

CPO/MAPP/CTB

Assessment of CFS predictions of U.S. severe weather activity

CFSv2 guidance for severe weather prediction

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Main idea

- Recent research connects **severe weather** with **climate signals**
 - Climate change, Pacific SST, MJO
 - **Severe weather** can be related to **environmental factors**
 - CAPE, vertical wind shear
 - NOAA Climate Forecast System
 - Resolves climate signals
 - Does not resolve severe thunderstorms
 - If the modulation of **severe weather** activity by predictable **climate signals** is expressed via **environmental factors** ...
 - Comprehensive forecast models like **CFS** may provide useful guidance
1. Can guidance tools bridge the time-scales of the SPC Outlook and CPC Hazards?
 2. Is there potential to extend to monthly time-scales?

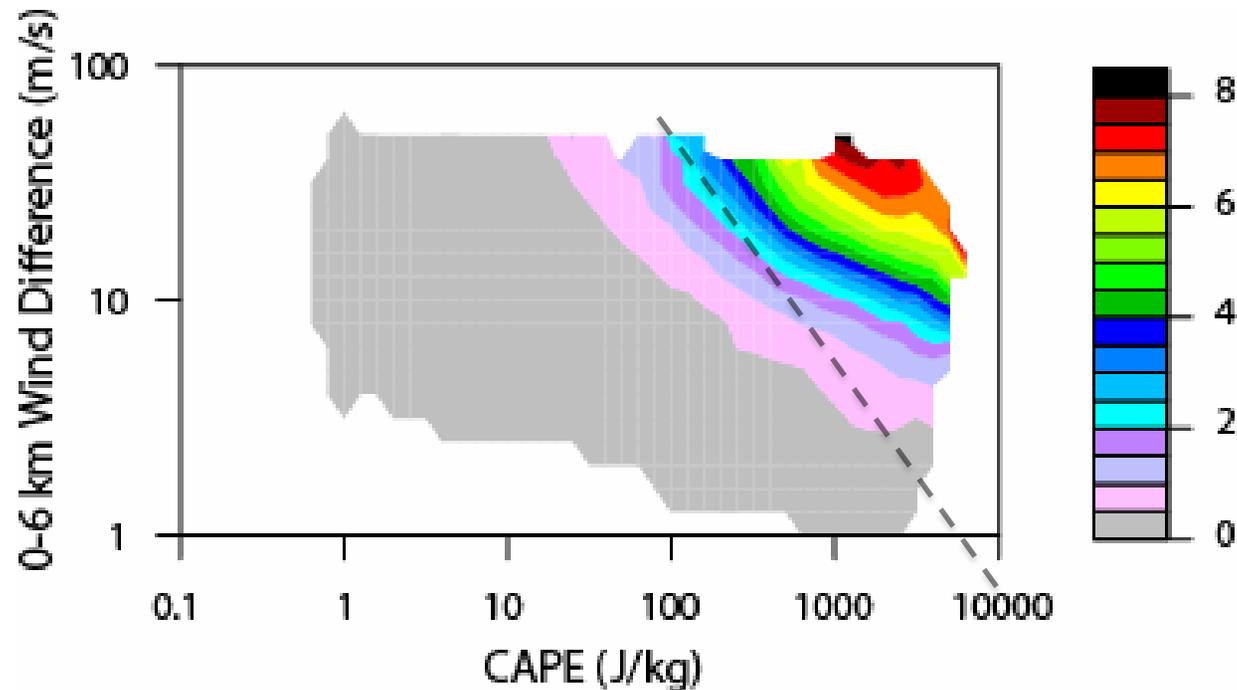
Seasonal forecast this afternoon.

Severe weather can be related
to environmental ingredients

Typical environmental ingredients associated with tornadoes

- Instability, updrafts, e.g., CAPE
- Vertical wind shear, e.g., 0-6km shear, Storm Relative Helicity (SRH)

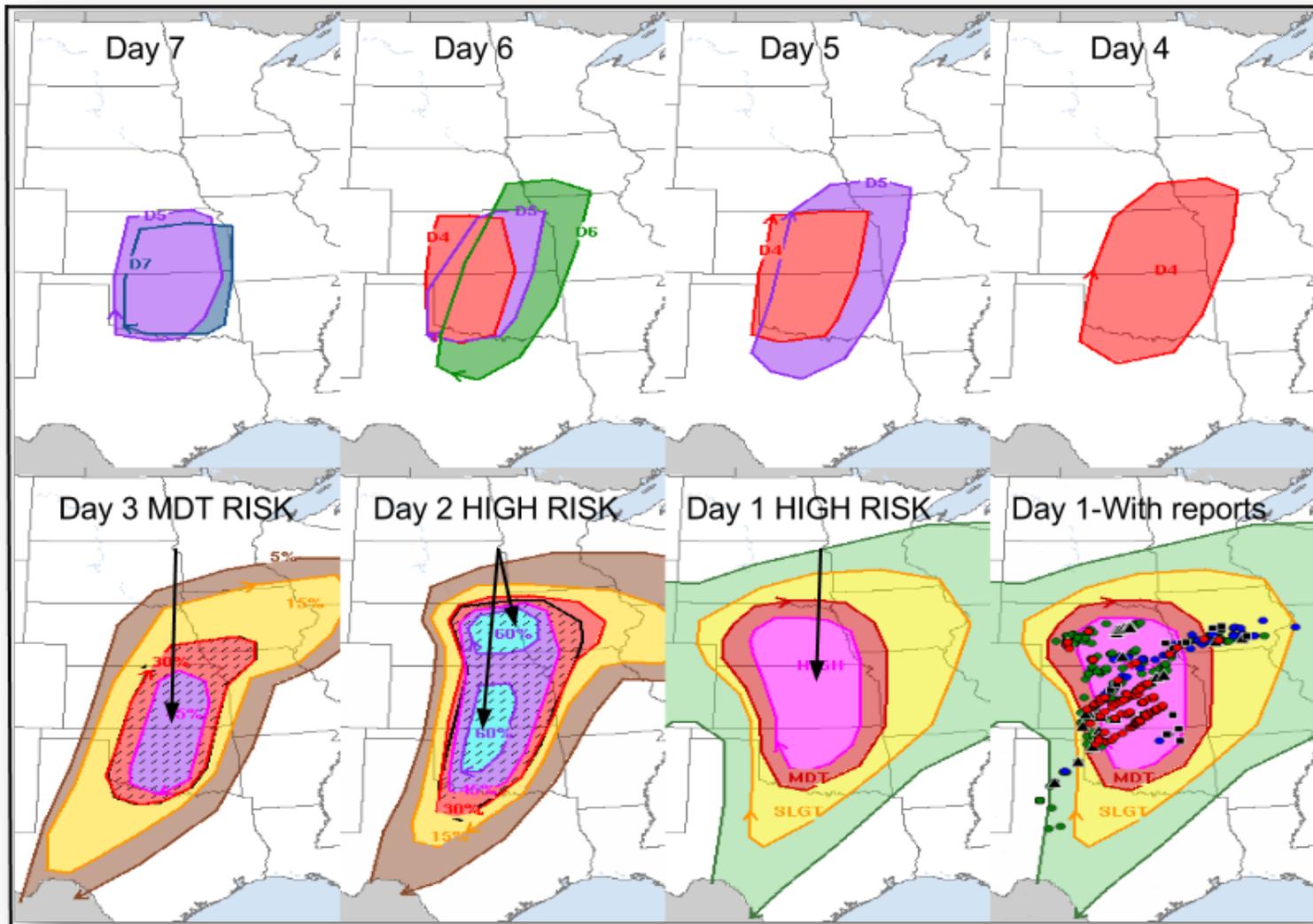
Probability of severe thunderstorm with F2 tornado, 5cm hail, or 120 km/h wind gusts



From operational US radiosonde network when soundings happened to be launched in the vicinity of severe thunderstorms.

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

Useful relation between forecast large-scale environmental parameters and tornado activity



Evolution of SPC Forecasts Leading to April 14, 2012

A tornado environment index

- $TEI = \exp(c0 + c1 \times SRH + c2 \times cPrctp)$
 - Monthly averages
 - SRH = 0-3km storm relative helicity
 - $cPrctp$ = convective precipitation
- Estimate 3 constants from annual cycle data
 - No annually varying data used to select parameters or fit constants
 - Fit 12 numbers at each gridpoint
- TEI = Expected number of tornadoes/month
- Data
 - NARR data 1x1 degree grid. 1979-2010.
 - SPC Tornado, Hail, and Wind Database. 1979-2010.
 - All tornadoes
- **Captures substantial aspects of climatological and interannual variability**

NARR data

It would be nice if updated NARR data were available from NCDC.

Nomads NCDC - NOAA Service Account

December 9, 2014 at 10:06 AM

To: Michael Tippet

Inbox - IRI 

Re: NARR-A data

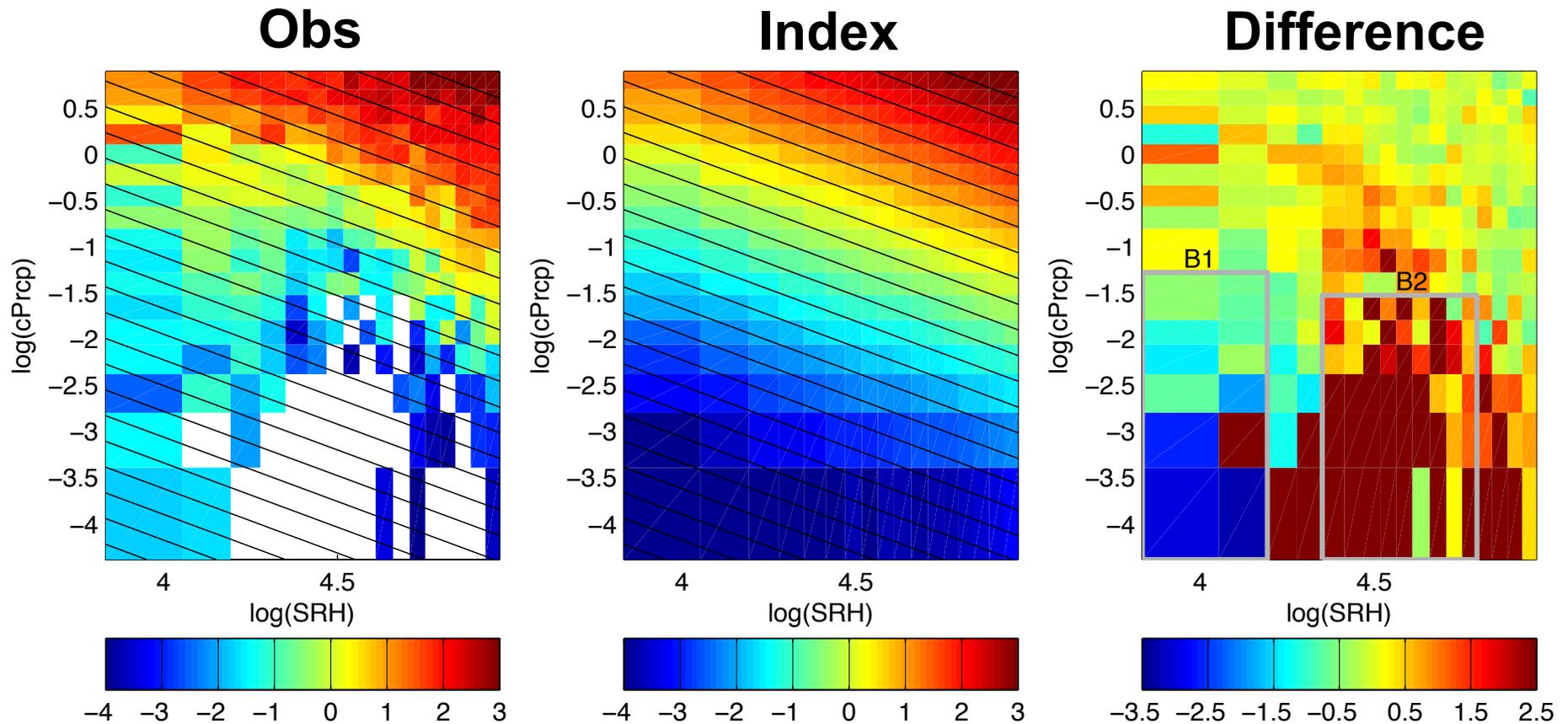
Mike,

Yes, Our NARR flow died with the nomadX.ncep.noaa.gov server series. It will be unavailable for an indefinite amount of time from our nomads.ncdc servers.

A note from Wesley E. from NCEP/CPC is as follows:

The flow of NARR analyses has been interrupted. Normally NARR is produced on our WCOSS machines and are downloaded to to nomad7.ncep.noaa.gov. From nomad7, NCDC and NCAR download the data. Finally users can get the data from nomad7, NCAR and NCDC. NCEP Central Operations (NCO) has turned off the development servers. This has interrupted the flow of non-operational data such as R1, R2, NARR, GODAS, grib1 versions of the forecasts, etc.

Parameter dependence



Log(Number of tornadoes)

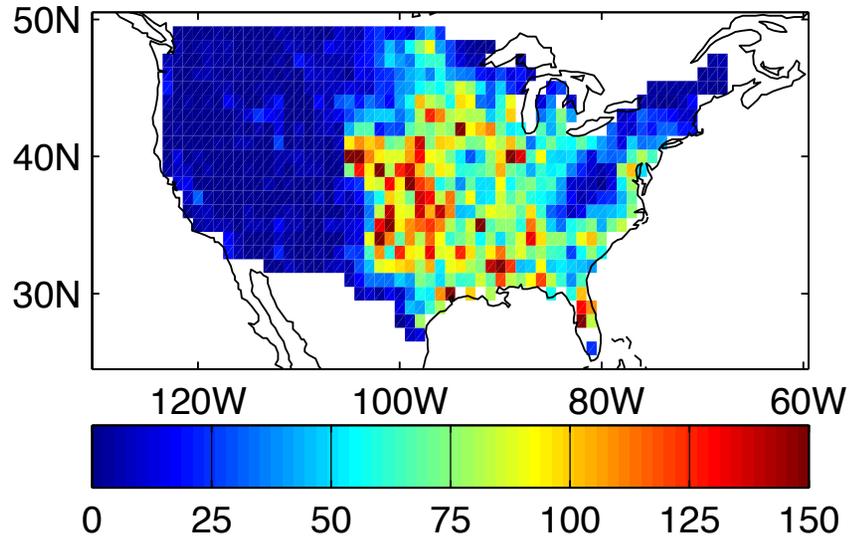
Monthly climatological relation functionally similar to high frequency

Climatology

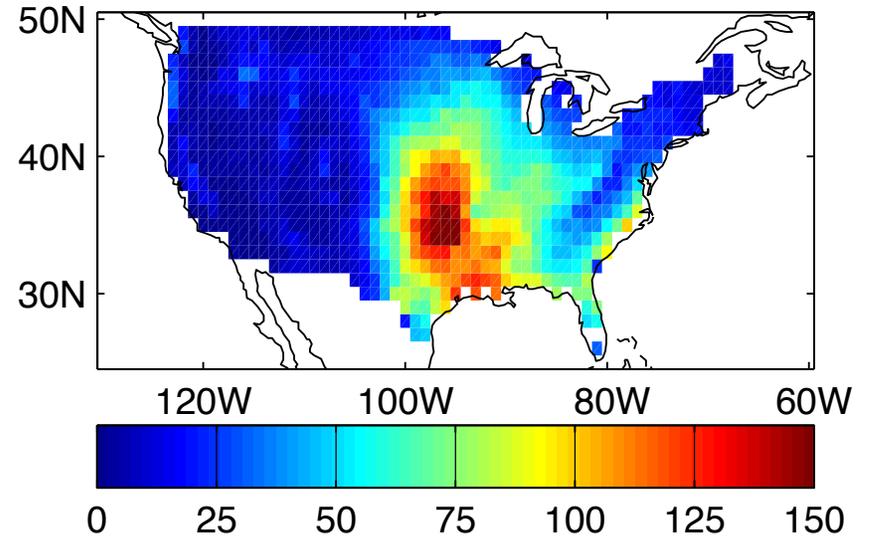
Observations

Index

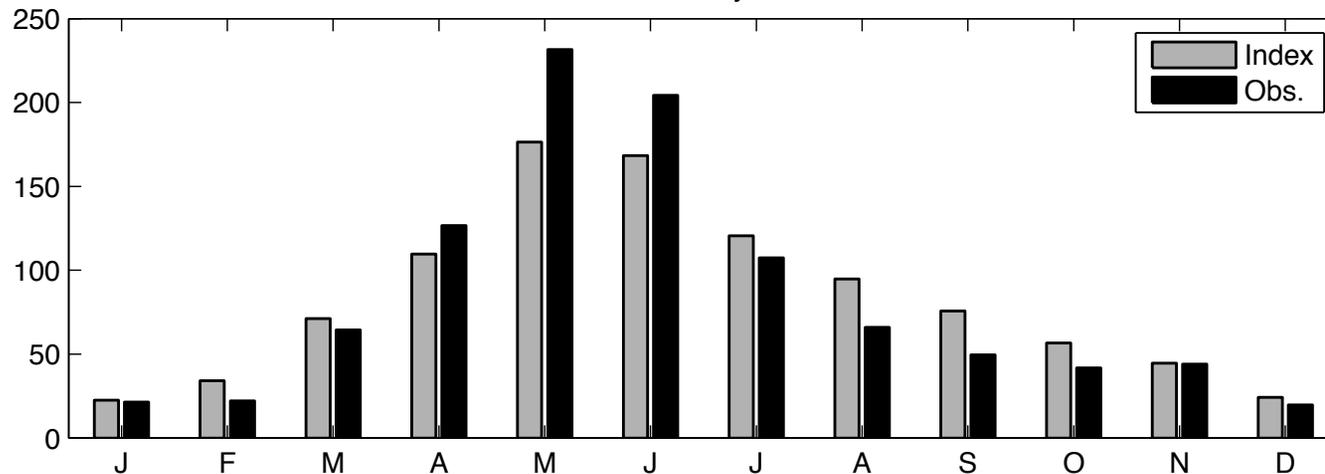
(a) observed number of tornadoes 1979–2010



(b) PR number of tornadoes 1979–2010

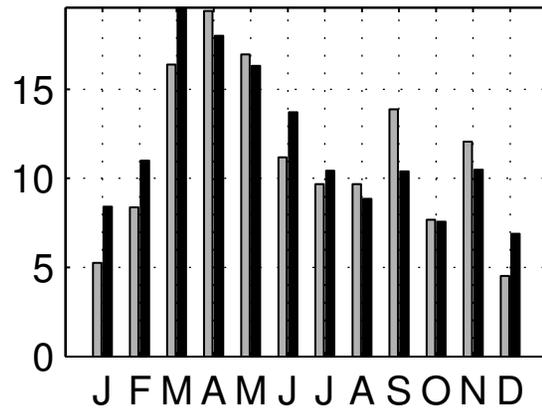


Annual cycle

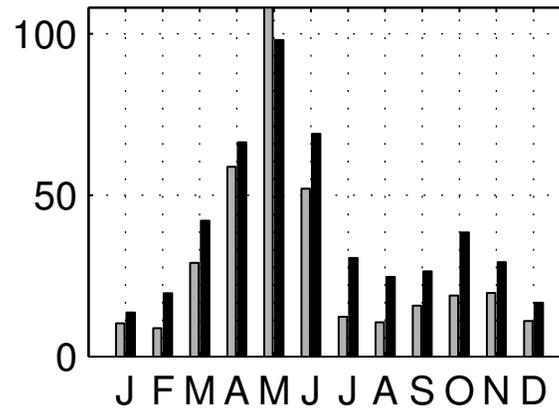


Regional climatology

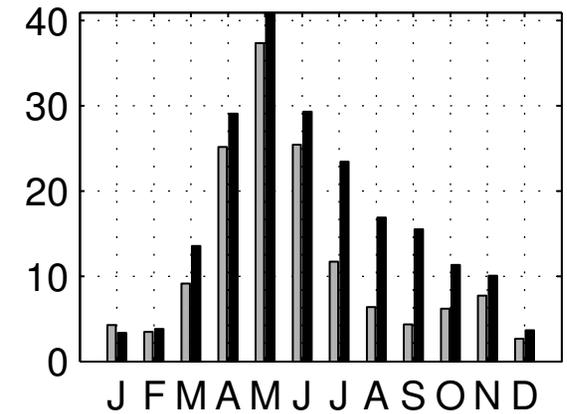
(a) Southeast (0.88,0.83)



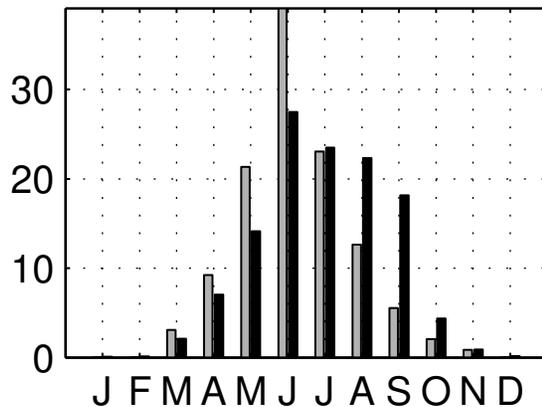
(b) South (0.97,0.92)



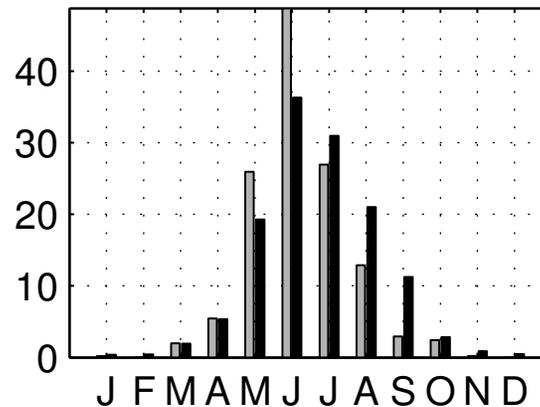
(c) Central (0.93,0.89)



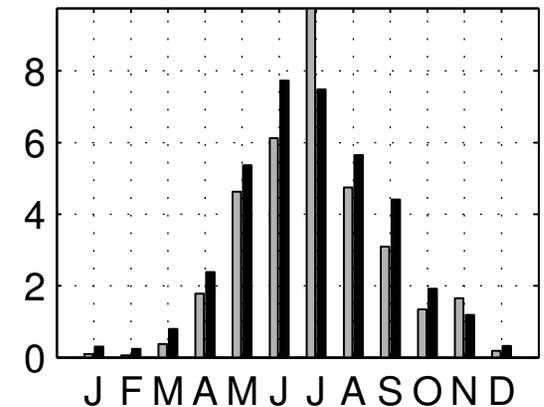
(d) Upper Midwest (0.85,0.94)



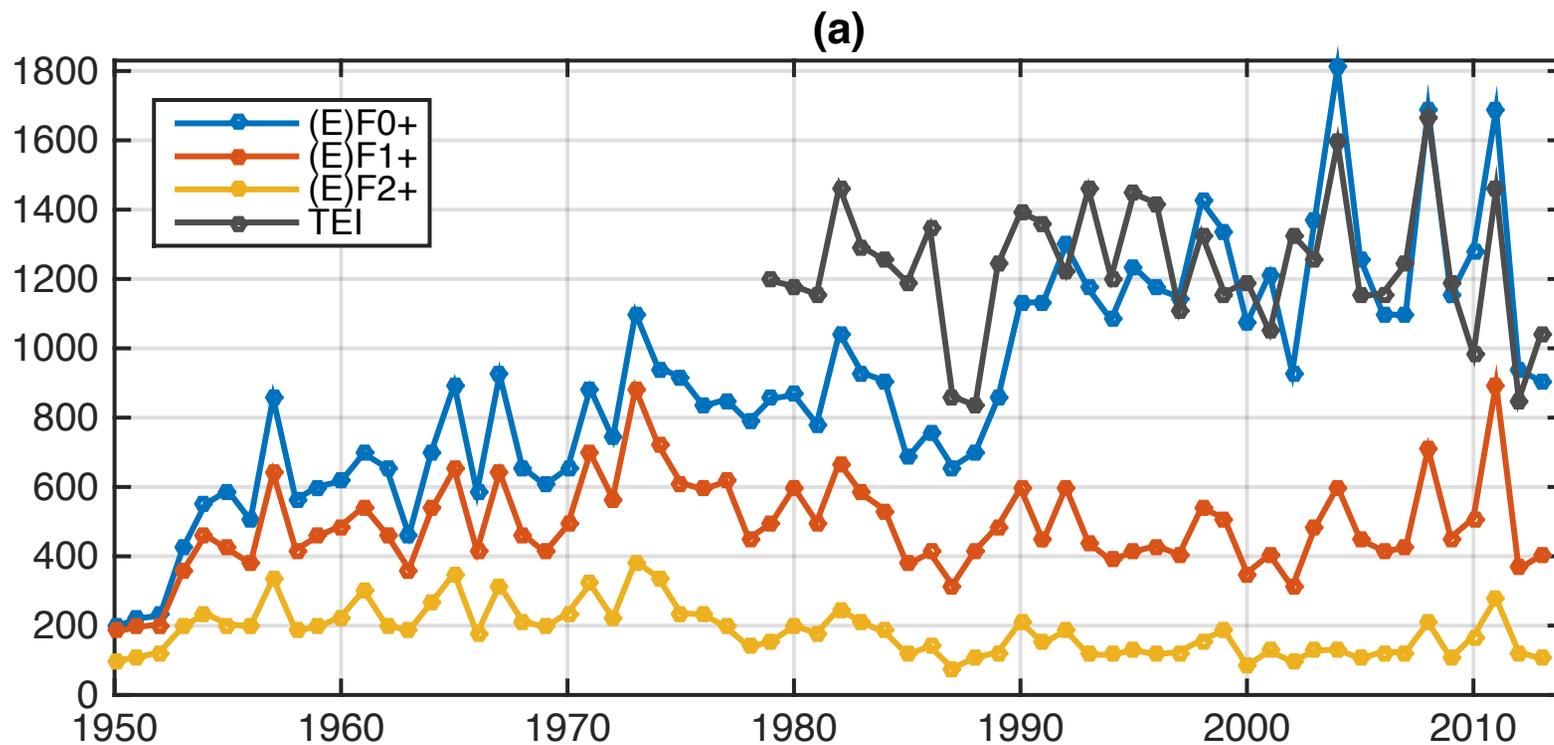
(e) Plains (0.94,0.94)



(f) Northeast (0.94,0.99)



Simulation of year-to-year variability of the number of US tornadoes



Changes in variability, too.

Interannual variability:

CONUS

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

NOAA climate regions

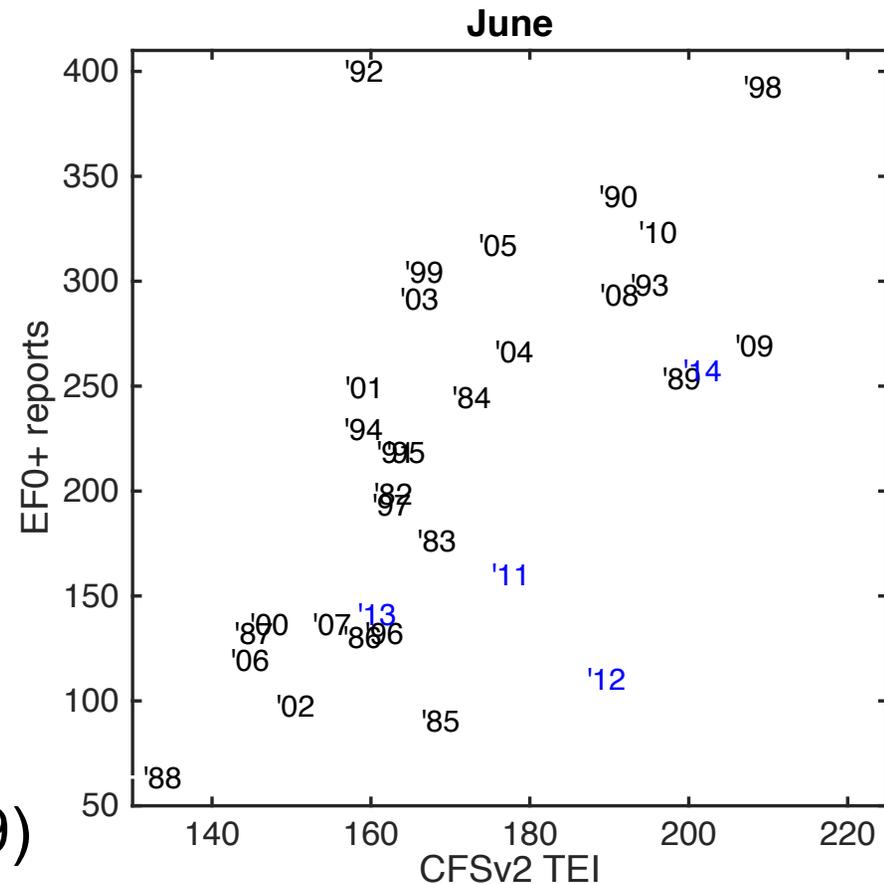
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
South	0.66	0.51	0.52	0.69	0.50	0.47	0.57	0.31	0.12	0.46	0.60	0.71	0.53
Southeast	0.53	0.54	0.36	0.47	0.68	0.46	0.54	0.42	0.67	0.41	0.57	0.69	0.30
Central	0.68	0.69	0.65	0.53	0.56	0.73	0.65	0.35	0.42	0.26	0.28	0.73	0.51
Upper Midwest	-	-	0.60	0.55	0.71	0.57	0.56	0.14	0.54	0.56	-	-	0.45
Plains	-	-	0.63	0.58	0.80	0.53	0.81	0.49	0.55	0.23	-	-	0.51
Northeast	-	-	-	0.38	0.13	0.61	0.50	0.41	0.37	0.71	0.29	-	0.36
Southwest	-	-	-	0.21	0.13	0.37	0.32	0.40	0.02	0.31	-	-	0.22
Northwest	-	-	-	0.03	0.44	0.36	-	0.07	-	-	-	-	0.15
West	-	0.49	0.60	-	-	-	-	-	-	-	-	-	0.34

TABLE 4. Correlation between the index and reported number of tornadoes by U.S. climate region and month for the period 1979-2010. Significant correlations are in bold font. Regions and months with less than 32 reported tornadoes are omitted.

Can CFSv2 predictions of TEI
provide useful guidance?

Monthly CFSv2 re-forecasts: CONUS totals

Correlation between forecast
index and observed number of
CONUS tornadoes (1982-2009)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NARR	0.75	0.64	0.54	0.50	0.60	0.67	0.75	0.40	0.15	0.25	0.48	0.74
CFSv2	0.36	0.38	0.30	0.35	0.31	0.72	0.59	0.41	-0.25	0.18	0.41	0.37

Monthly CFSv2 re-forecasts: NOAA climate regions

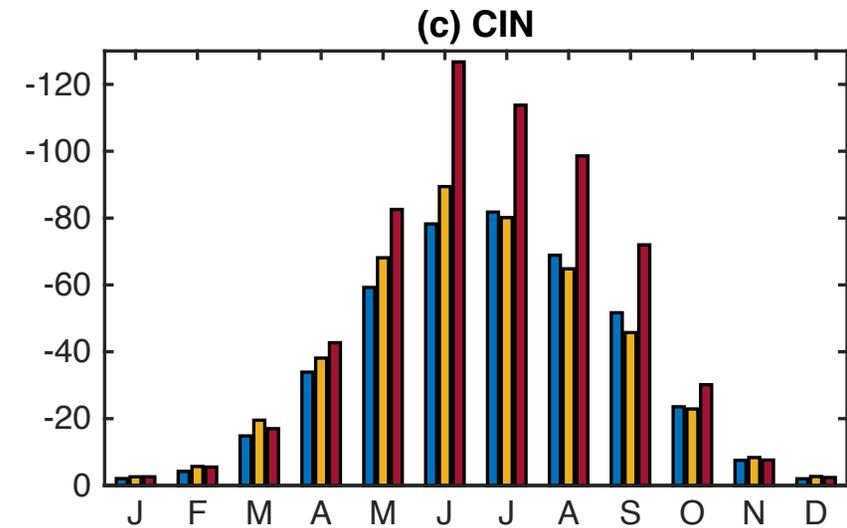
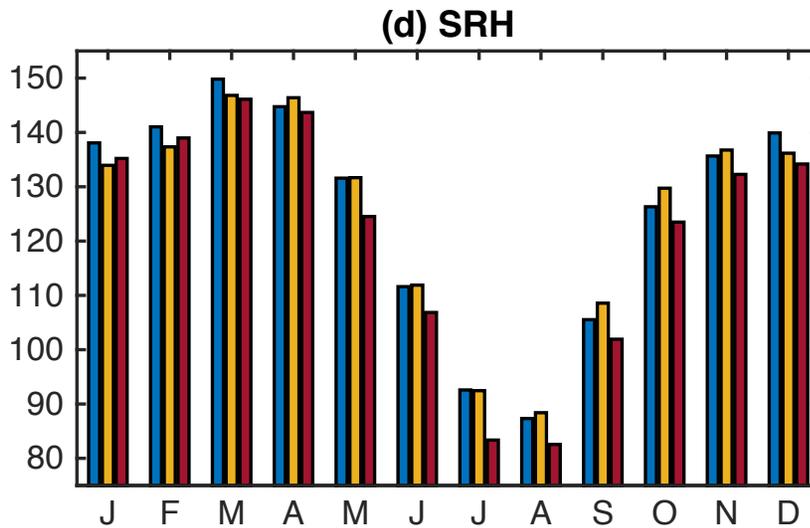
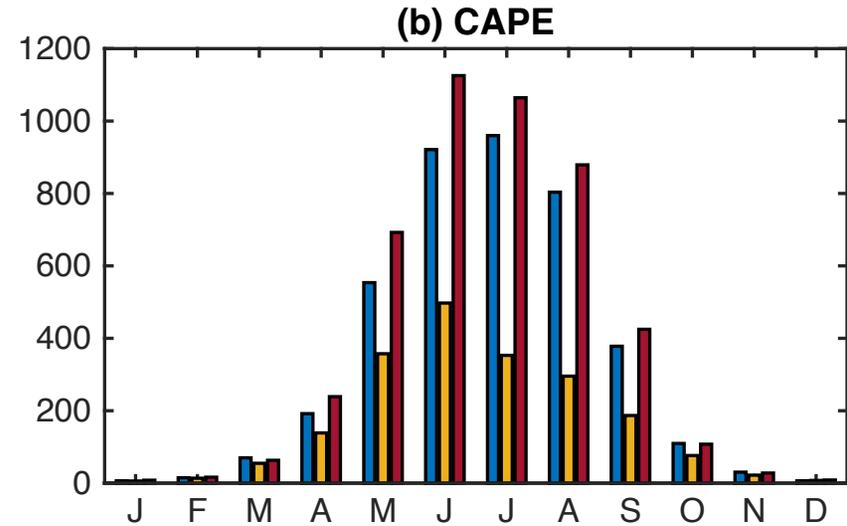
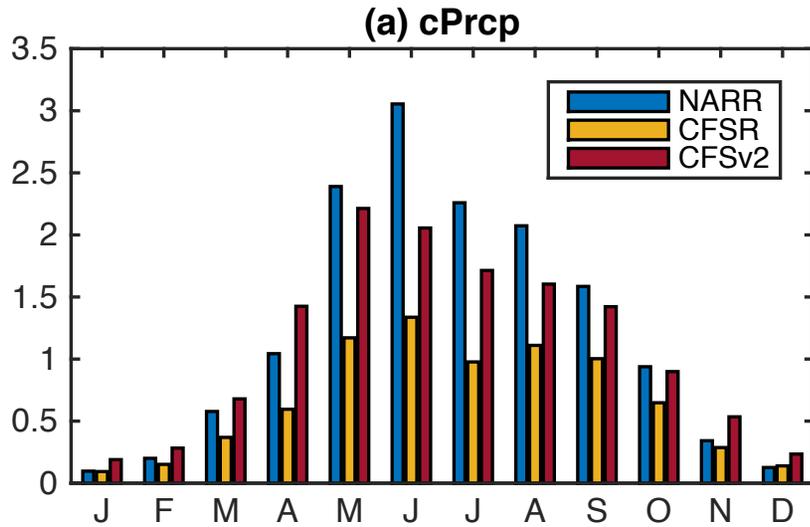
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
South	0.16	0.36	0.29	0.05	0.28	0.51	0.09	0.34	0.05	0.30	0.29	0.33
Southeast	0.22	0.24	0.00	0.41	0.66	0.25	-0.01	0.00	0.49	0.26	0.45	0.47
Central	0.47	0.50	0.64	0.23	0.37	0.45	0.42	0.05	0.19	0.03	0.24	0.42
Midwest			-0.12	0.58	0.15	0.67	0.39	0.42	0.02	0.39	-0.04	
Plains			0.12	0.37	0.40	0.50	0.53	0.27	-0.03	0.03		
Northeast				0.15	0.05	0.15	0.41	0.18	0.70	0.15	-0.02	
Southwest				0.02	-0.10	0.32	0.04	-0.01	-0.44	0.30		
Northwest				-0.14	0.15	0.30		0.19				
West		0.21	0.34	0.13								

(1982-2009)

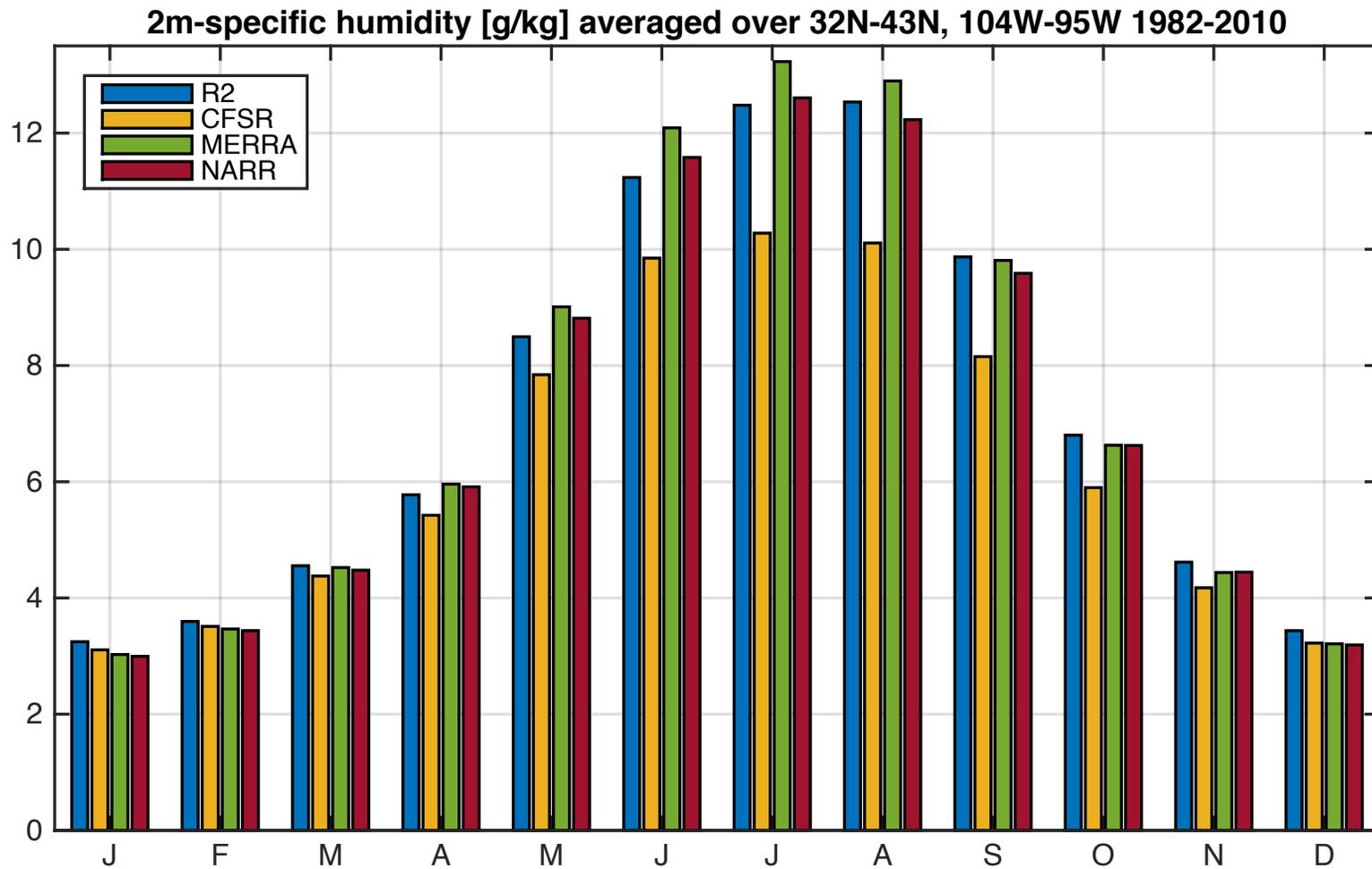
Wait ...

- How do the severe weather parameters climatologies from different models compare?
 - NARR
 - CFSR
 - CFSv2 (first month lead)

NARR/CFSR/CFSv2



Specific humidity

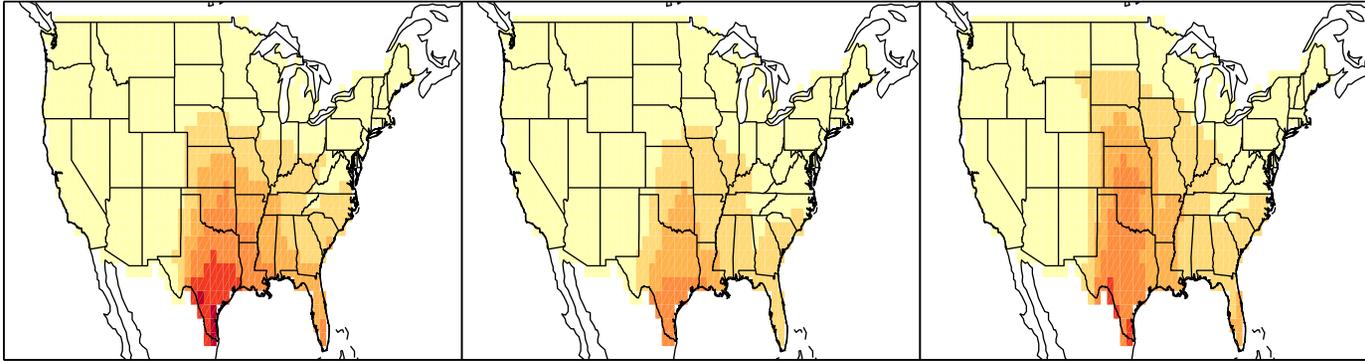


NARR/CFSR/CFSv2

NARR CAPE May

CFSR CAPE May

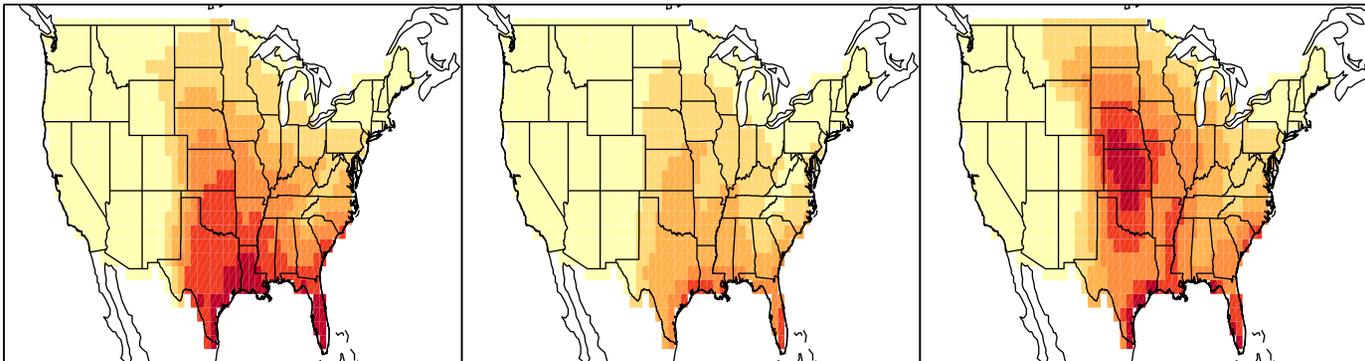
CFSv2 CAPE May



NARR CAPE Jun

CFSR CAPE Jun

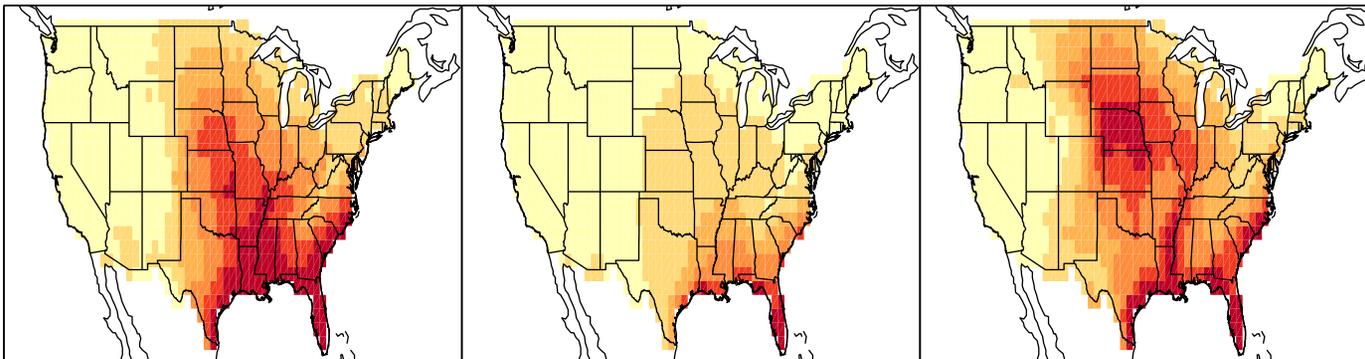
CFSv2 CAPE Jun



NARR CAPE Jul

CFSR CAPE Jul

CFSv2 CAPE Jul

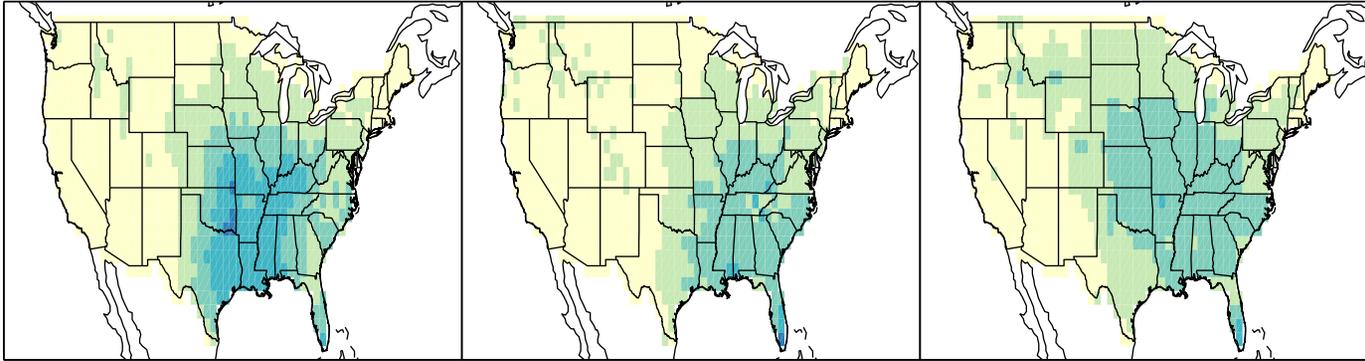


NARR/CFSR/CFSv2

NARR cPrpc May

CFSR cPrpc May

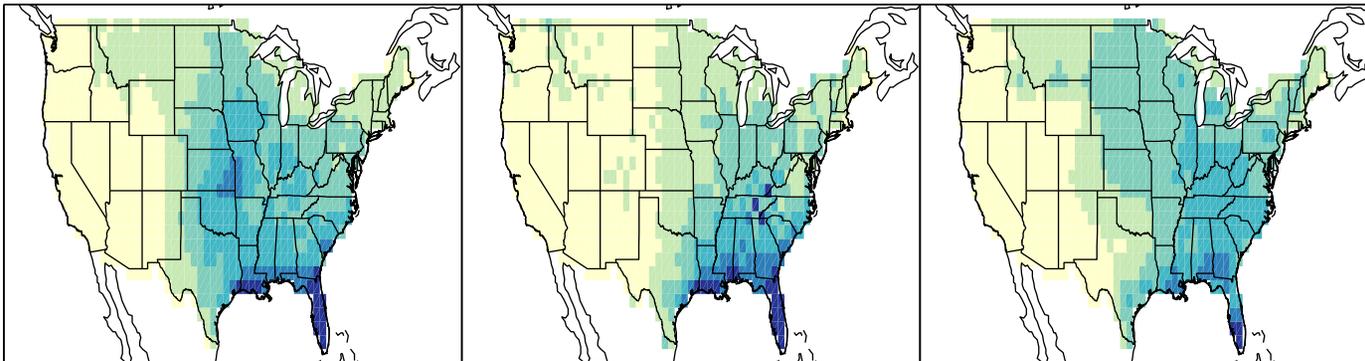
CFSv2 cPrpc May



NARR cPrpc Jun

CFSR cPrpc Jun

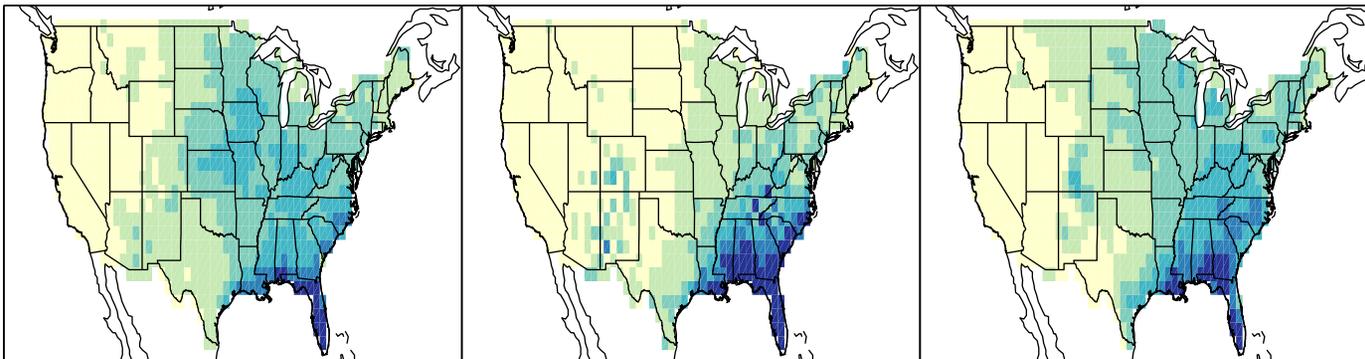
CFSv2 cPrpc Jun



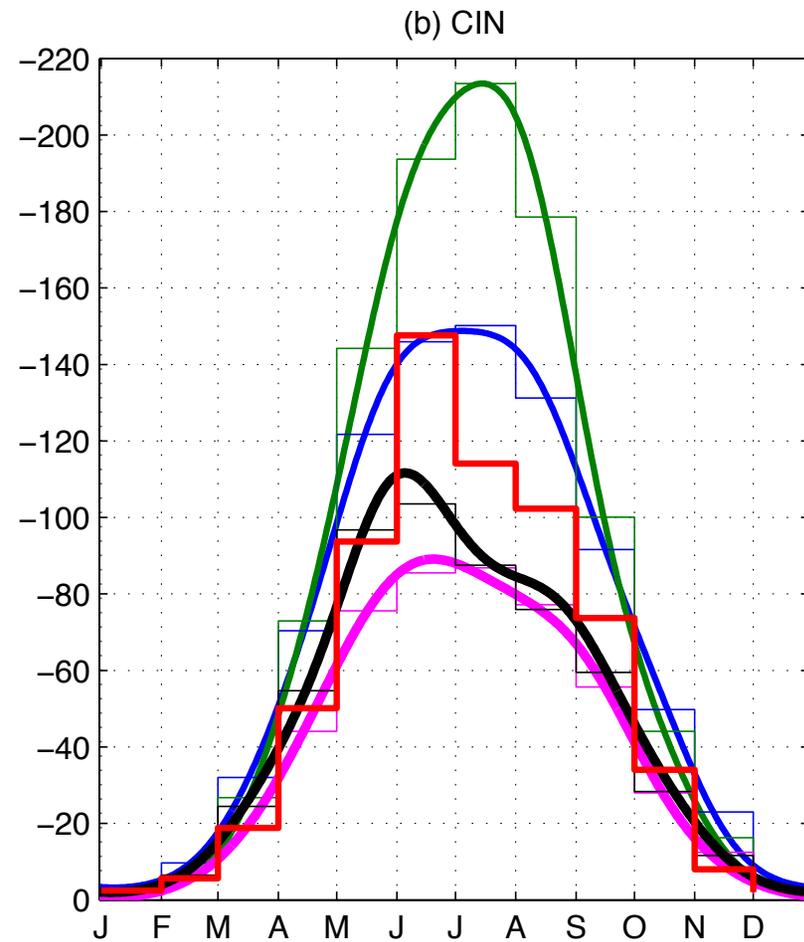
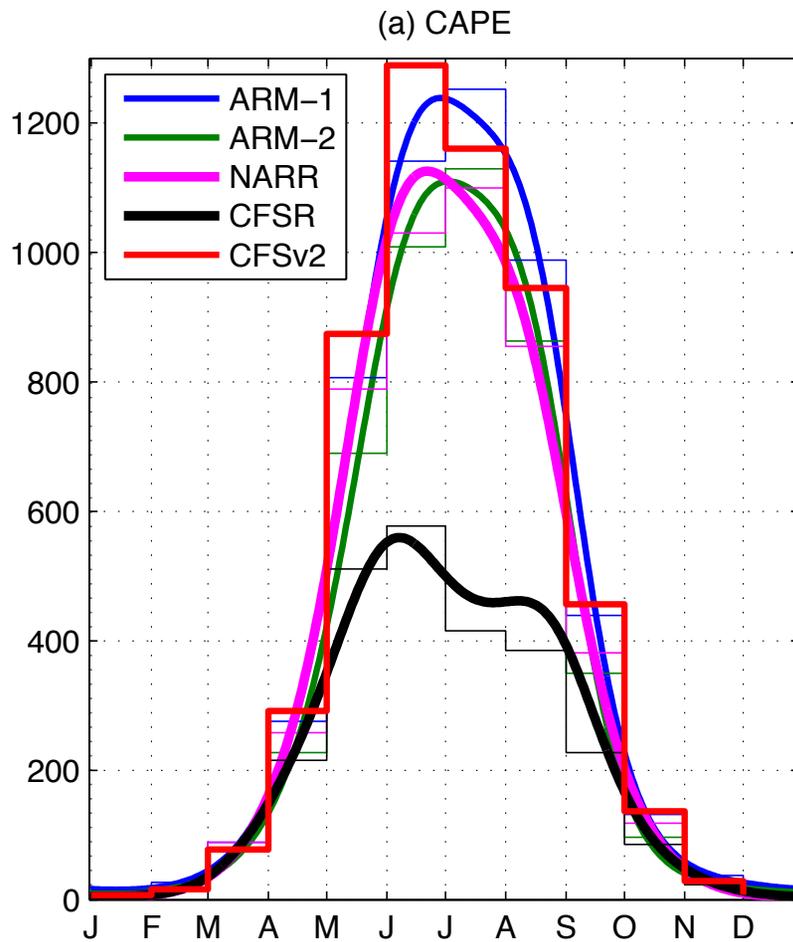
NARR cPrpc Jul

CFSR cPrpc Jul

CFSv2 cPrpc Jul

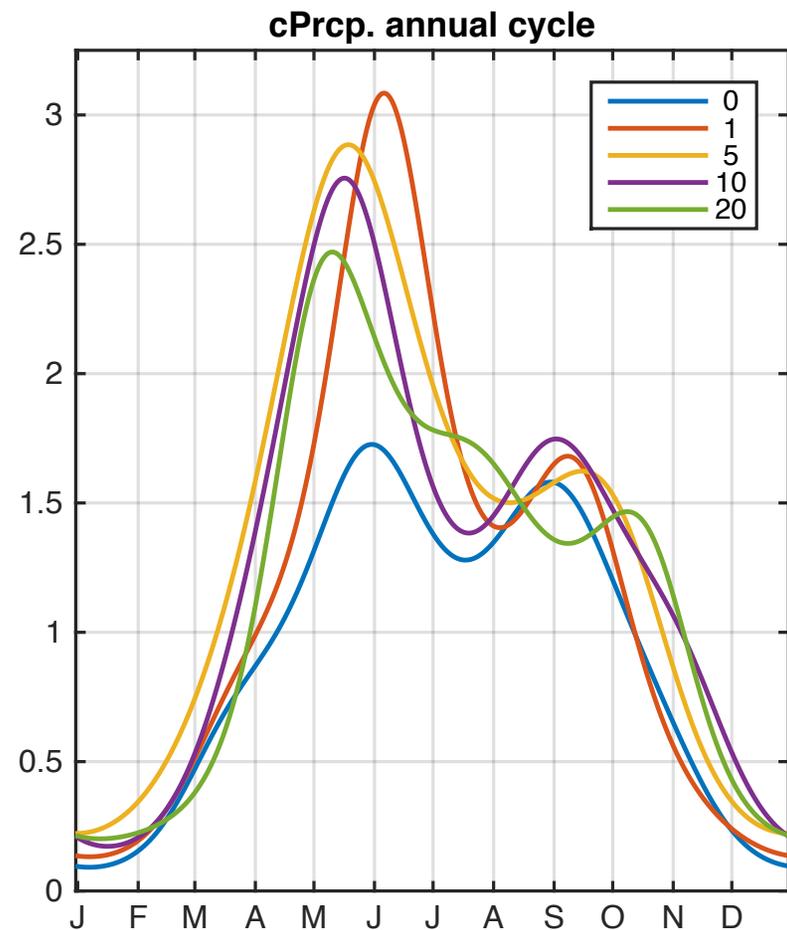
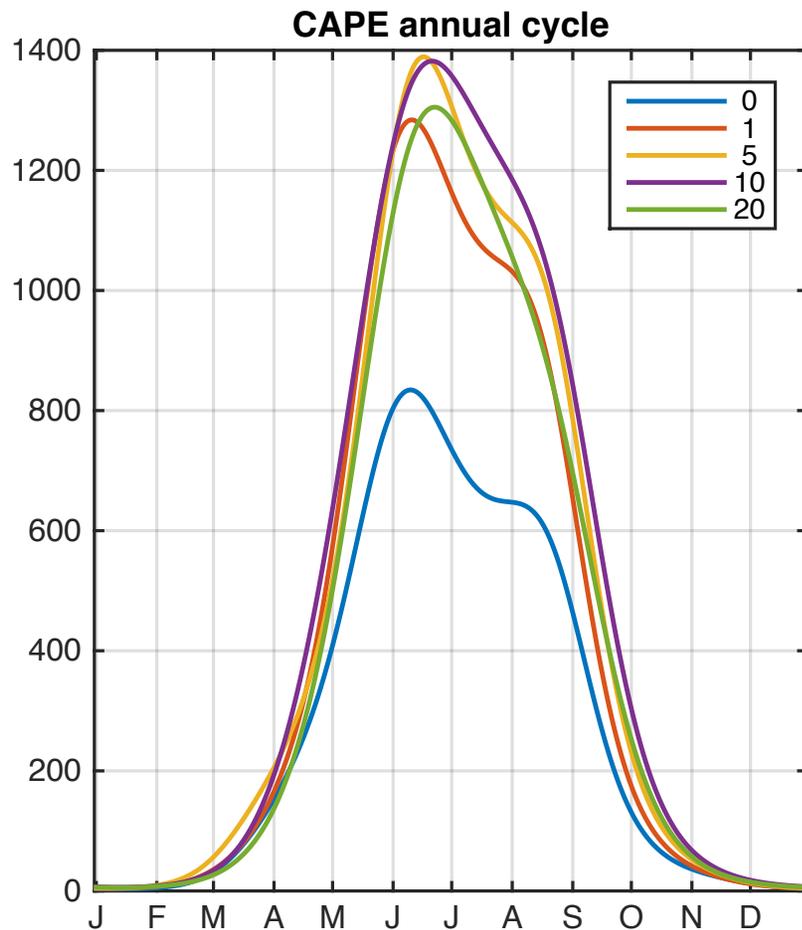


SGP ARM site



1995-2010

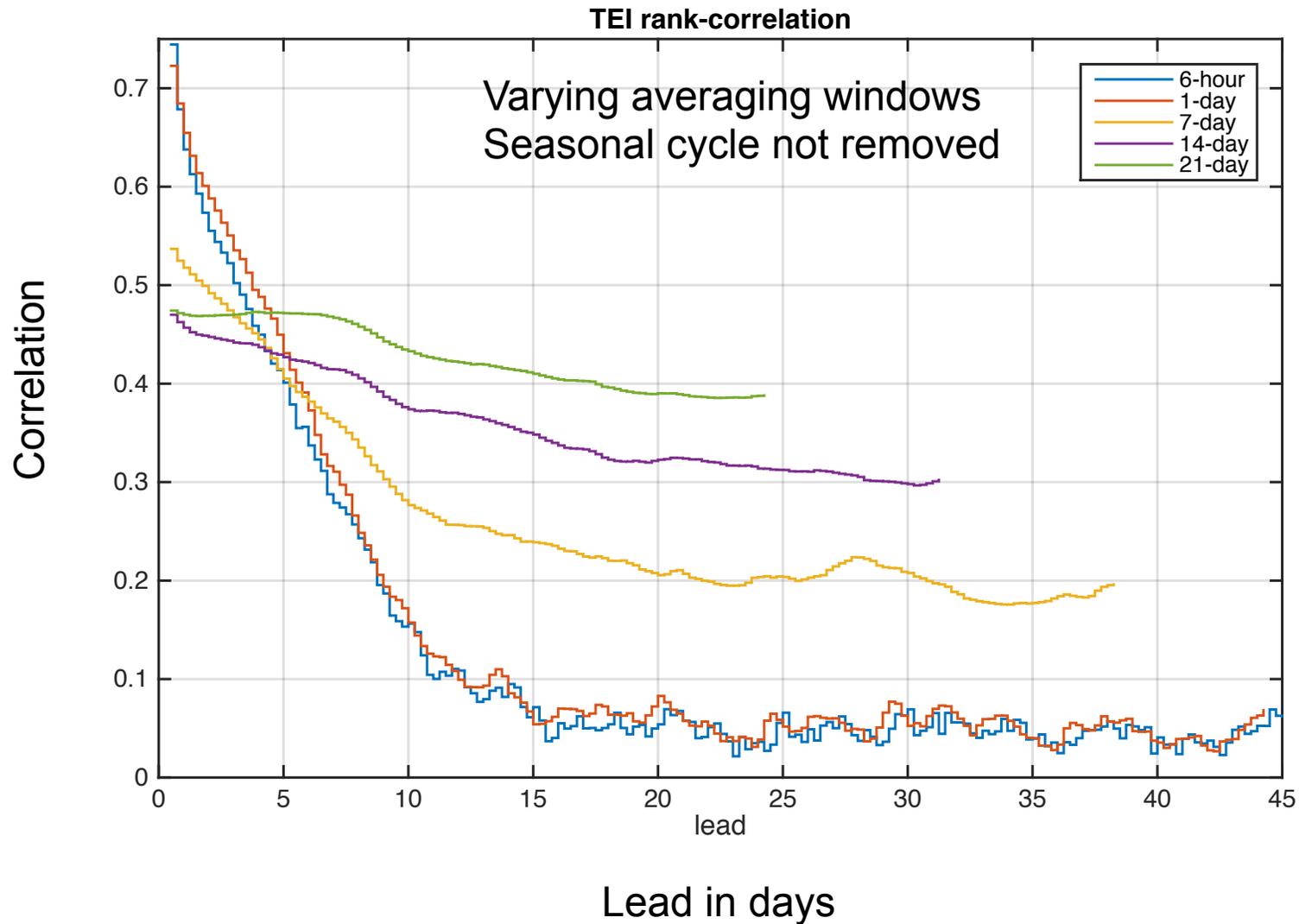
Lead time dependence



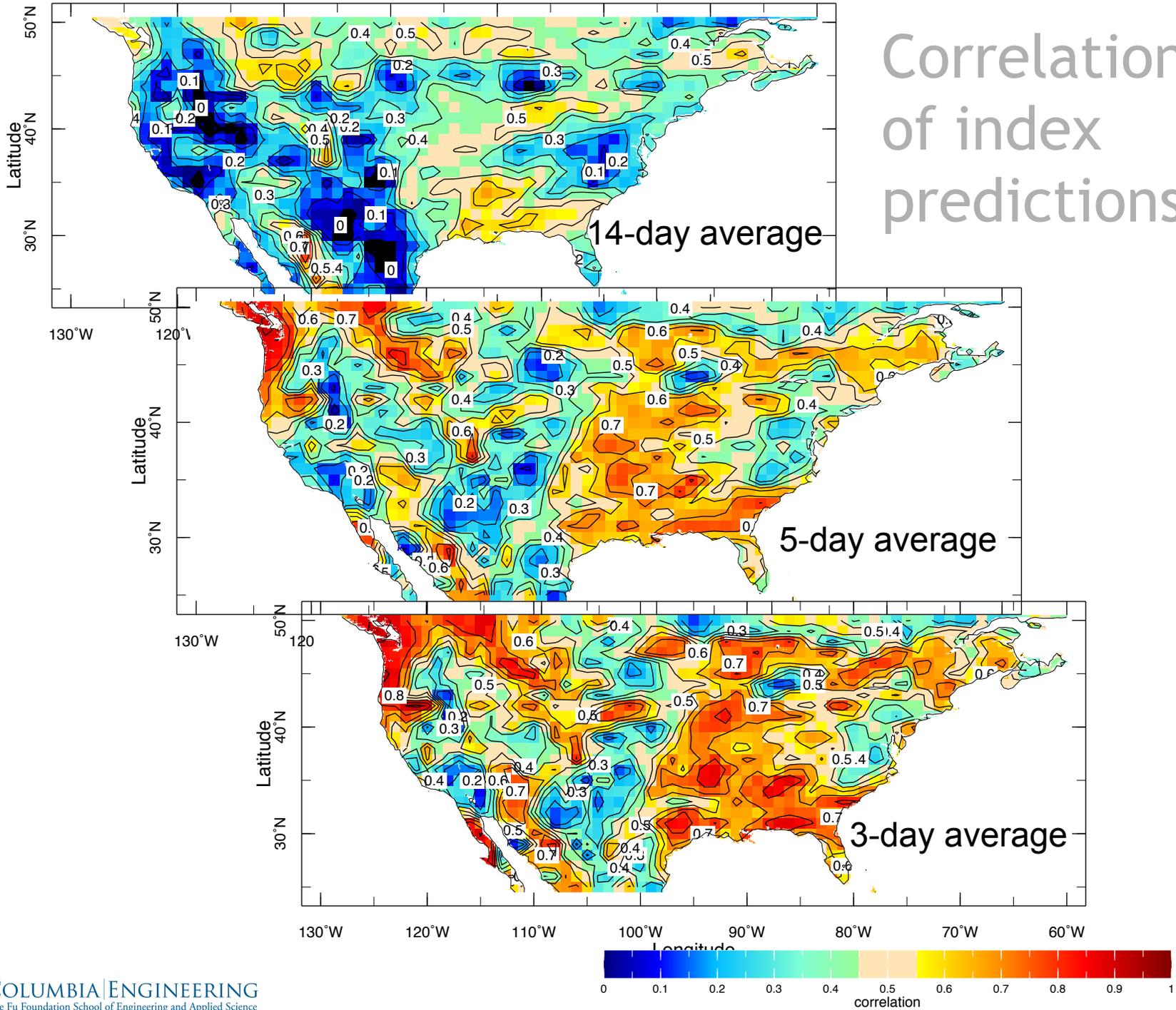
Predictability of the index in CFS 45-day forecasts 2013-now

How well can CFS predict the index

Correlation of CONUS index



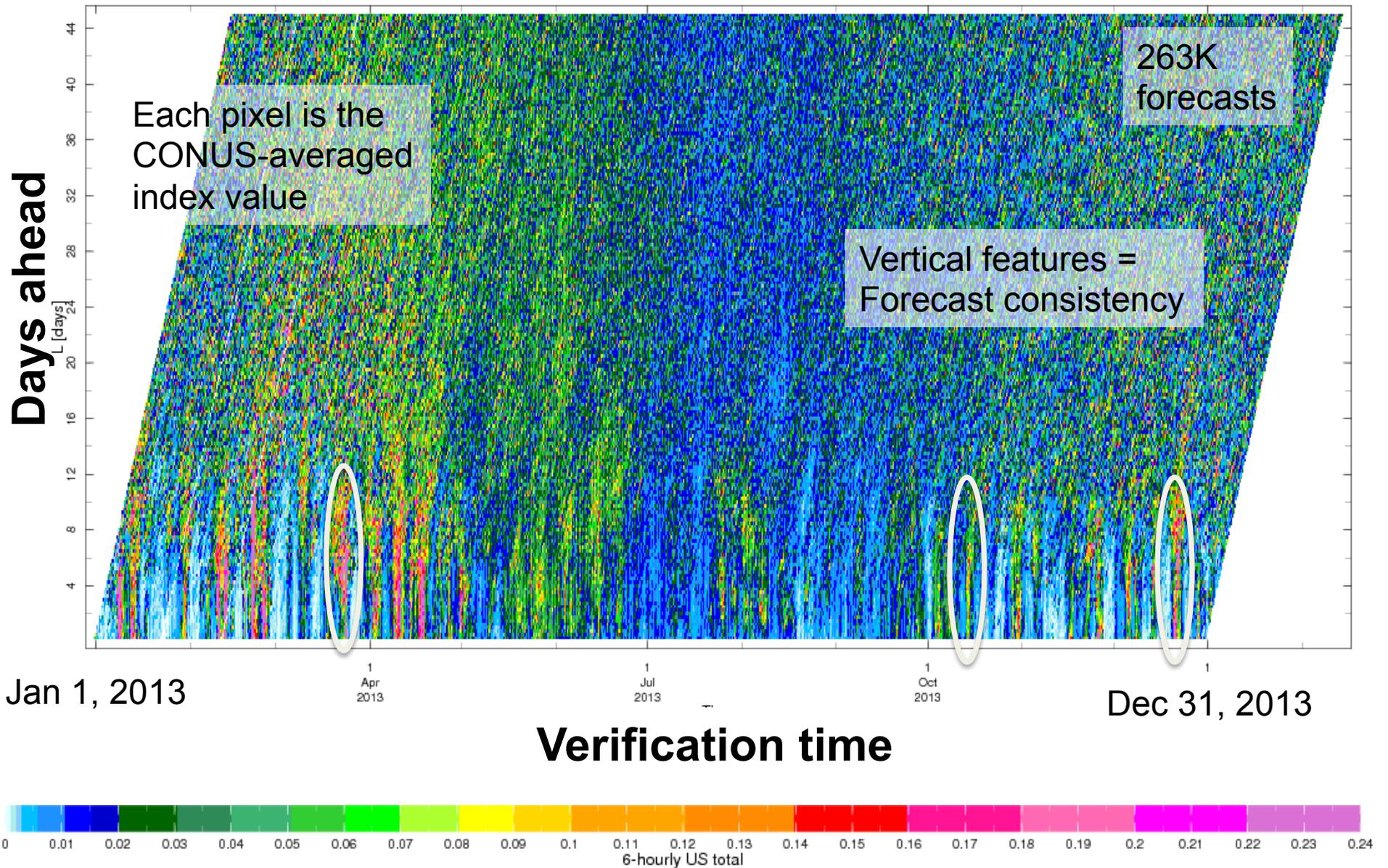
Correlation of index predictions



Can skillful high-impact forecasts be identified a priori?

- “After the fact” is of dubious scientific value and no practical value
- Use forecast *consistency* to identify potential forecasts of opportunity
 - Across ensemble members
 - CFS 4-members every 6 hours
 - Across forecast runs
 - 16 CFS runs per day
- **Visualization tool**
 - Forecast “Hovmoller” or “Chiclet chart”
 - Vertical features indicate consistency

Visualizing index predictability



Conclusions

- Index methods relate model output with severe weather occurrence
- CFS forecasts show potential
 - Days 3-14 guidance
 - Method for identifying forecast consistency
- What can be said past 2 weeks?
 - Beyond events
 - Activity forecasts?
- Who can use this information?