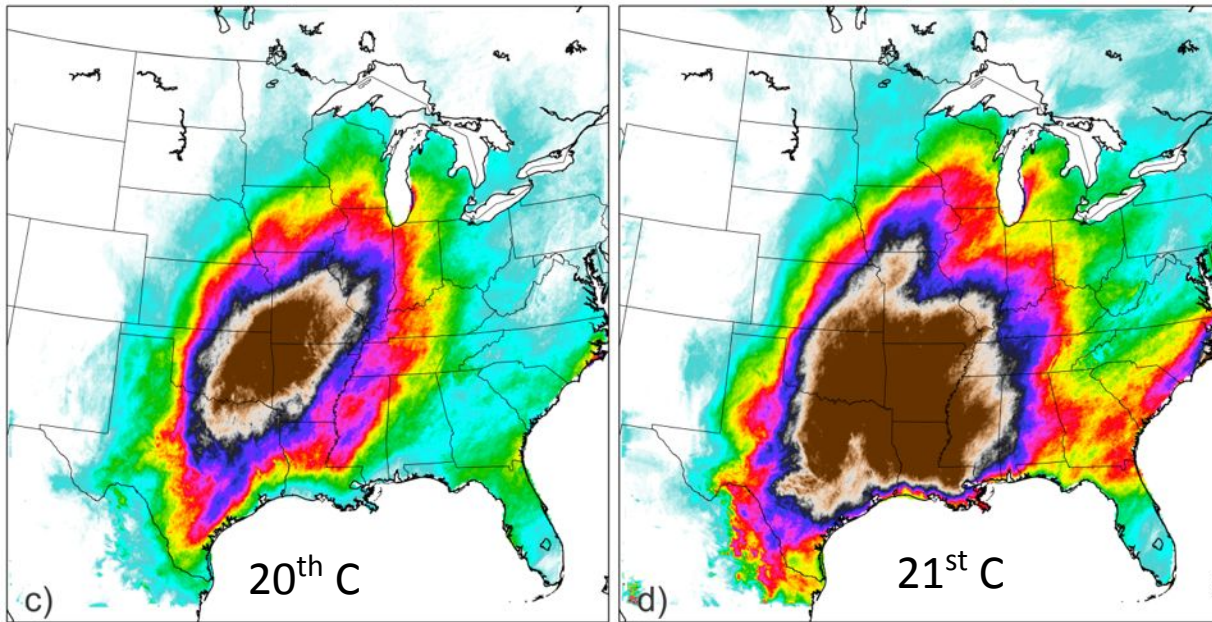
Ensemble S/N > 2

Convective Parameter Climate Model Changes Spring

CAPE>2000

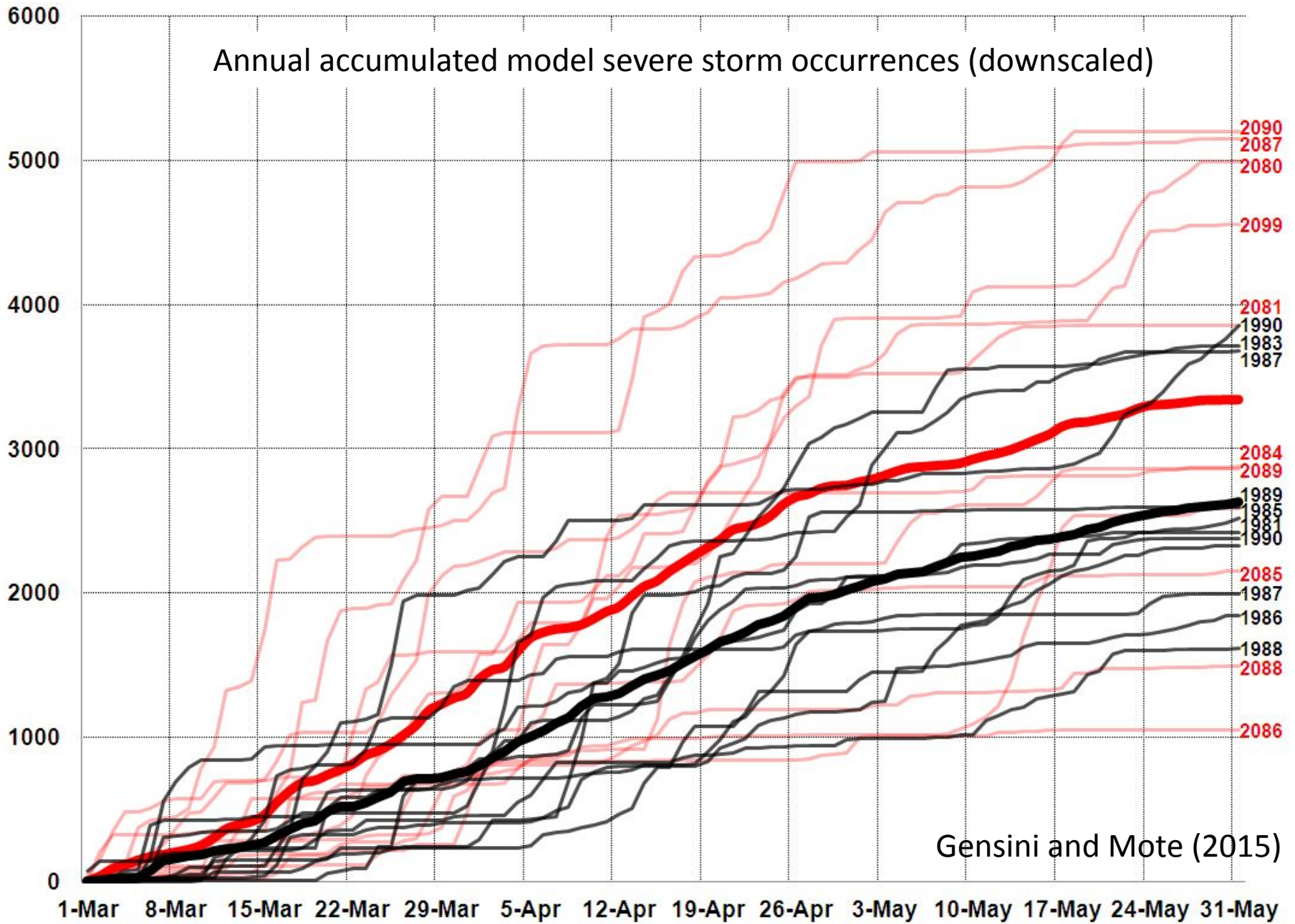


CAPE*Shear>20,000



Gensini and Mote (2015)

Annual accumulated model severe storm occurrences (downscaled)



Gensini and Mote (2015)

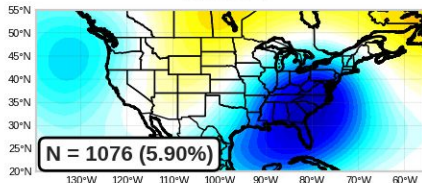
Patterns



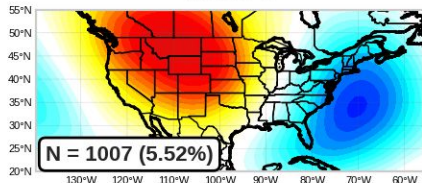
- Find typical “weather maps” and relationship to storms

500hPa Height Std. Anomaly SOM Patterns

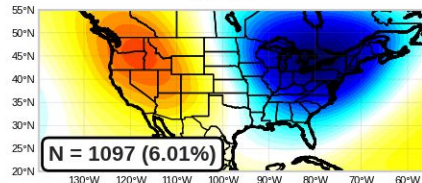
Node 1



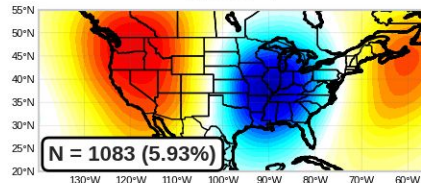
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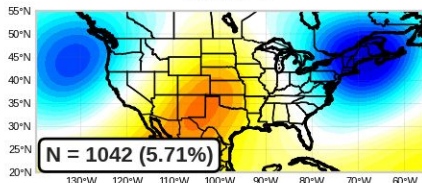
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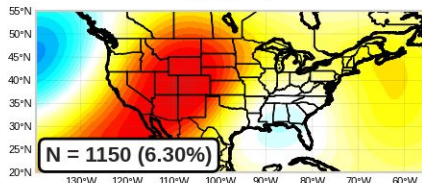
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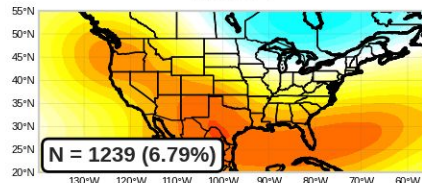
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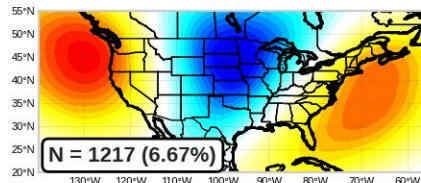
Node 6



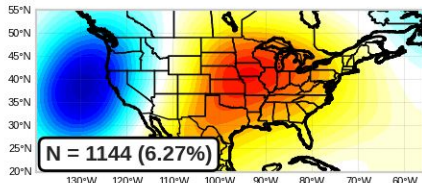
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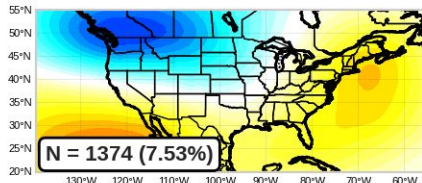
Node 8



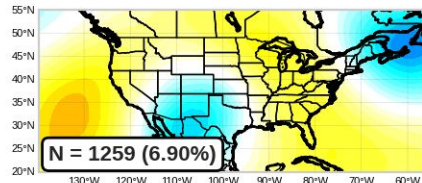
Node 9



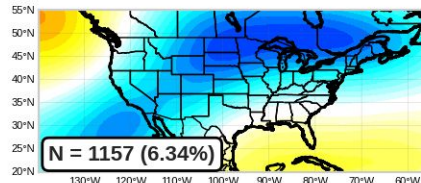
Node 10



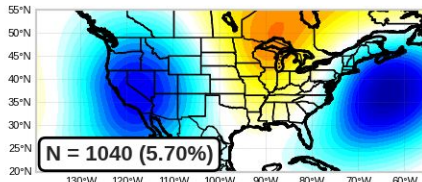
Node 11



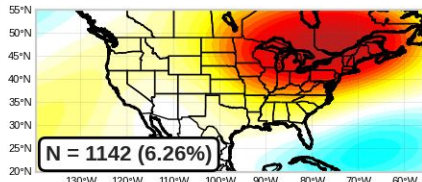
Node 12



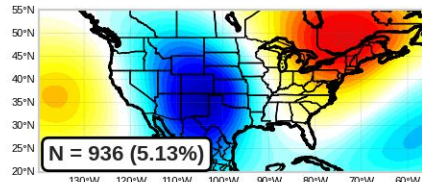
Node 13



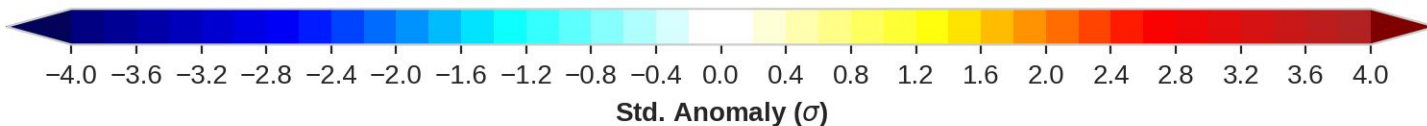
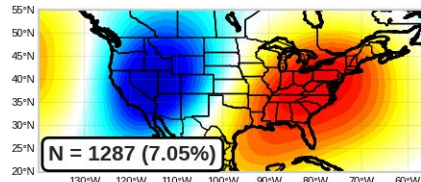
Node 14



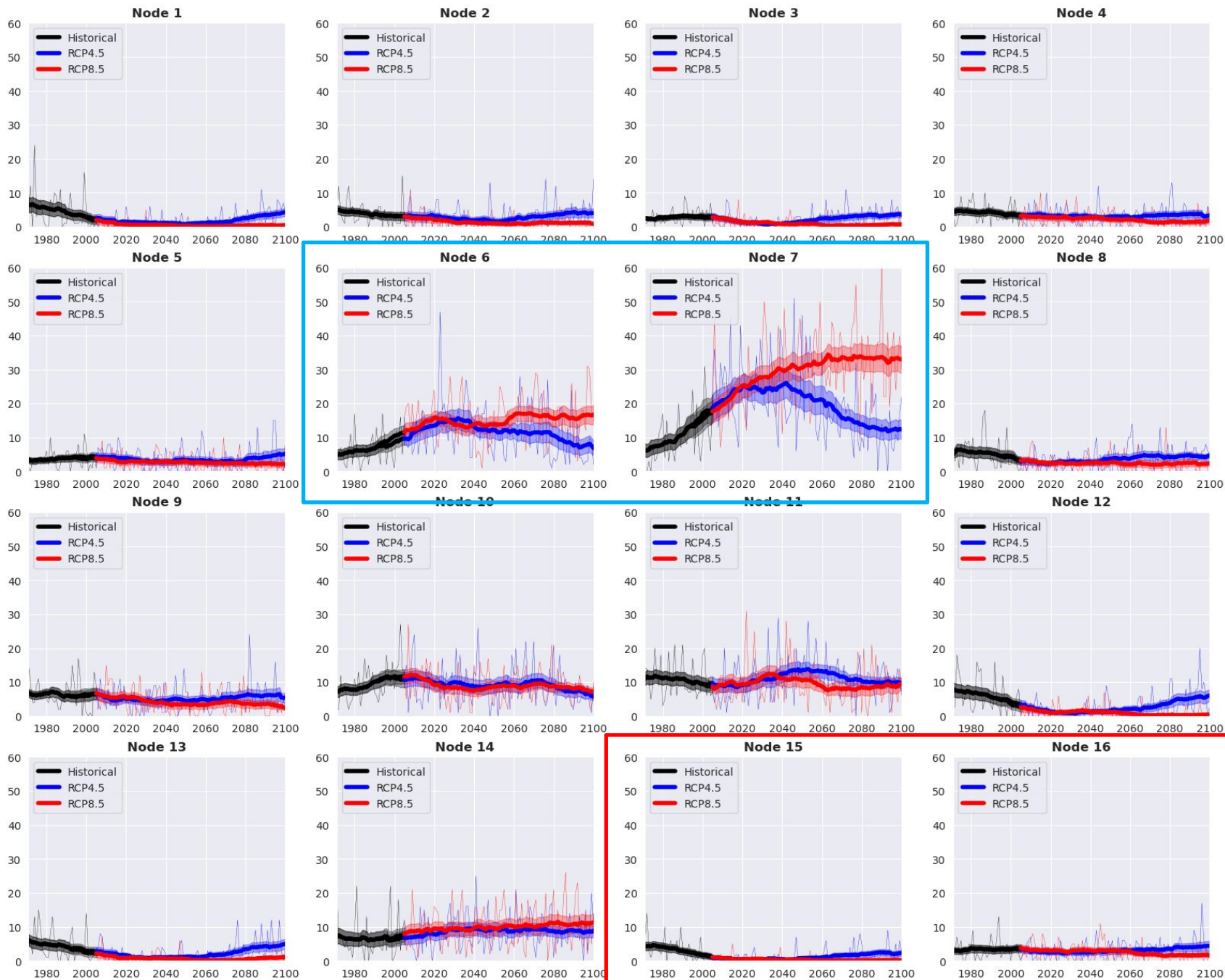
Node 15



Node 16



Favorable for Tornadoes **Unfavorable for Tornadoes**



Bottom line



- North America

- Likely increase in non-tornadic severe storm occurrence in future
- Increase in variability

- Challenge-

- Environment-event relationships
- Pattern-event relationships
- Will those relationships change?