Forecasting temperature extremes with the North American Multi-Model Ensemble (NMME)

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40th CDPW, Denver CO, 27Oct2015

* and INNOVIM

Why go to extremes?

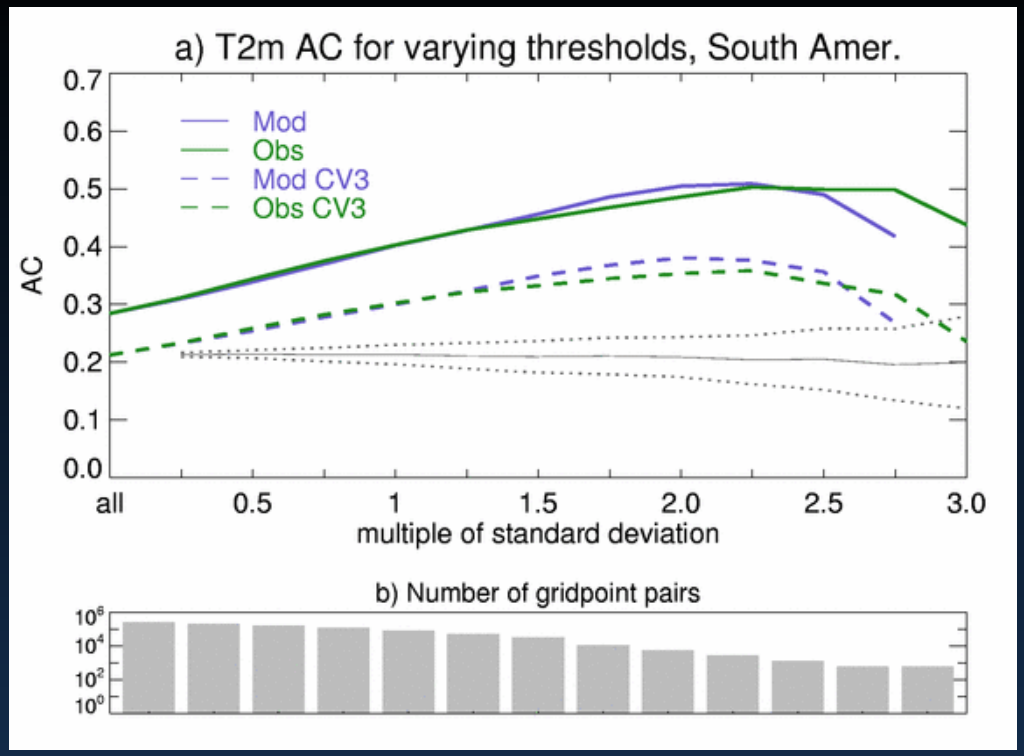
-Extremes are where the real impact of weather and climate are felt.

-The World Climate Research Programme (WCRP) has identified “Understanding and Prediction of Weather and Climate Extremes” as one of its five Grand Challenges.

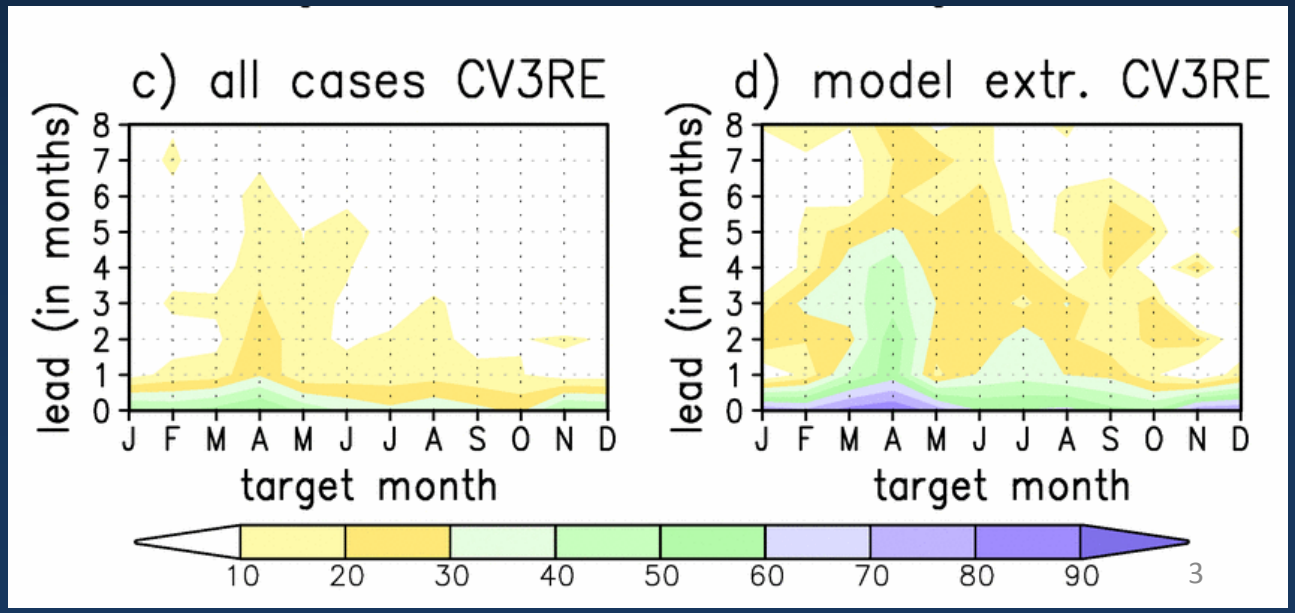
-Very few forecasts for short-term climate extremes

Short-term climate extremes (STCE): monthly or seasonal means well above or below the mean, at leads of 1 – 8 months.

Forecasts for extremes are more skillful than "all cases" forecasts



CFSv2 anomaly correlation for South (top) and North (bottom) America T2m



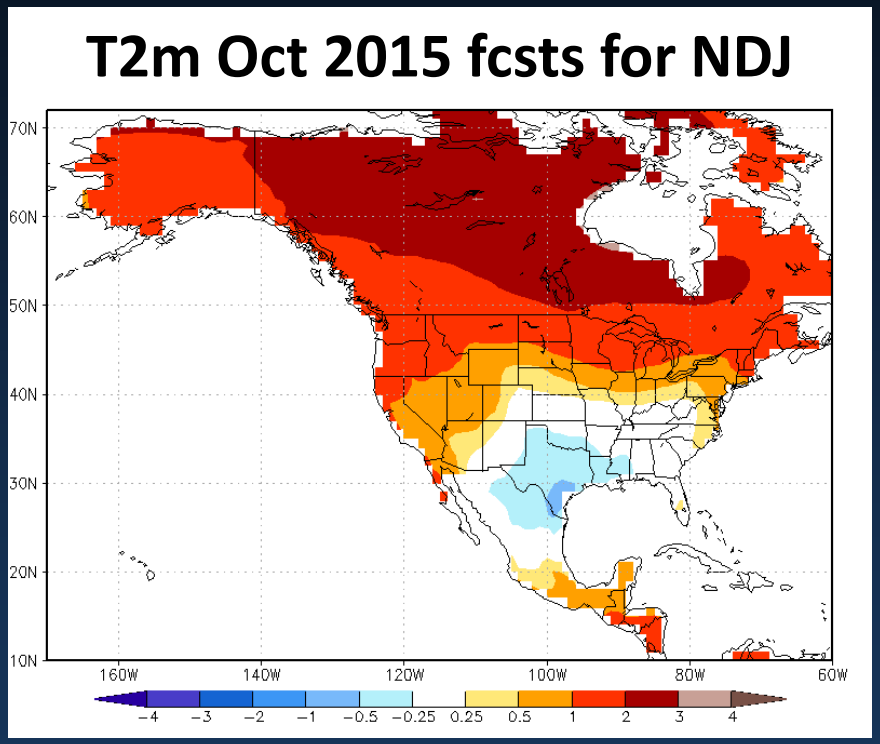
Becker et al. 2013

- NMME (North American Multi-Model Ensemble) is an unprecedented MME system intended to improve intra-seasonal to interannual (ISI) operational predictions based on the leading US and Canada climate models.
- Seasonal forecasting guidance available monthly, following CPC operational sched. since Aug. 2011.
- This study uses 1982-2010 hindcasts from 7 currently active forecast models: CFSv2, Can-CM3 & 4, GFDL-CM2.1 & FLOR, NASA-GEOS5, NCAR-CCSM4

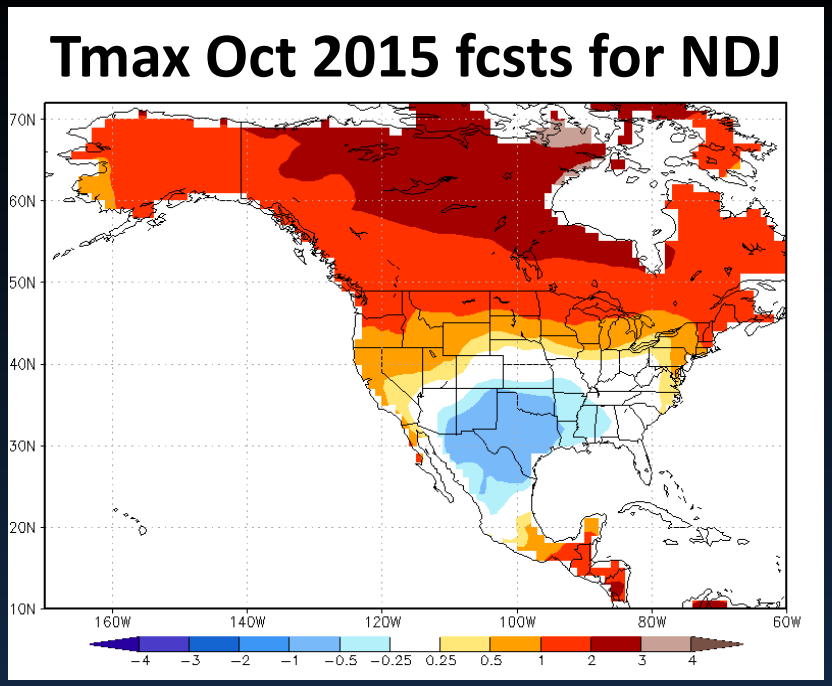
http://www.cpc.ncep.noaa.gov/products/NMME

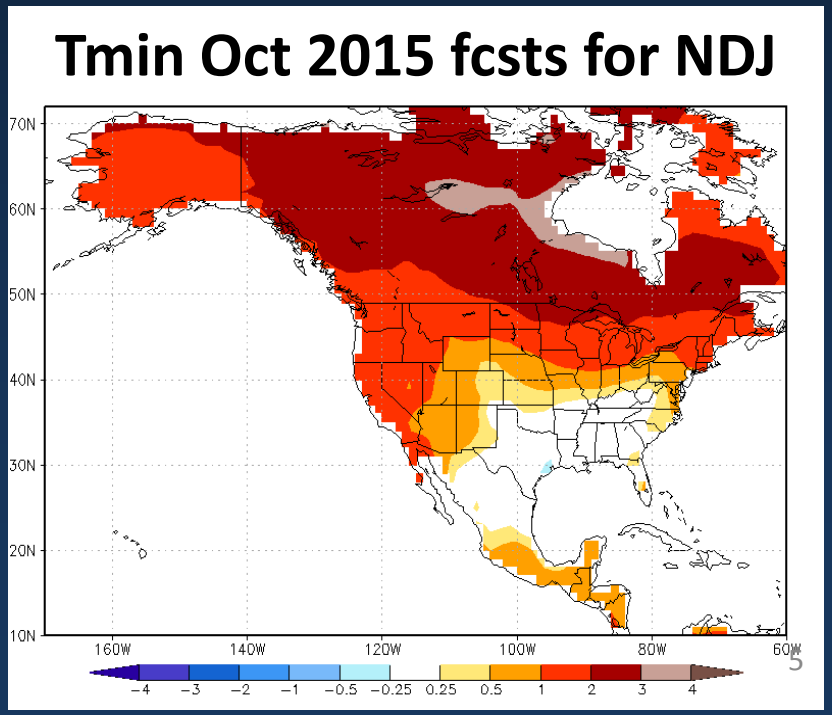
NMME Tmax/Tmin

- Debuted in April 2013



- Used by…??
- Lacked a verification dataset until recently

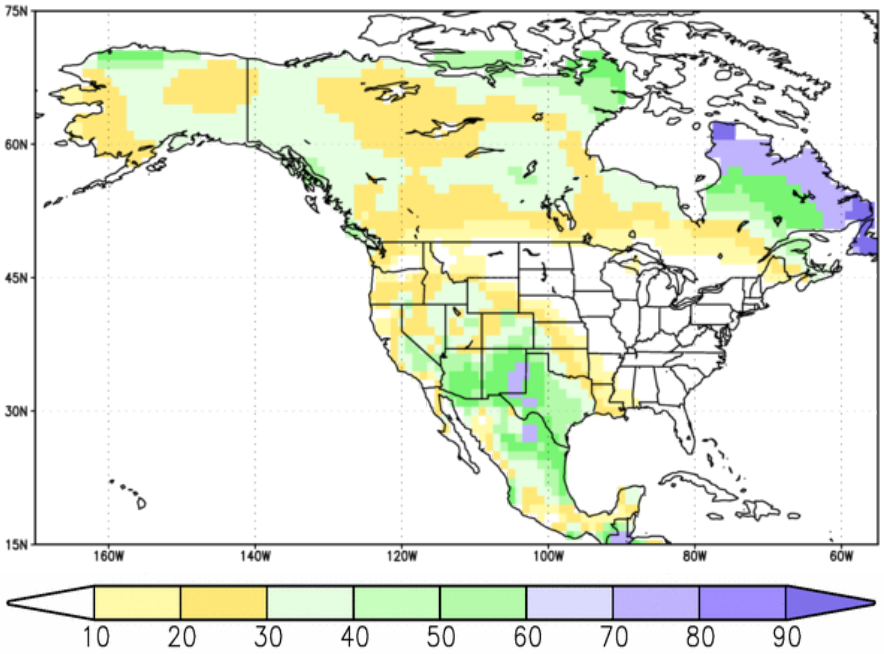




NMME Tmax/Tmin

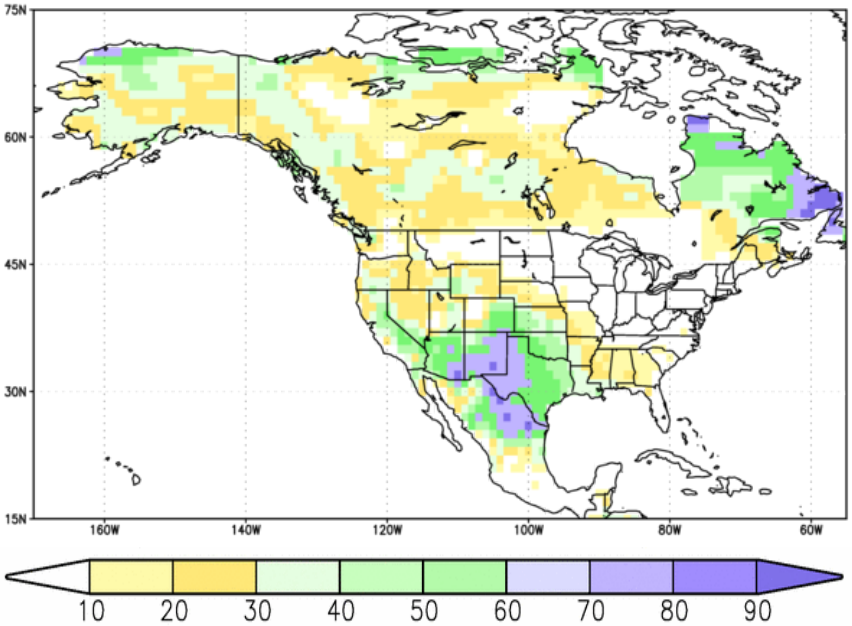
Anomaly correlation based on 1982-2010 hindcasts

T2m AC Oct fcsts for NDJ

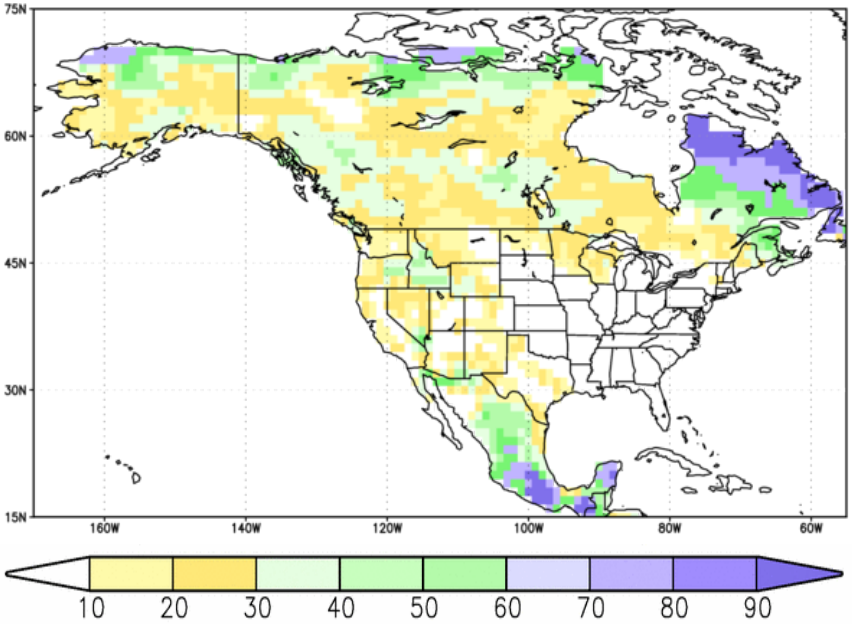


Thanks to CPC's Wei Shi for his global gridded Tmax/Tmin data.

Tmax AC Oct fcsts for NDJ



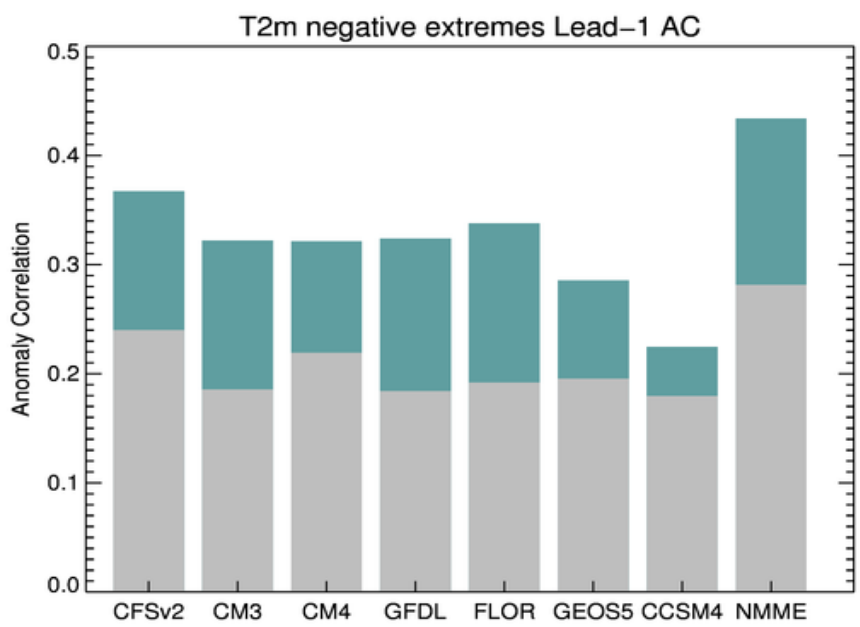
Tmin AC Oct fcsts for NDJ

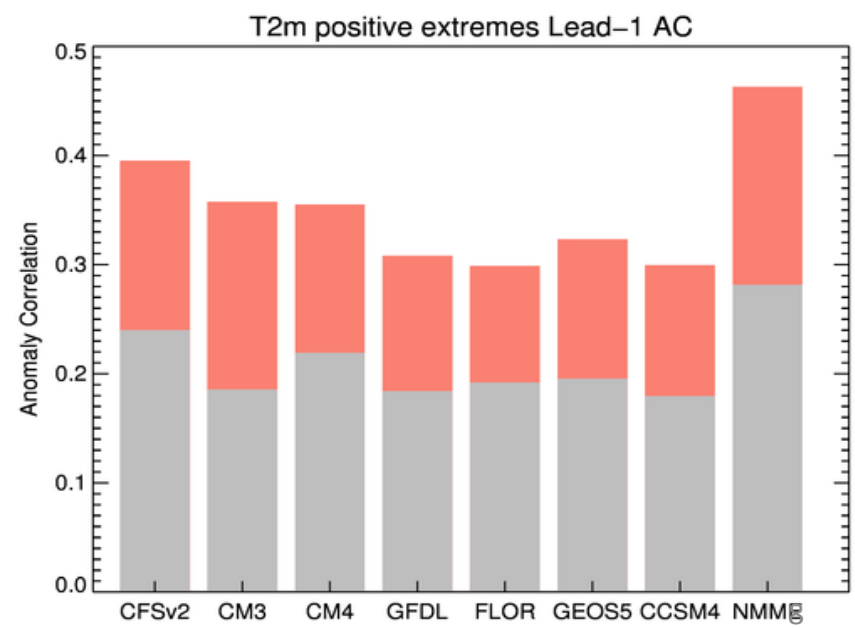


Temperature extremes

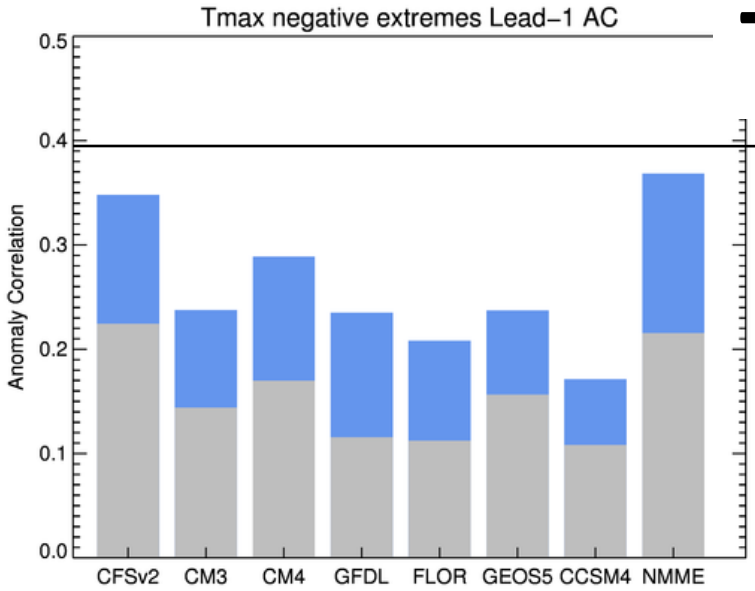
- Decile (top 10% of historical record) determined by fitting Gaussian distribution to observations and forecasts from 1982-2010 at each gridpoint
- $1.282\sigma = 10^{th}$ percentile
- Both high and low extremes
- Forecast verification: there was a forecast for an extreme. Did it come true?
- Deterministic forecasts (forecast for a specific anomaly)
- One-month lead monthly mean forecast

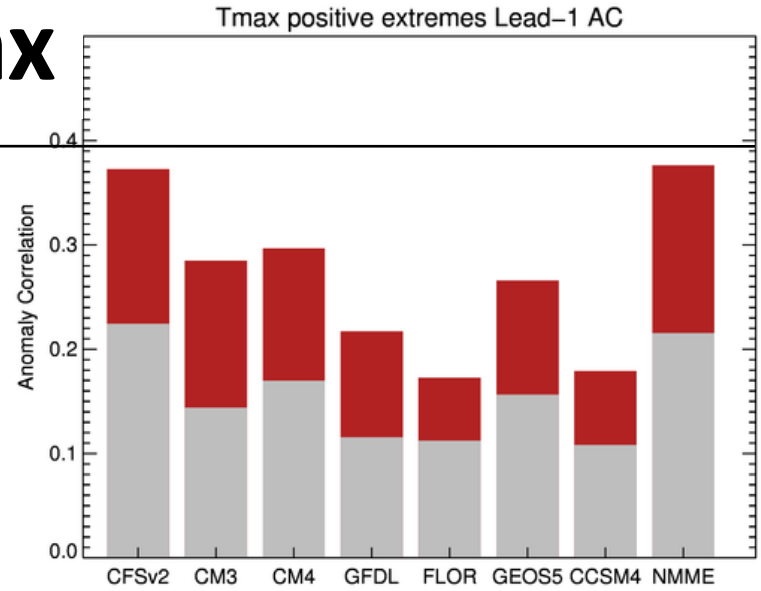
- Anomaly correlation (AC)
- Area-aggregated over North America
- Averaged over all 12 initial conditions
- Cross-validated forecasts from 1982-2010
- Gray bars show all forecasts (same in both figs)
- Upper decile (positive extremes) and lower decile (negative extremes)





Tmax


Tmax negative extremes Lead−1 AC
Anomaly Correlation
0.0
0.1
0.2
0.3
0.4
0.5
CFSv2
CM3
CM4
GFDL
FLOR
GEOS5
CCSM4
NMME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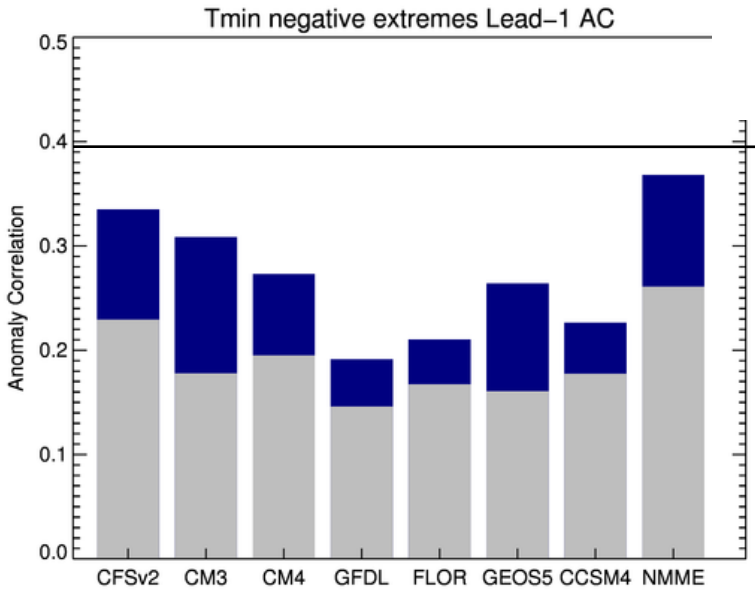
Tmin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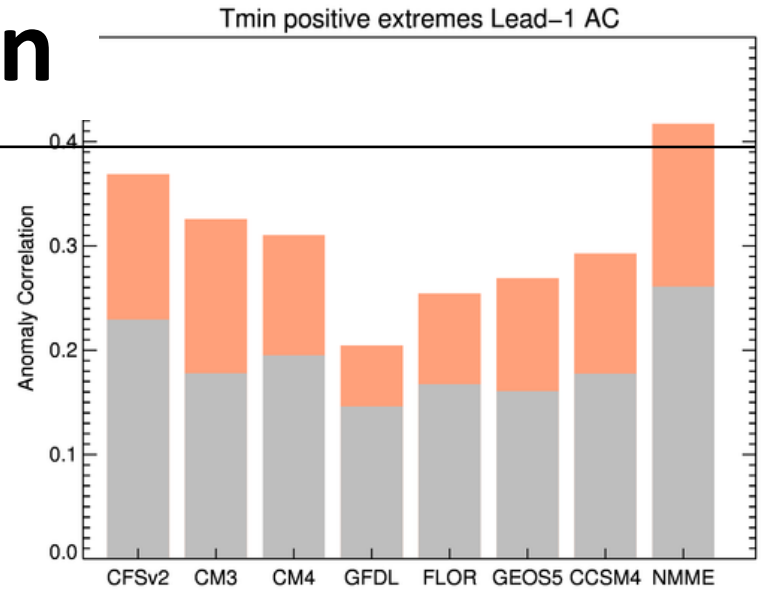
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SEDI score

- Symmetric Extremal Dependence Index (Ferro and Stevenson 2011)
- Non-degenerate for rare events
- Normalizes hit rate using false alarm rate

	Obs Y	Obs N
Fcst Y	a	b
Fcst N	c	d

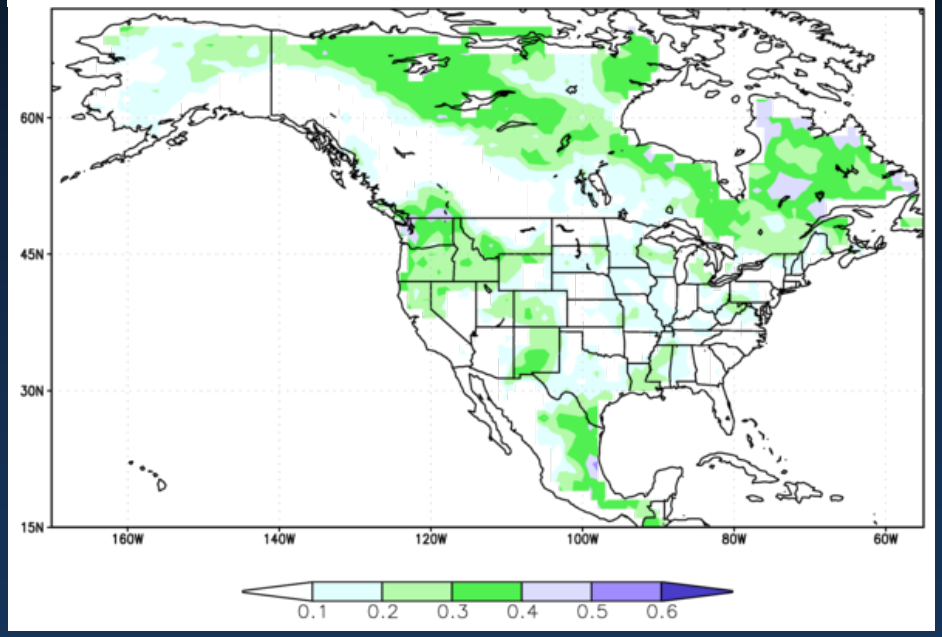
Hit Rate = a/(a+c)

False Alarm Rate = b/(b+d)

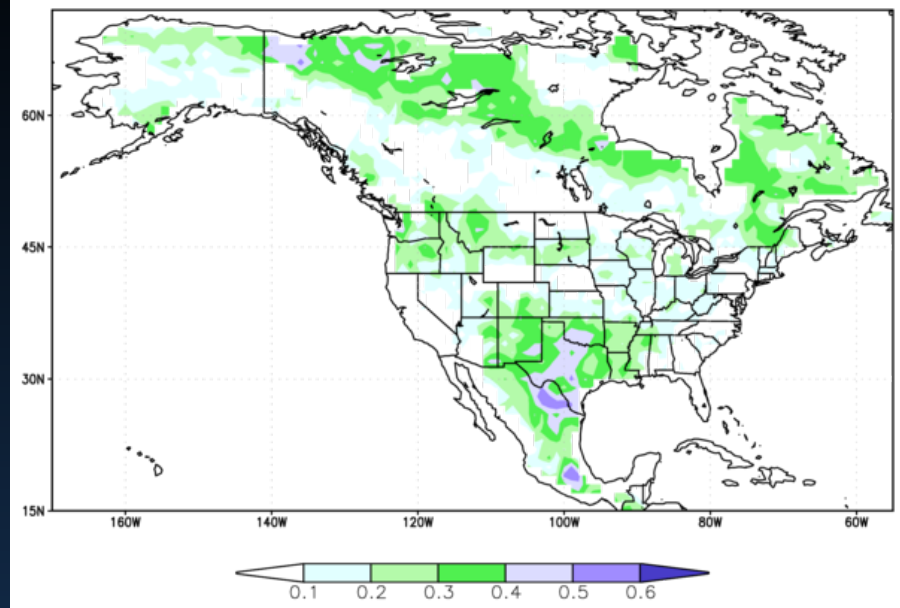
SEDI = 0.2 indicates forecast is 20% better than a random forecast, etc.

Sample includes lead-1 one-month extremes (decile) from all 12 initial conditions

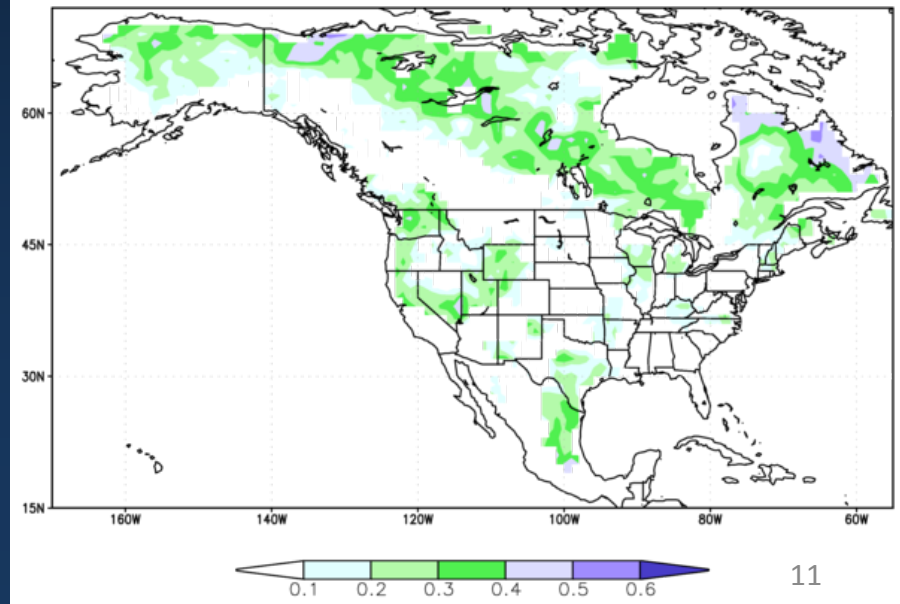
T2m Positive extremes SEDI



Tmax Positive extremes SEDI



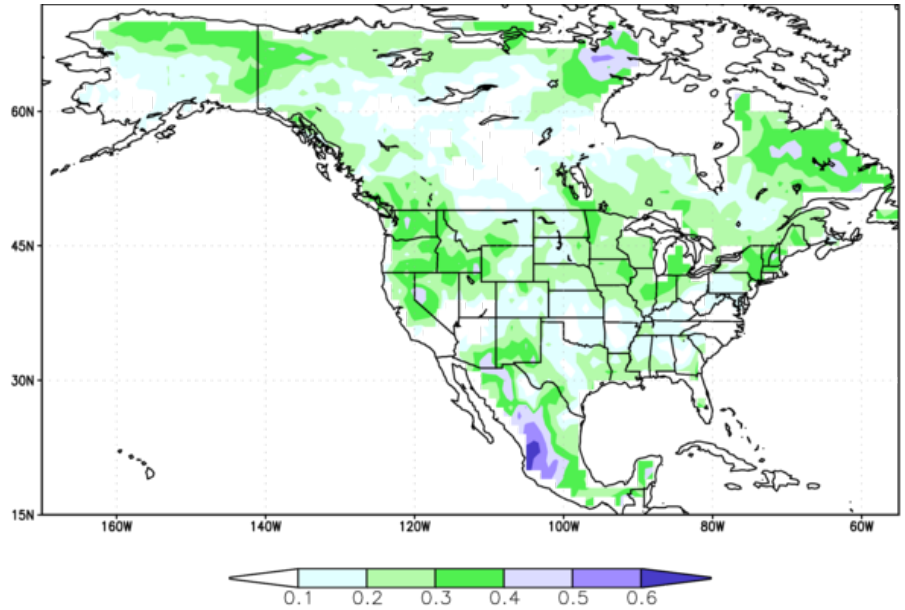
Tmin Positive extremes SEDI



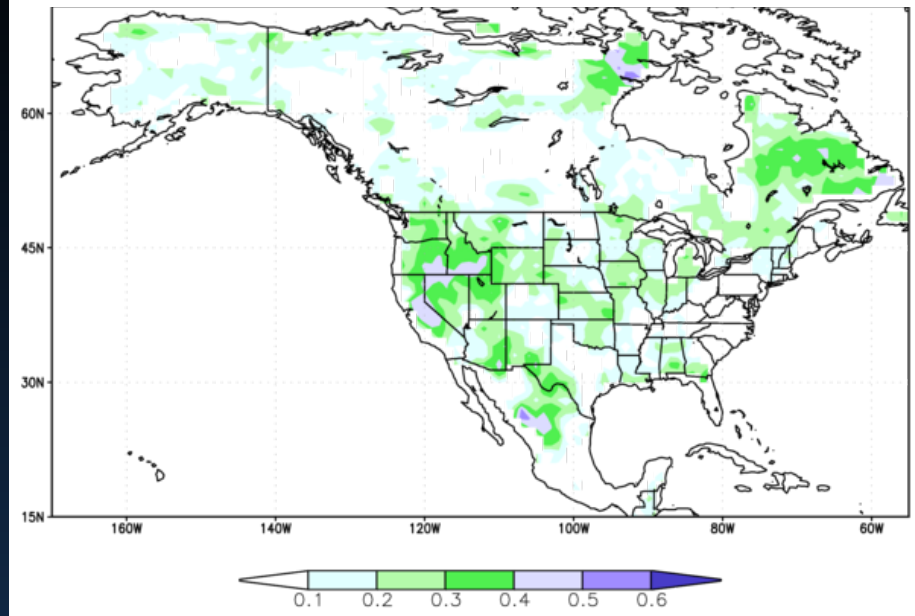
12 IC * 29 yrs * 0.1 ~ 35 events per gridbox.

Sample includes lead-1 one-month extremes (decile) from all 12 initial conditions

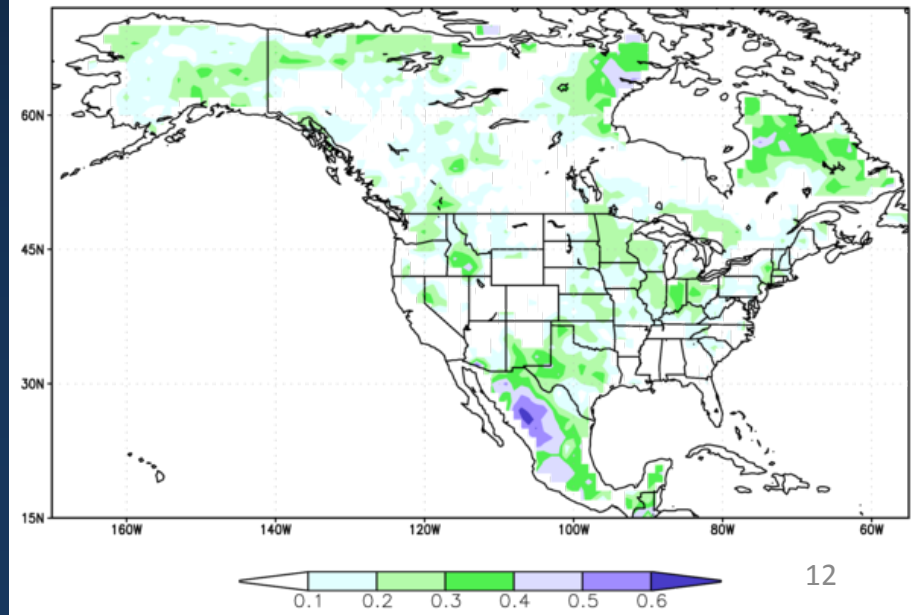
T2m negative extremes SEDI



Tmax negative extremes SEDI



Tmin negative extremes SEDI



Some remarks (mostly more questions)

- Tmax/Tmin mean and extreme provide more information beyond T2m forecasts… but how to make use of this?
- Forecasts for thresholds, e.g. Tmin < 0°C, Tmax > 30°C …?
- Forecasts for negative extremes are somewhat less skillful than positive. In real-time NMME, cold anomalies have been harder to forecast than warm…
- Assumption of normal distribution may not be the best… some regions and some models have a more skewed distribution, especially for Tmax/Tmin.

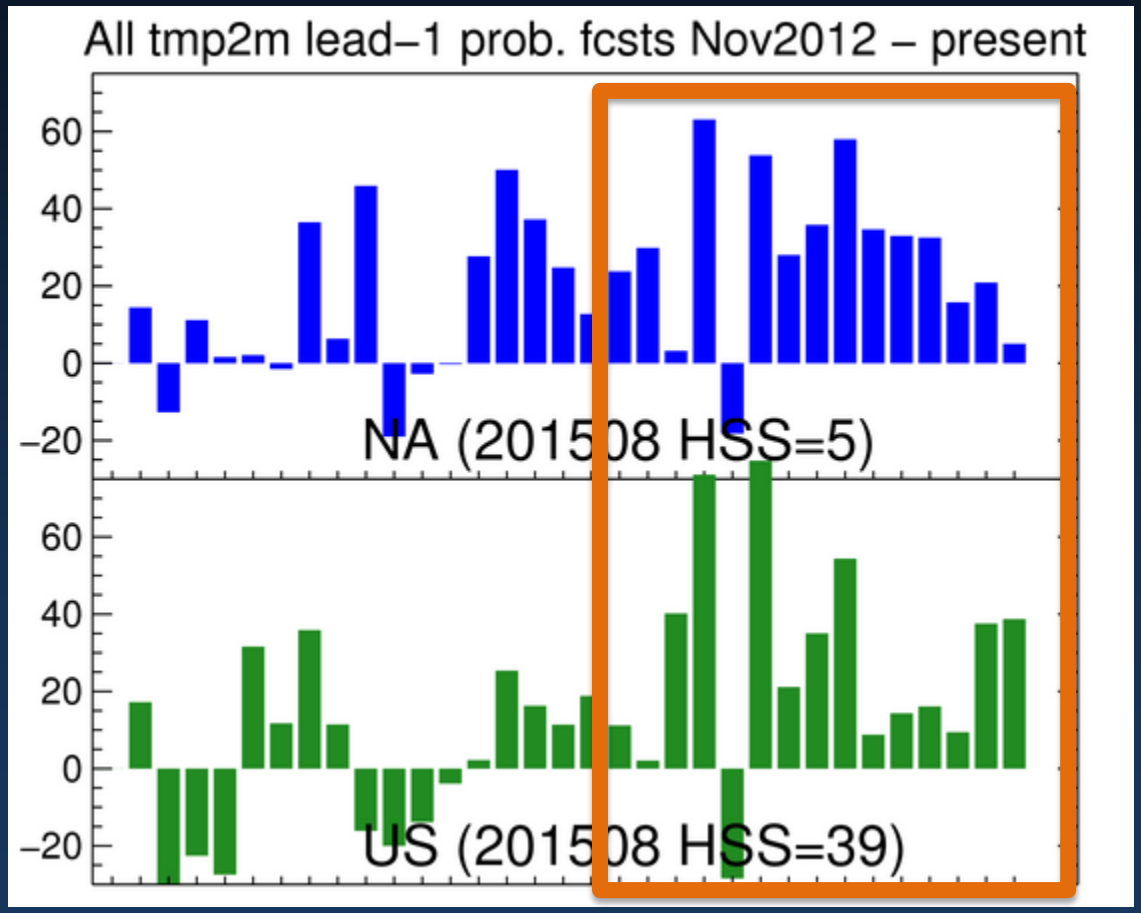
Even more questions

- Probabilistic forecasts: what threshold to use? E.g., a 20% chance for an event with a 10% climatological chance?
- To what extent does a strong probability for a tercile forecast map to an extreme?
- Overall, Tmin is predicted slightly better than Tmax. Tmin is more affected by warming trend…
- What would results look like for the rest of the world? The trend over SE North America is less warm than most other areas…

NMME Phase I Forecasts:

Year 4 in review

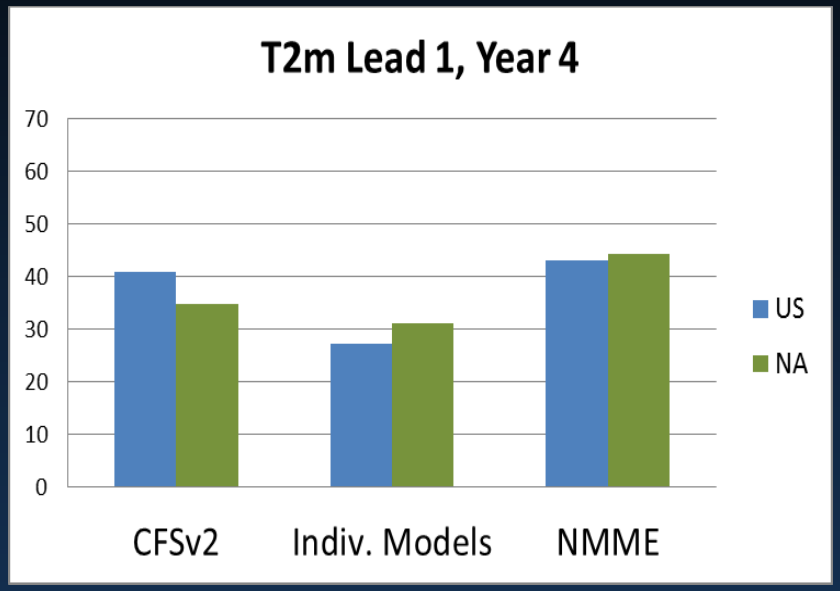
NMME Year 4 verification: T2m probability forecasts

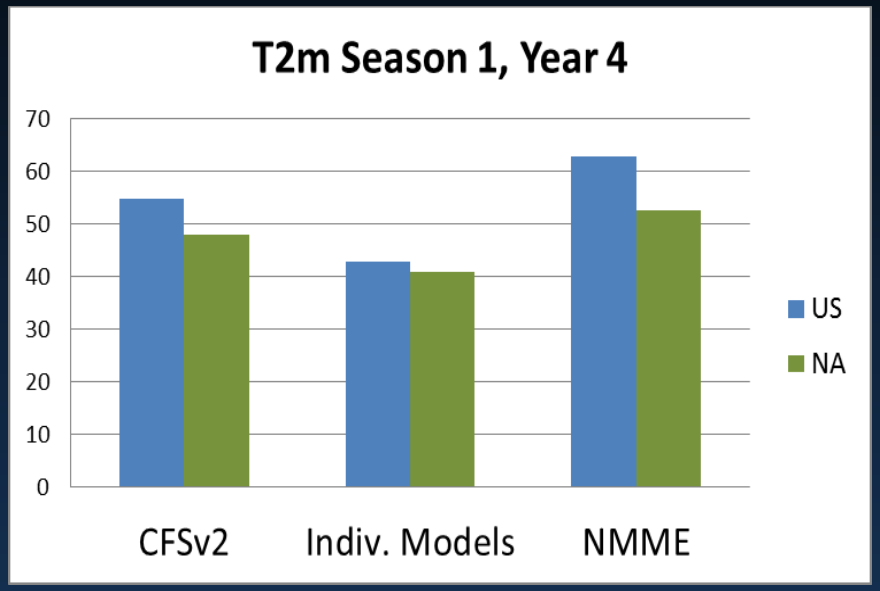


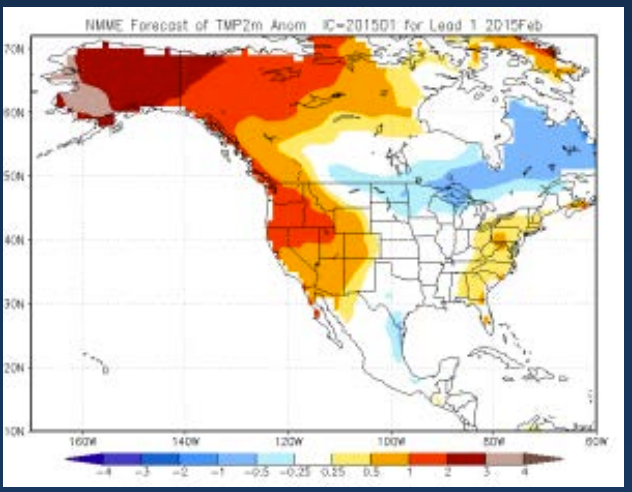
- NA: Lead 1 HSS=27.2
- Seas 1 HSS=25.3 (not shown)

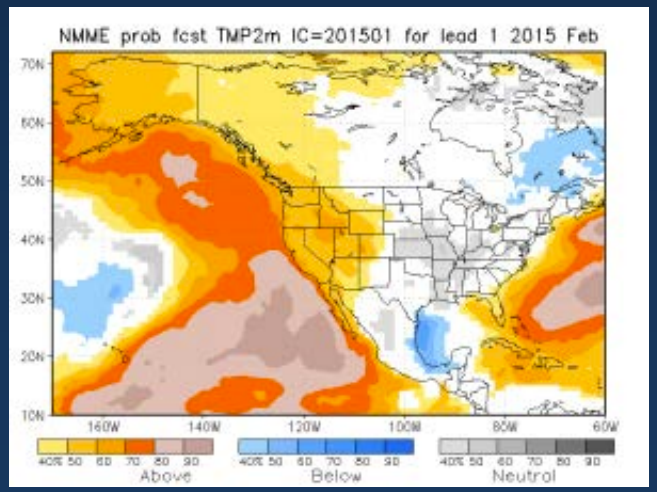
- US: Lead 1 HSS=23.2
- Seas 1 HSS=23.2 (not shown)

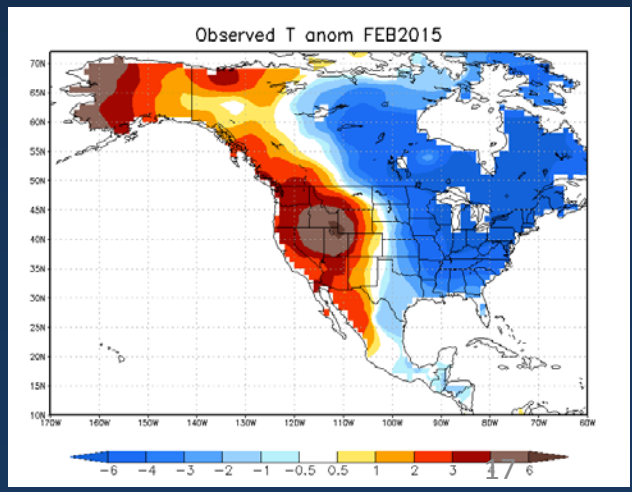
NMME Year 4 verification: T2m anomaly forecasts



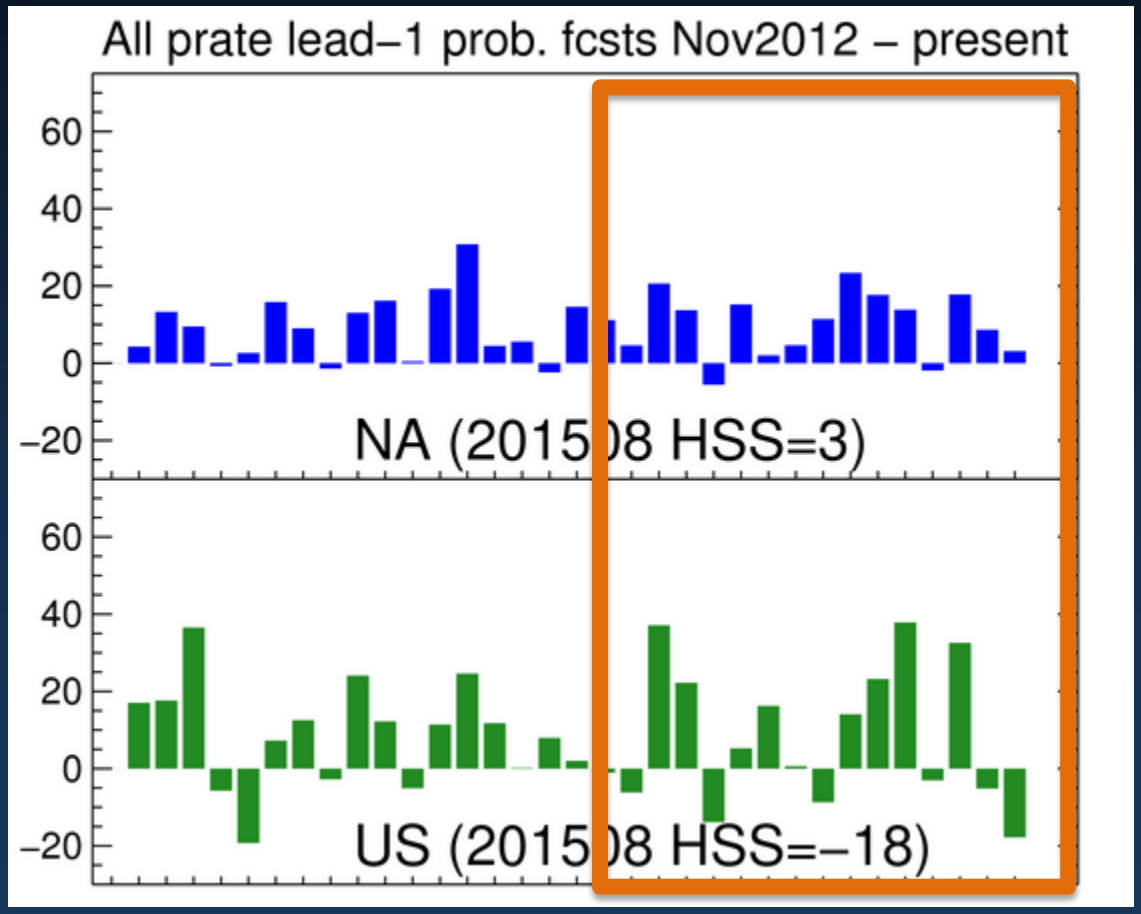








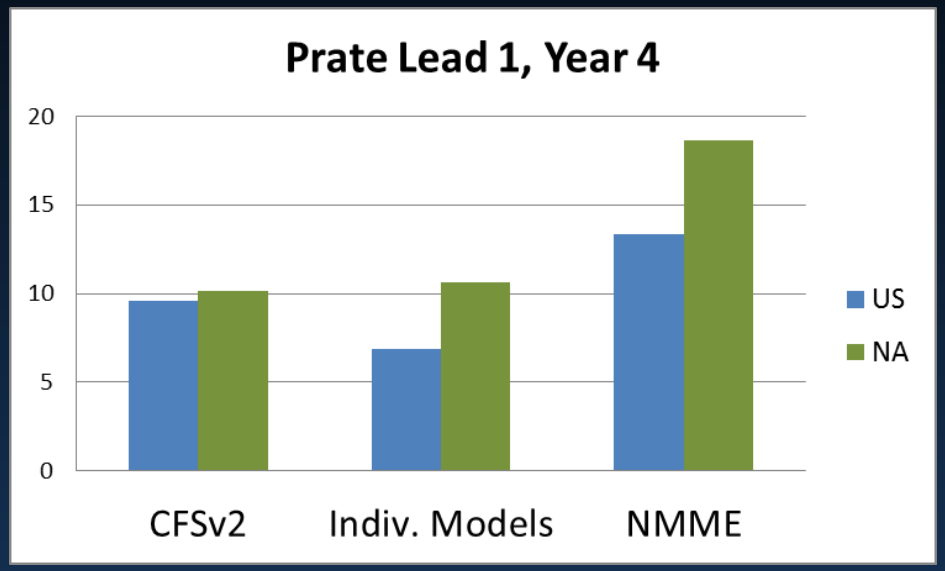
NMME Year 4 verification: Prate probability forecasts

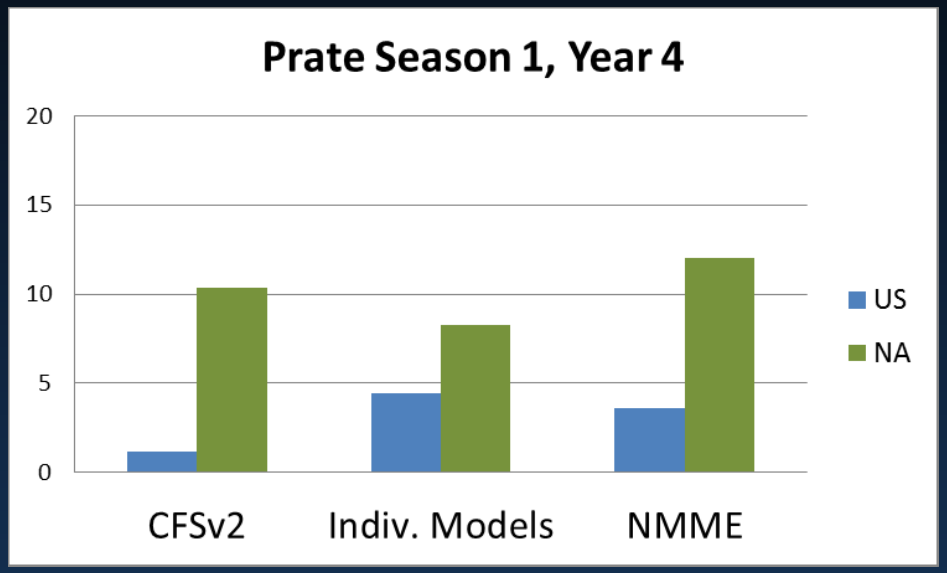


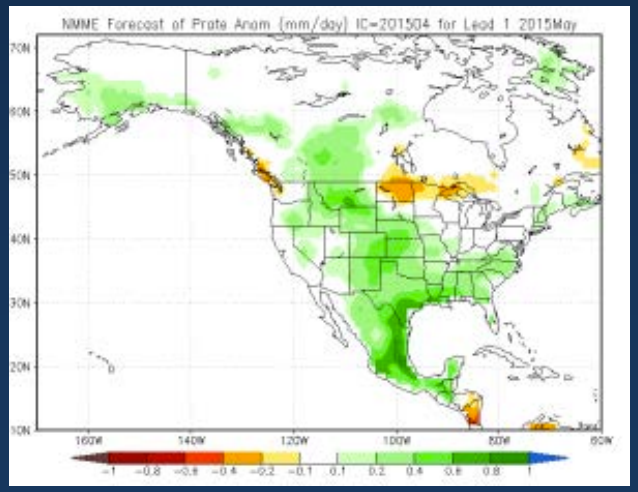
- NA: Lead 1 HSS=10.2
- Seas 1 HSS=8.75 (not shown)

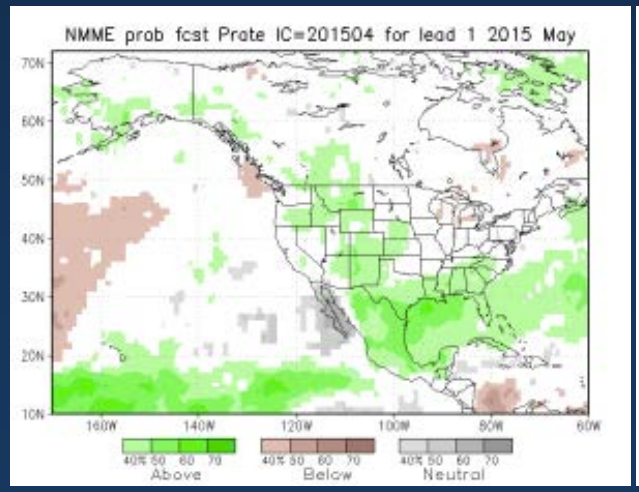
- US: Lead 1 HSS=8.7
- Seas 1 HSS=4.8 (not shown)

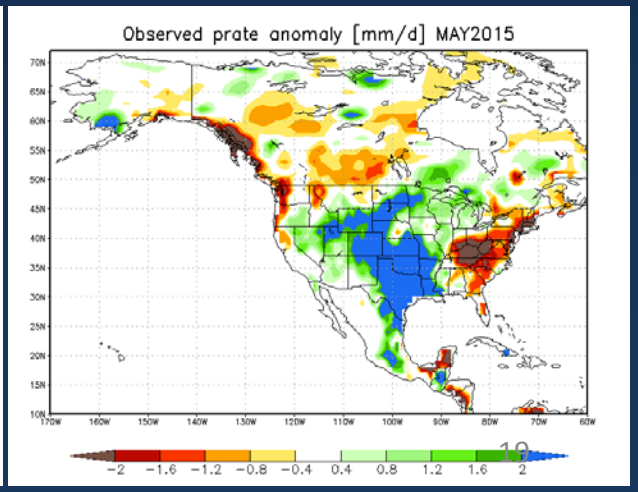
NMME Year 4 verification: Prate anomaly forecasts











Quote from Huug van den Dool, July 2011

[advice to me as I am building the NMME webpage]:

"Just set it up through 2014. There's no way this project will go on past then."

Tmax/Tmin verification data

- Thanks to CPC's Wei Shi for providing his Version 1 global, daily, 0.5° x 0.5° gridded Tmax/Tmin data. Generated from CADB reports.
- Averaged to monthly, regridded to 1° x 1°
- Likely has some issues over Canada due to known station metadata problems. (Hence "Version 1"!)
- This study focuses on North America; future work may expand to global
- Monthly mean (T2m) verification uses GHCN+CAMS (Fan and van den Dool 2008); (Tmax+Tmin)/2=T2m