A Conditional Skill Mask for Improved Seasonal Predictions

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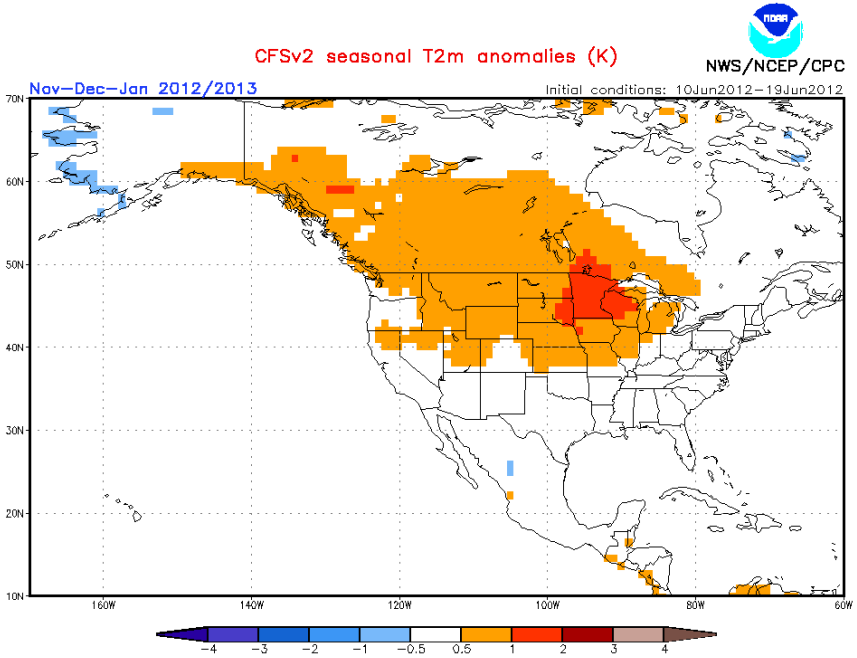
CIRES

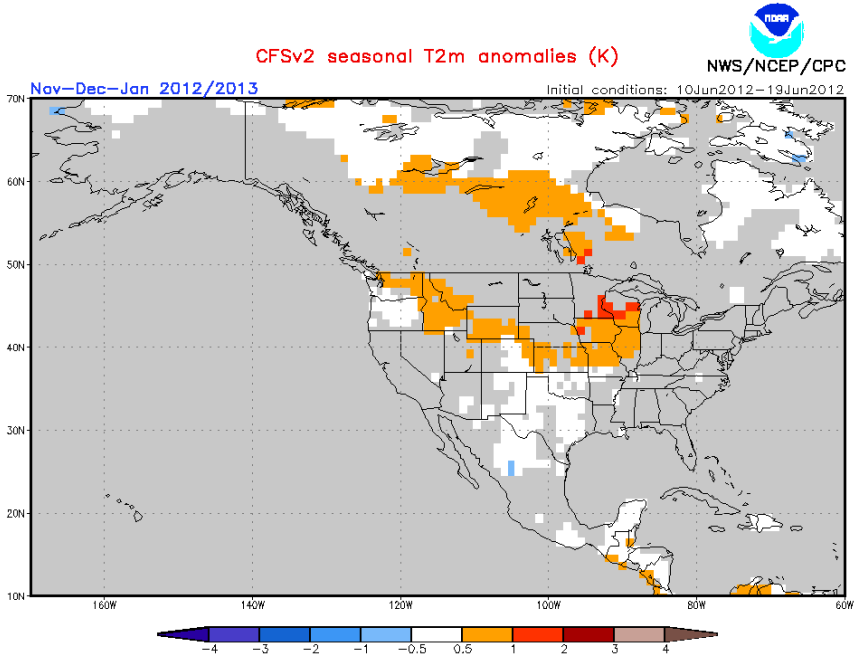
What is a Skill Mask?

ICs: 20120609 -20120619

CFSv2 T2M Forecast



CFSv2 Forecast w/Skill Mask Applied



(Areas of expected skill less than 0.3 are shaded in grey.)

- Skill Mask is Determined from Re-forecasts
- Average anomaly correlation skill over 1982-2009
- Function of initial month and lead-time
- *Average* AC skill < 0.3 is considered not skillful

Skill mask is a simple model to forecast forecast skill

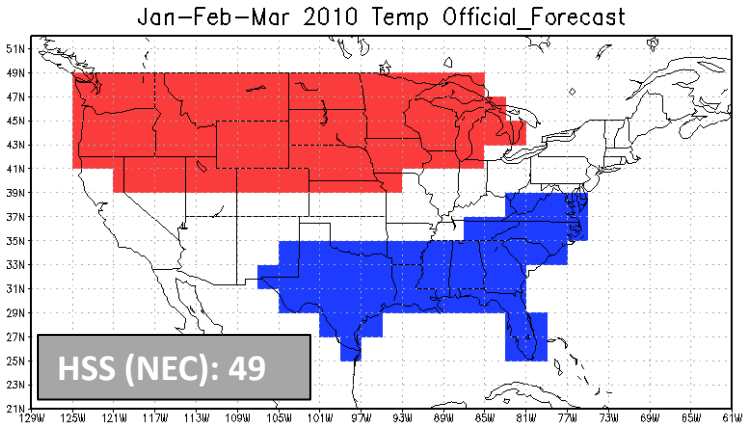
From NOAA/NWS/NCEP/CPC (http://www.cpc.ncep.noaa.gov/products/people/wwang/cfsv2fcst/)

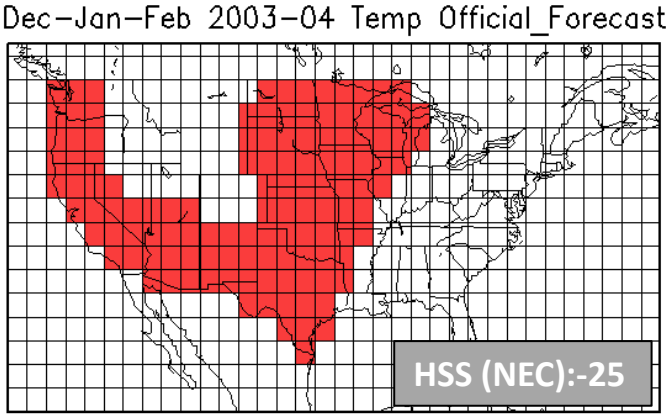
Forecast Skill Varies From Year-to-Year Due to ENSO

ONI=1.4

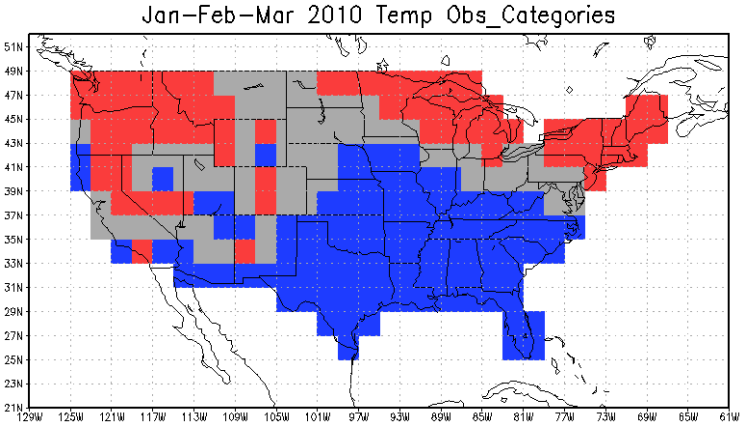
CPC Official Forecast

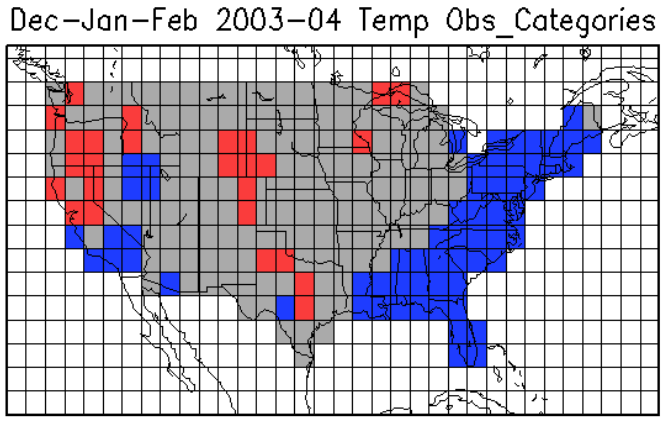
ONI=0.3





OBS





From NOAA/NWS/NCEP/CPC (http://www.cpc.ncep.noaa.gov/products/predictions/long_range/tools/briefing/seas_veri.grid.php)

Can we improve seasonal forecasts by creating a skill mask that is conditional upon ENSO?

Data & Methodology

Data

- CFSv2 Re-forecasts (24 ensemble members per month, 1982-2009)
- 0, 3, 6-month leads
- U.S. 2m Temperature & Precipitation

Perfect Model Approach

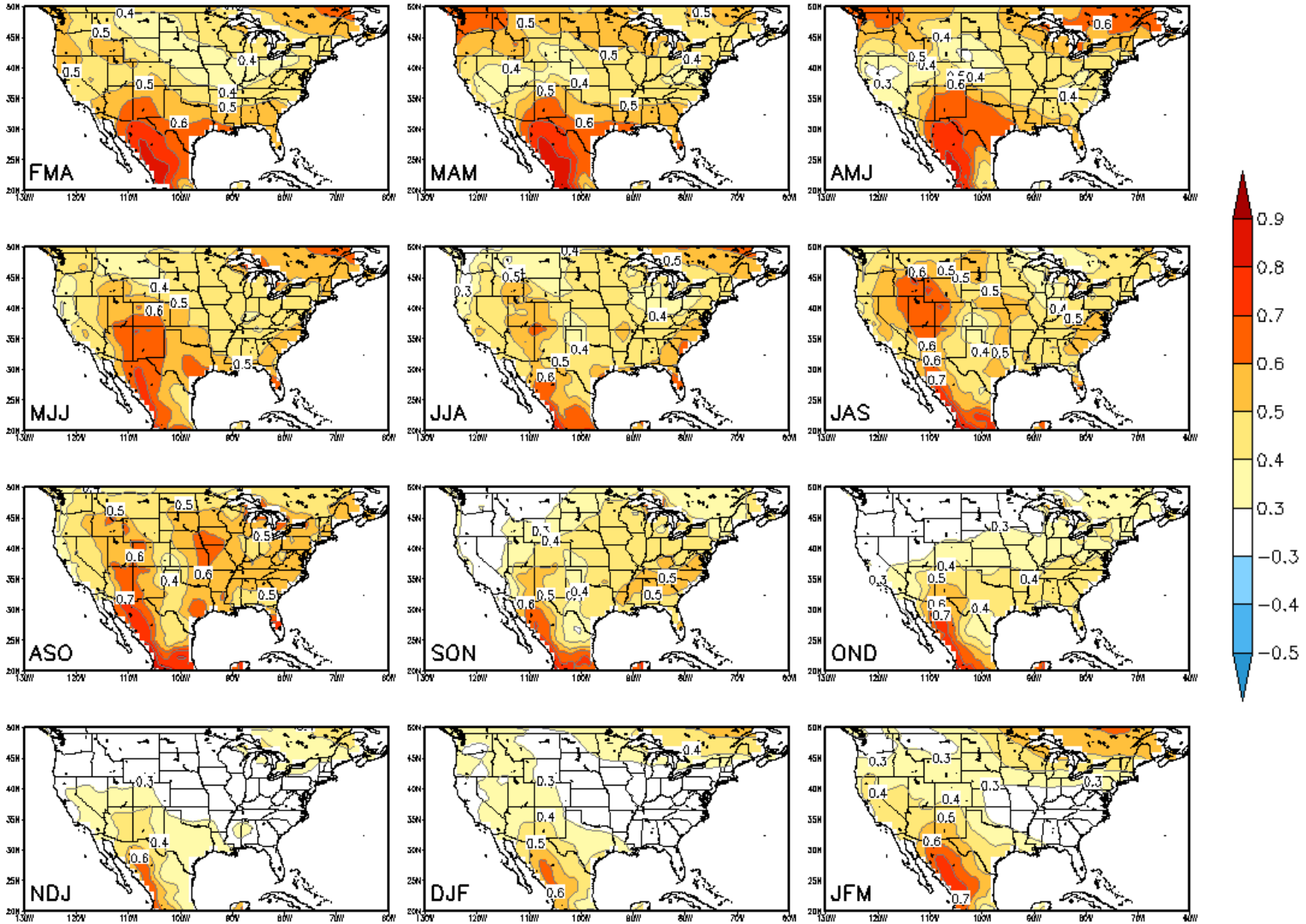
- Withhold one ensemble member as “truth” and determine forecast using the other 23 members. Repeat for all members.

- Expected Conditional (year-to-year) Anomaly Correlation for a given lead-time, based on the signal-to-noise ratio (S) and number of ensemble members:

$$r_n(t) = \frac{S^2(t)}{\left\{\left[S^2(t)+1\right]\left[S^2(t)+\frac{1}{n}\right]\right\}^{1/2}}$$

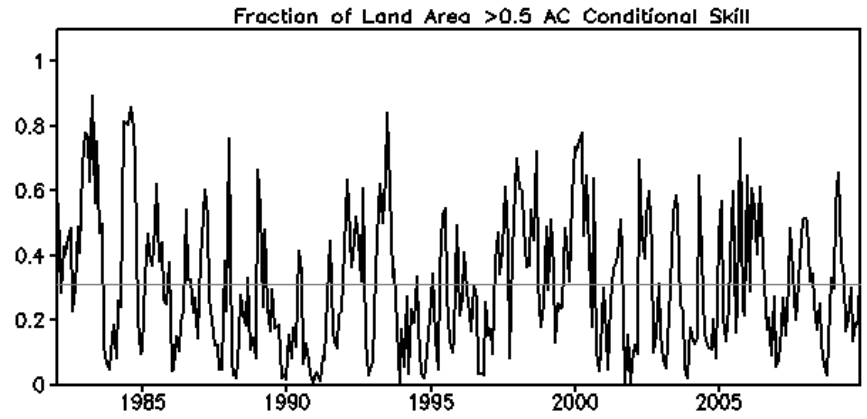
$$S = \frac{\|ensemble\ mean\ anomaly\|}{\|ensemble\ spread\|}$$

“Unconditional” or Average Correlation Skill
0-month lead CFSv2 Perfect Model Forecasts (1982-2009)
2m Temperature

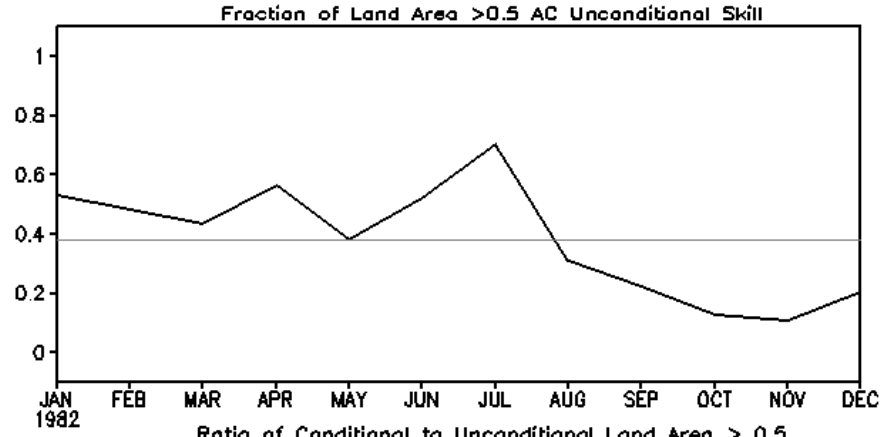


Conditional (Year-to-Year) Perfect Model Skill: 0-lead, 2m Temperature

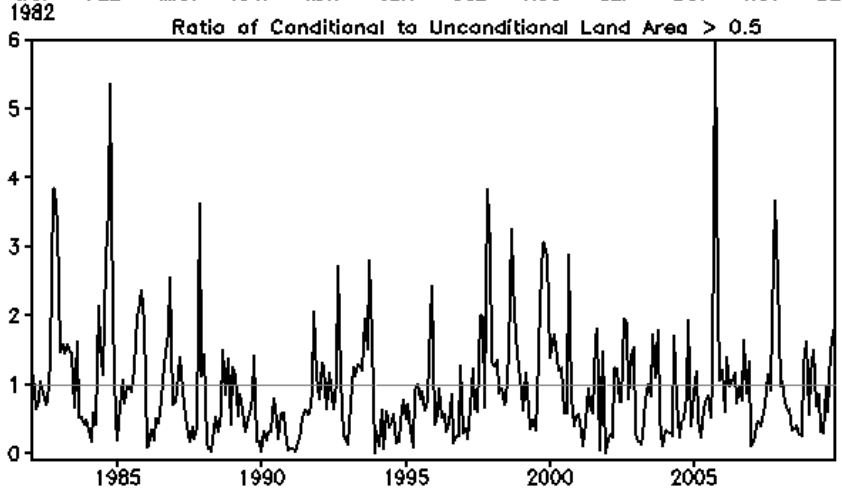
Conditional



Unconditional



Ratio of Conditional to Unconditional



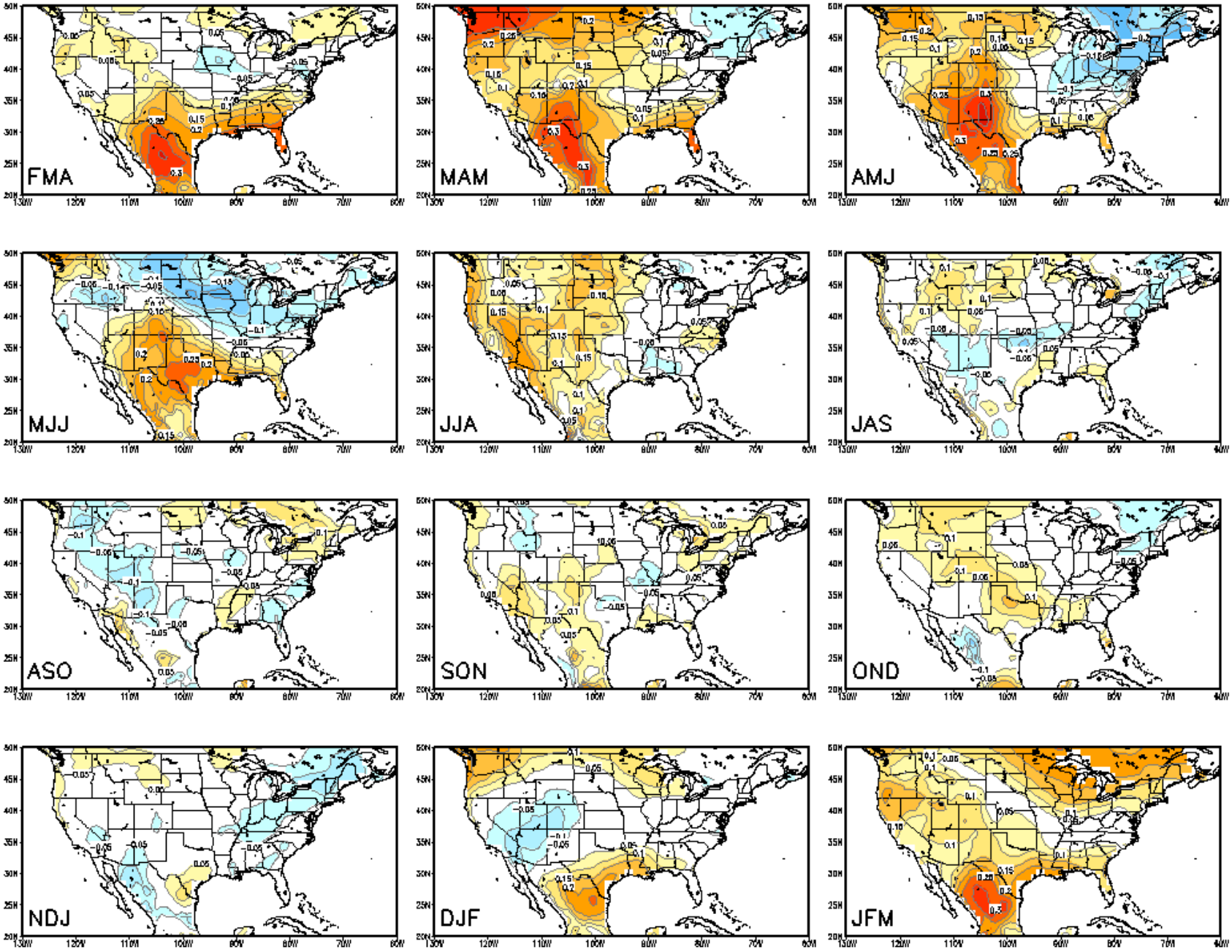
Is Nino3.4 a good predictor of Forecast Skill?

Regression model of Perfect Model Conditional Forecast Skill with Nino3.4 as a predictor:

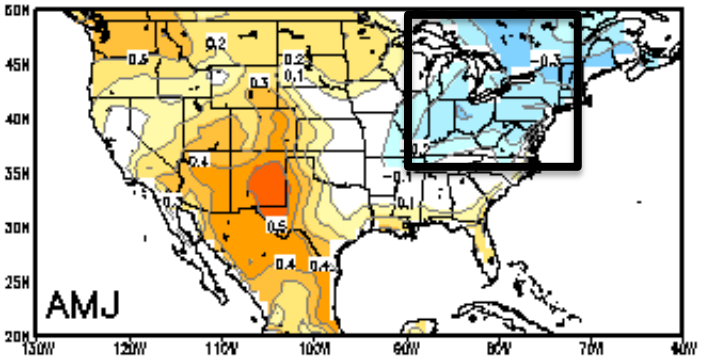
$$y_{i,j,l}(seas, year) = m_{i,j,l}(seas) * x_l(seas, year) + b_{i,j,l}(seas)$$

i=lons, j=lats, l=lead-time
Y=Perfect Model Forecast Skill (Anomaly Correlation)
X=ABS(Nino3.4); simultaneous ensemble mean forecast

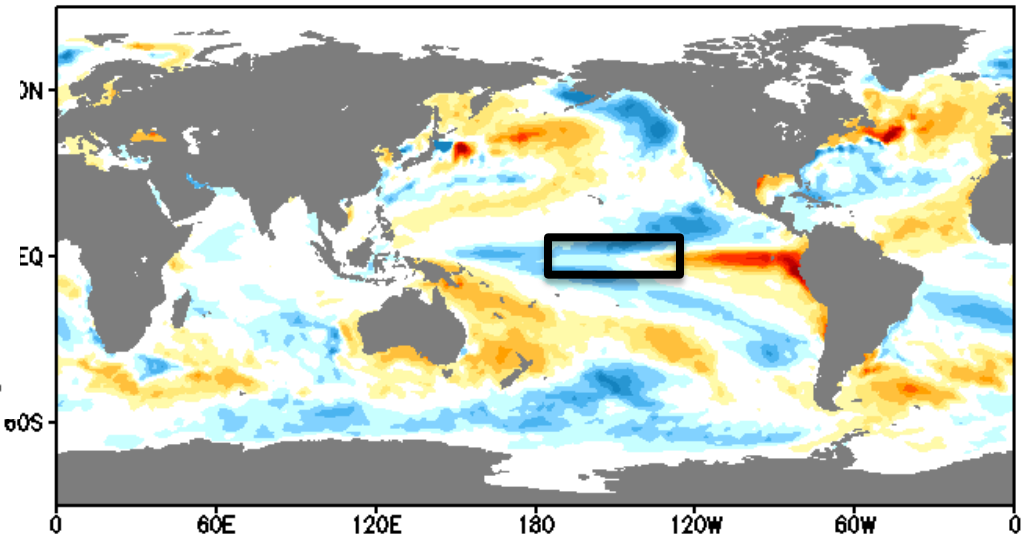
Regression between Conditional Skill and ABS(NINO34) (units: correlation/std)
0-month lead; 2m Temperature

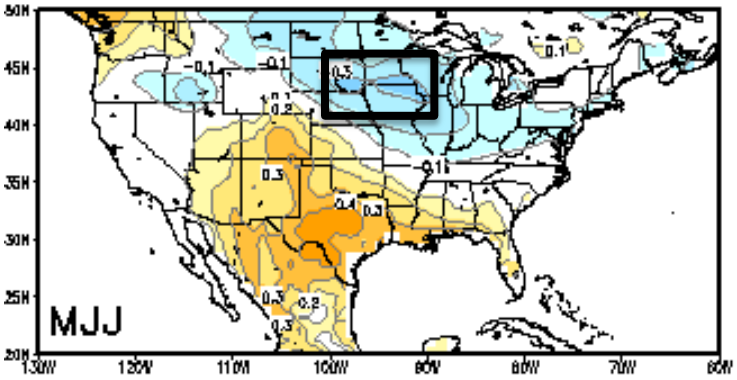


0-month Lead T2M Skill Regressed w/0-lead SST Anomalies

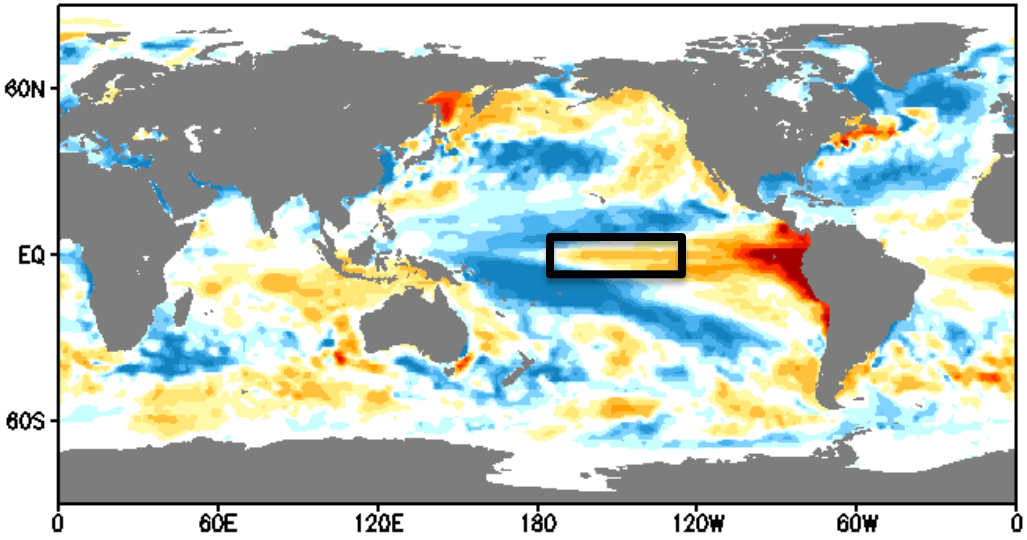


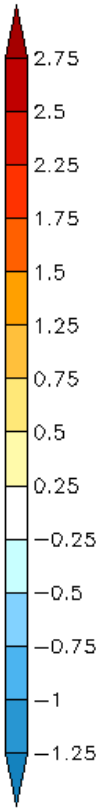
Northeast U.S. Apr-May-Jun



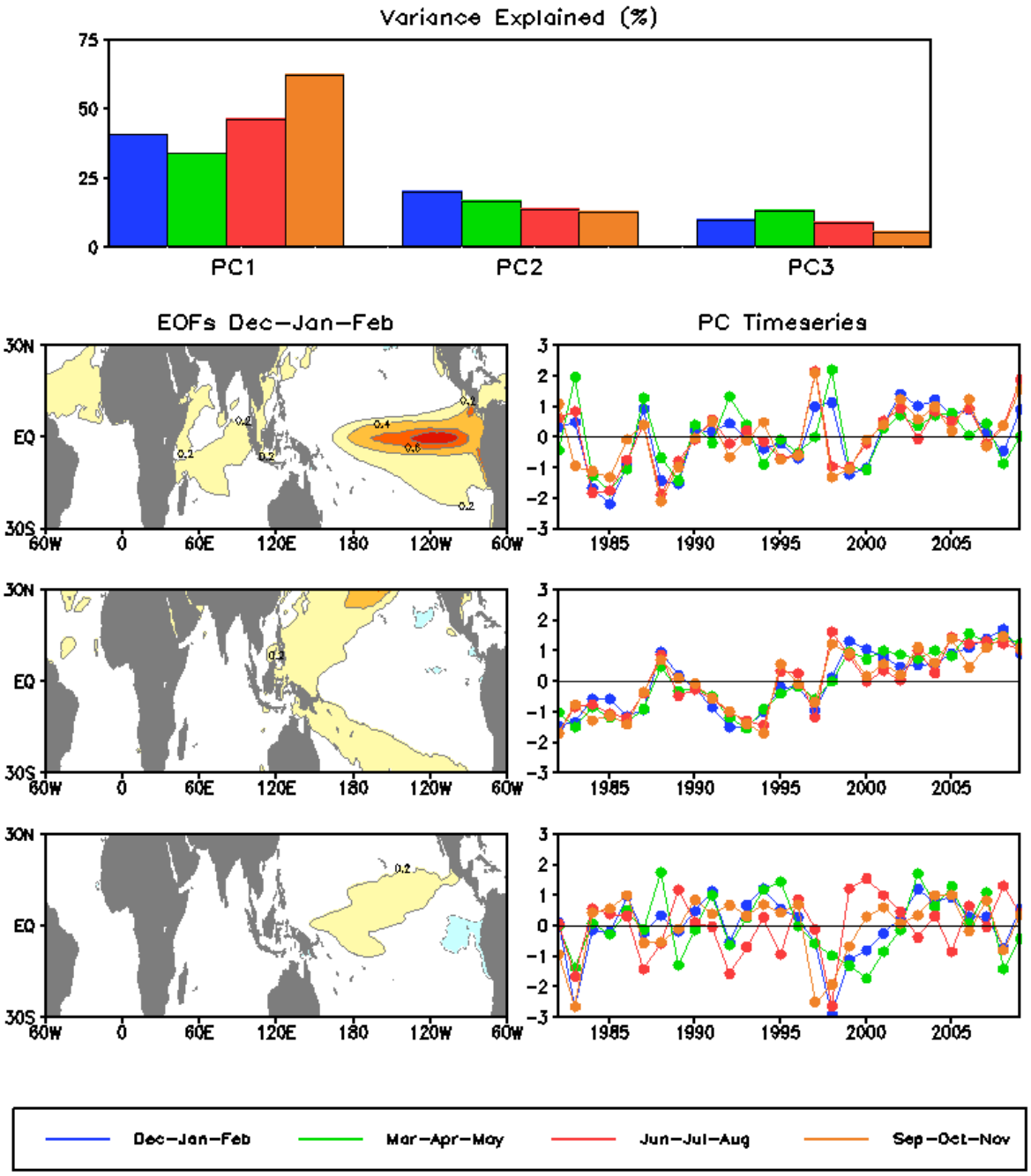


North Central U.S. May-Jun-Jul





Is There a Better Predictor?



Is PC1 a good predictor of Forecast Skill?

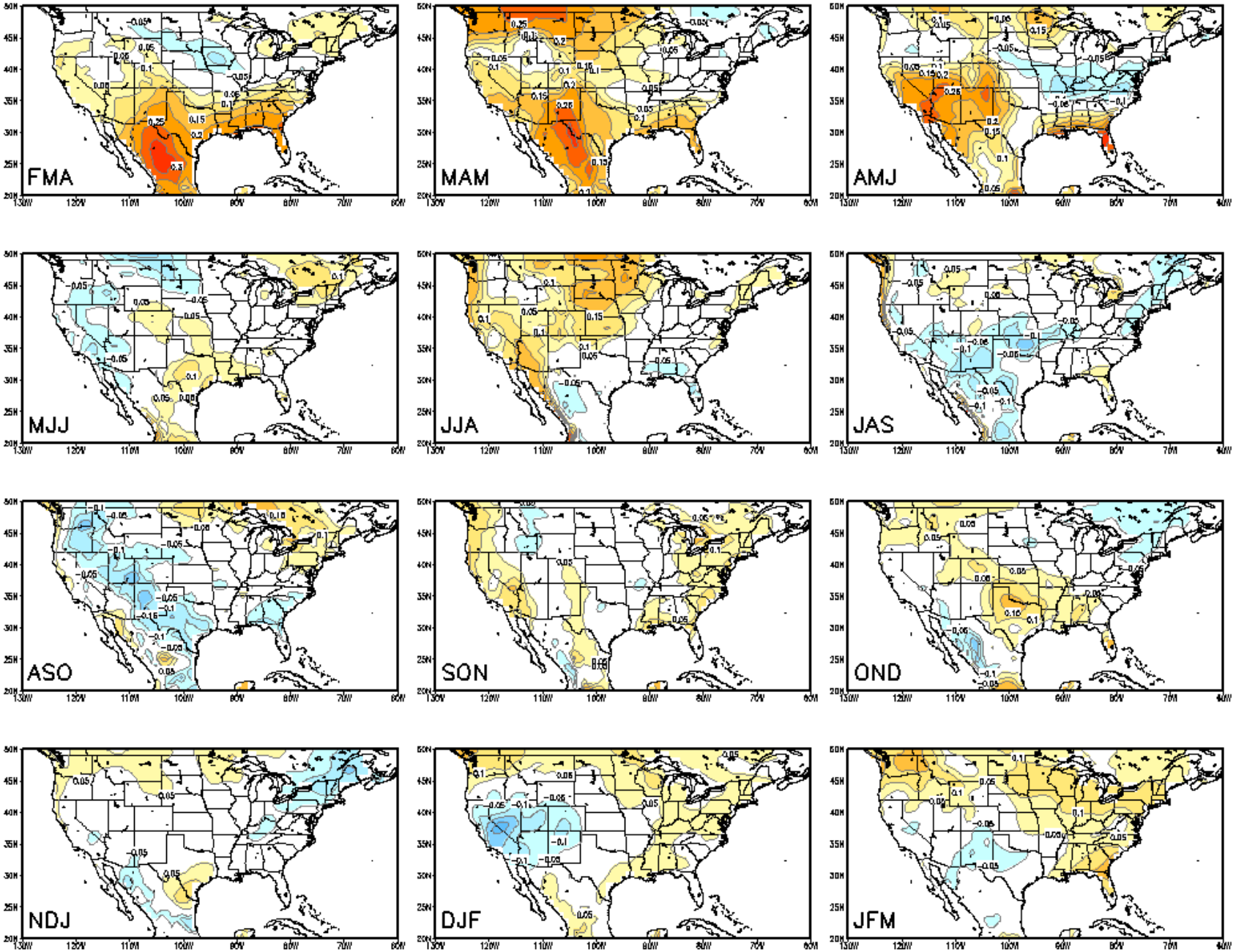
Regression model of Perfect Model Conditional Forecast Skill with PC1 as a predictor:

$$y_{i,j,l}(seas, year) = m_{i,j,l}(seas) * x_{i,j,l}(seas, year) + b_{i,j,l}(seas)$$

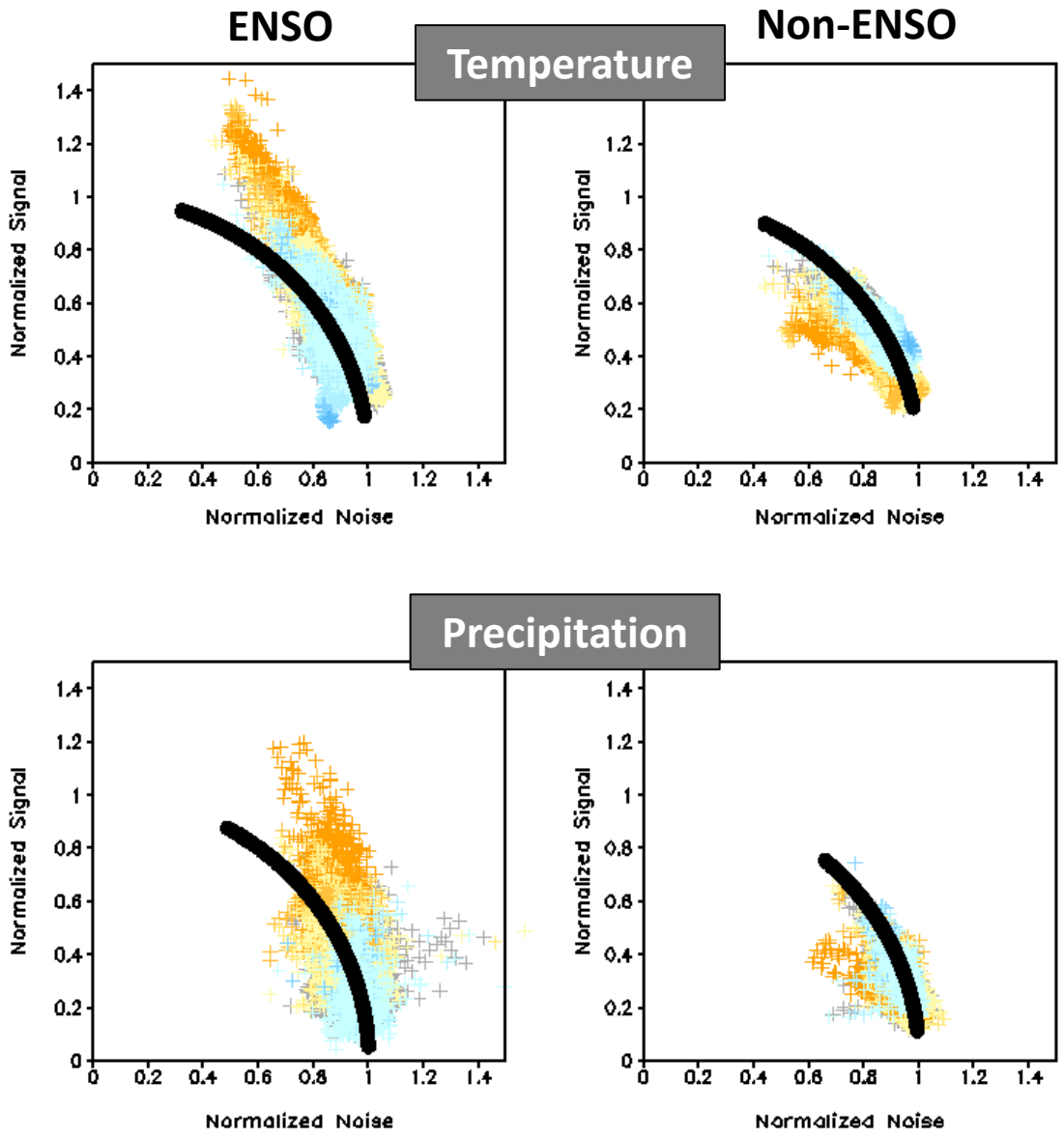
i=lons, j=lats, l=lead-time (0-month lead)

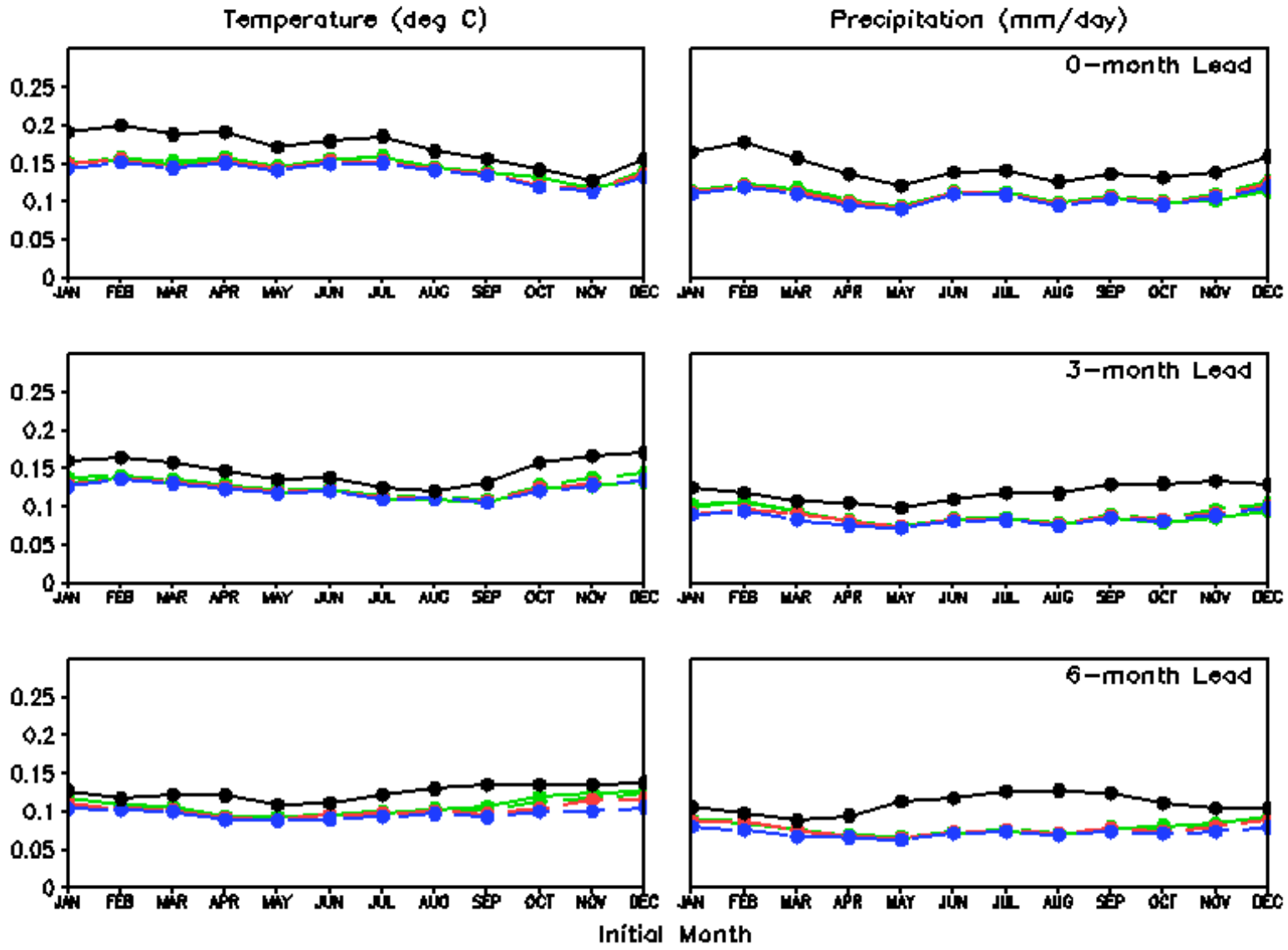
Y=Perfect Model Forecast Skill (Anomaly Correlation)
X=ABS(PC1); simultaneous ensemble mean forecast

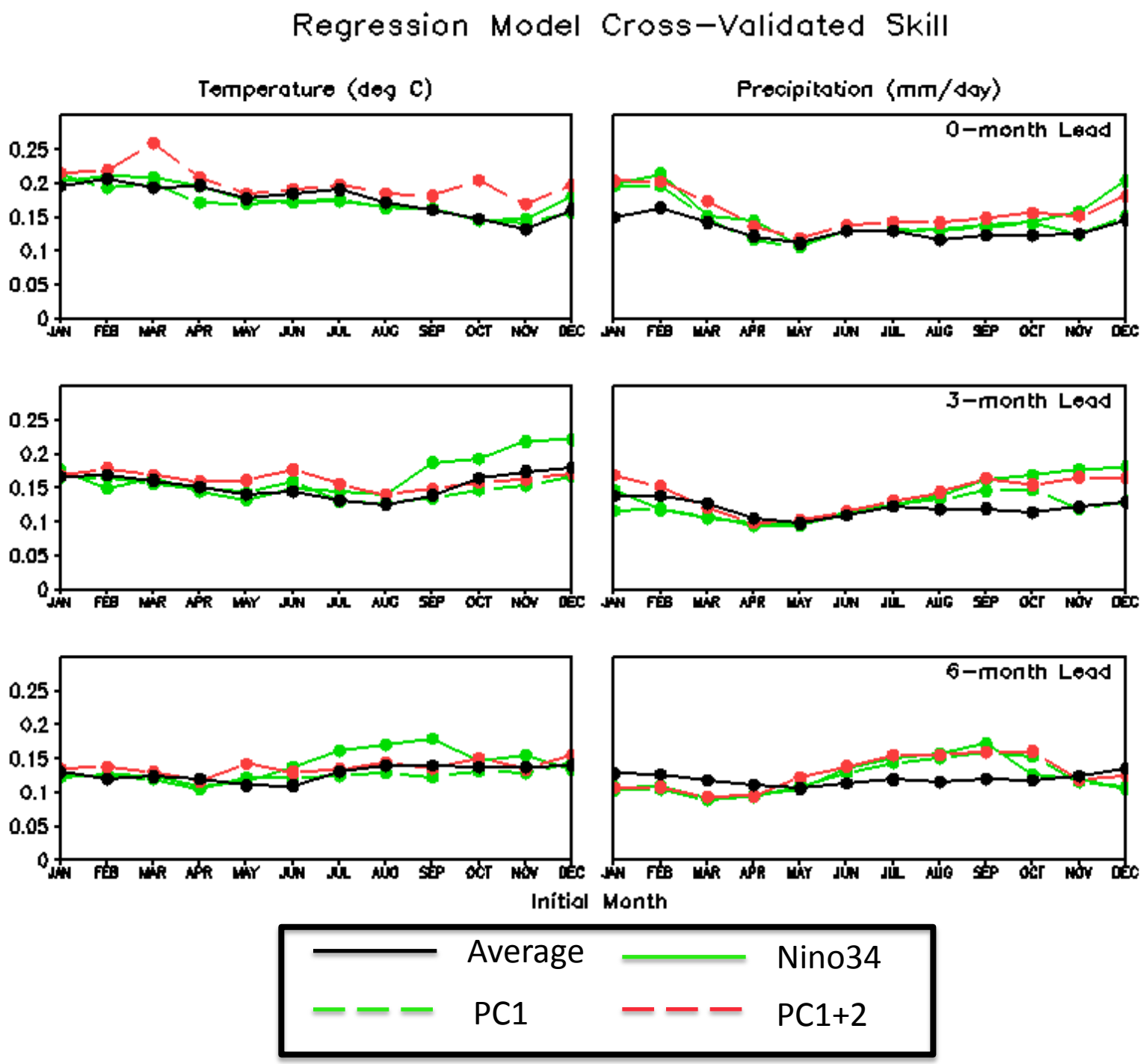
Regression between Conditional Skill and ABS(PC1) (units: correlation/std)
0-month lead; 2m Temperature



Signal vs. Noise

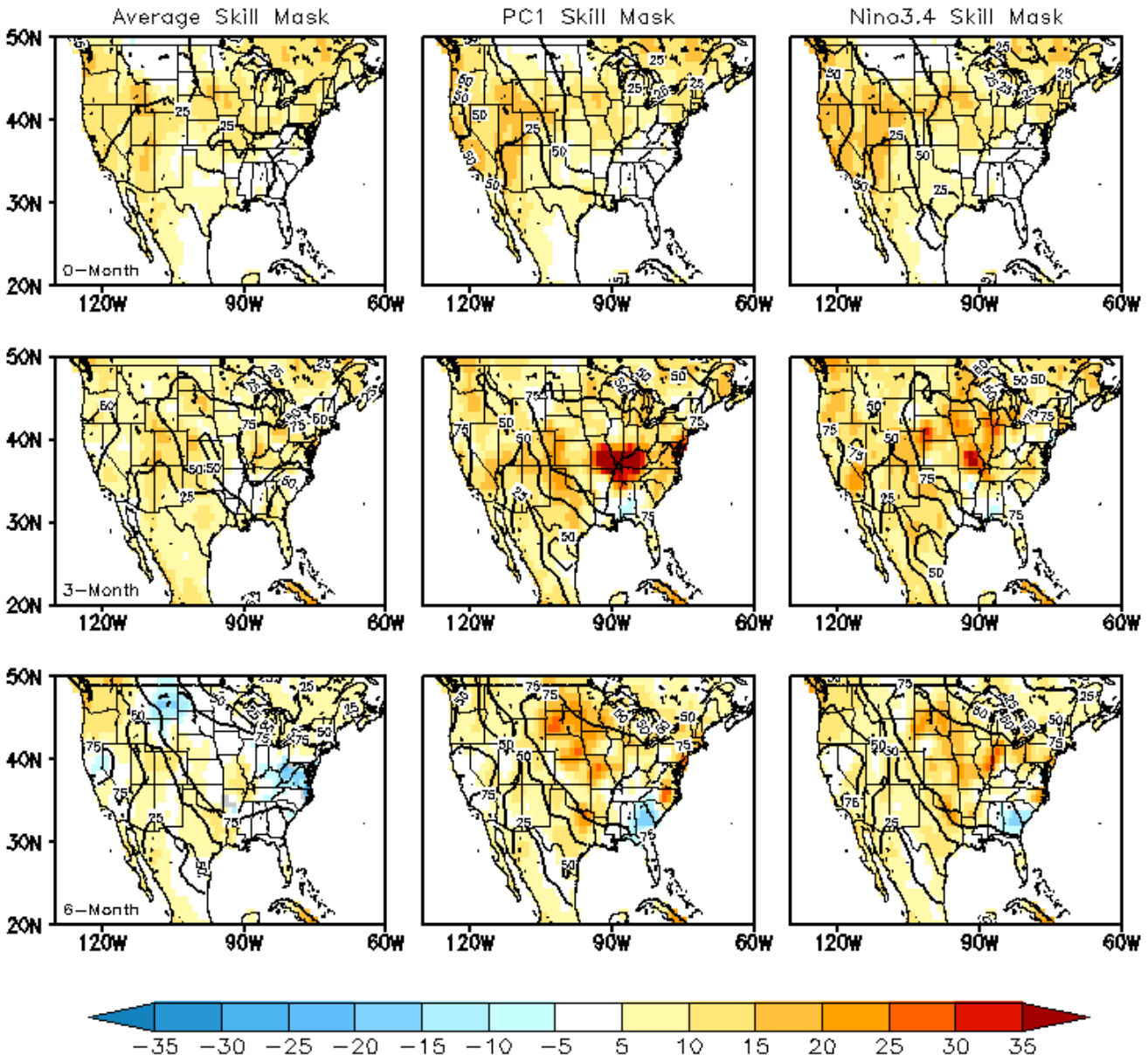



Regression Model RMSE Fit
Temperature (deg C)
Precipitation (mm/day)
0-month Lead
3-month Lead
6-month Lead
0.25
0.2
0.15
0.1
0.05
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Initial Month
Average
Nino34
PC1
PC1+PC2
PC1+PC2+PC3

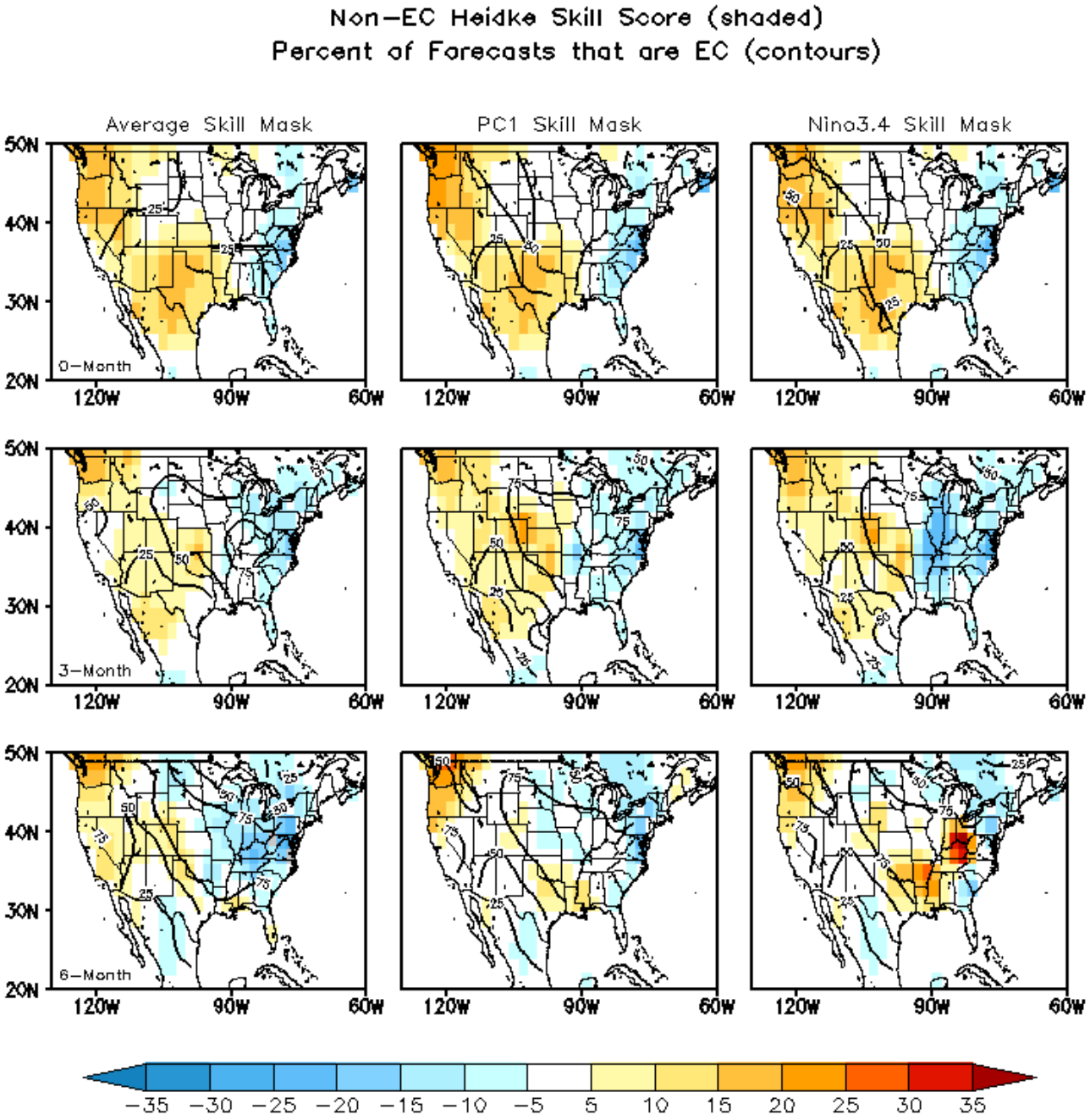

Regression Model Cross-Validated Skill
Temperature (deg C)
Precipitation (mm/day)
0-month Lead
3-month Lead
6-month Lead
0.25
0.2
0.15
0.1
0.05
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Initial Month
Average
Nino34
PC1
PC1+2

Perfect Model Tercile Seasonal Forecasts (T2M)

Non-EC Heidke Skill Score (shaded)
Percent of Forecasts that are EC (contours)



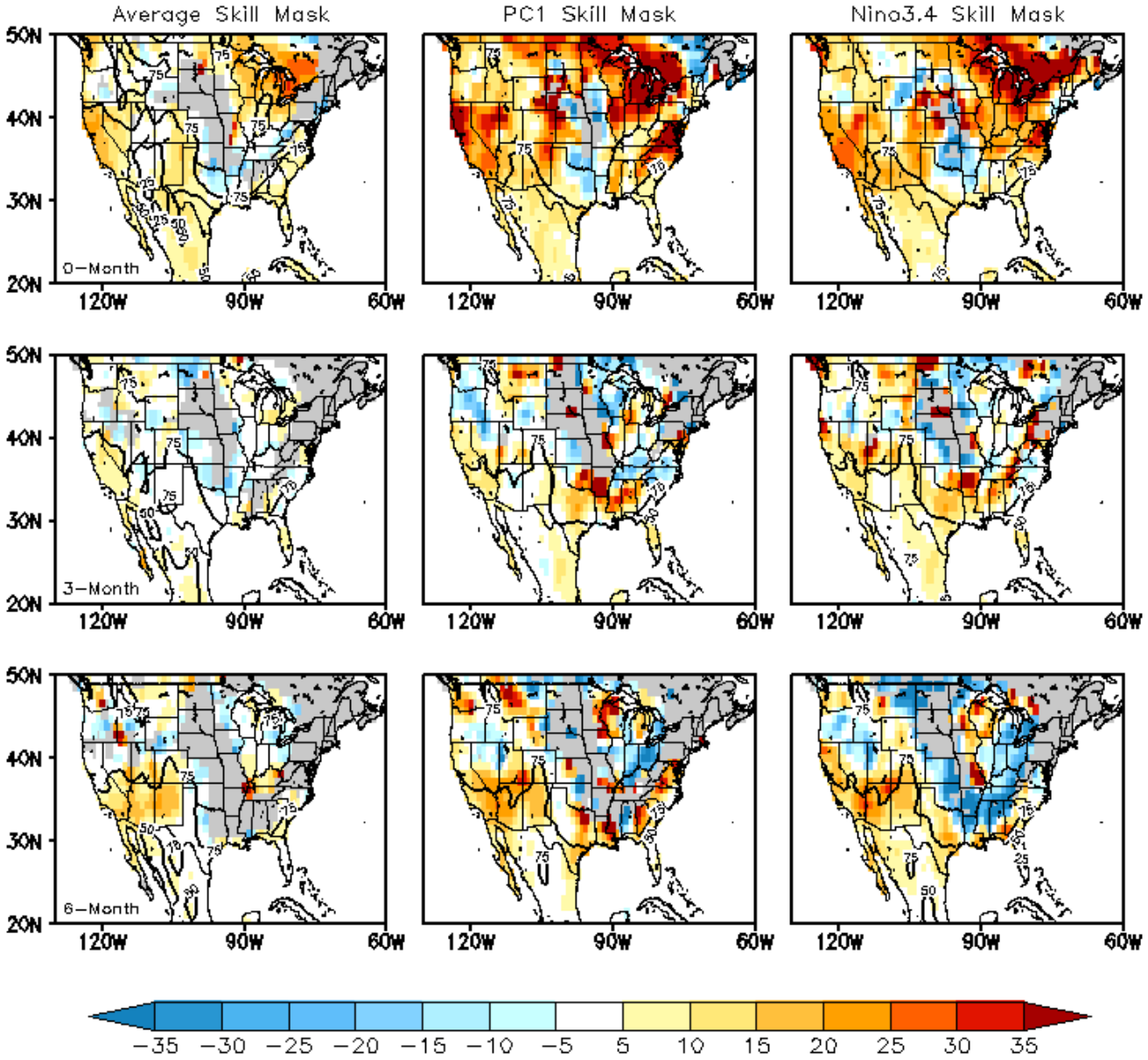
Real World Tercile Seasonal Forecasts (T2M)



Perfect Model Tercile Seasonal Forecasts (Precip)

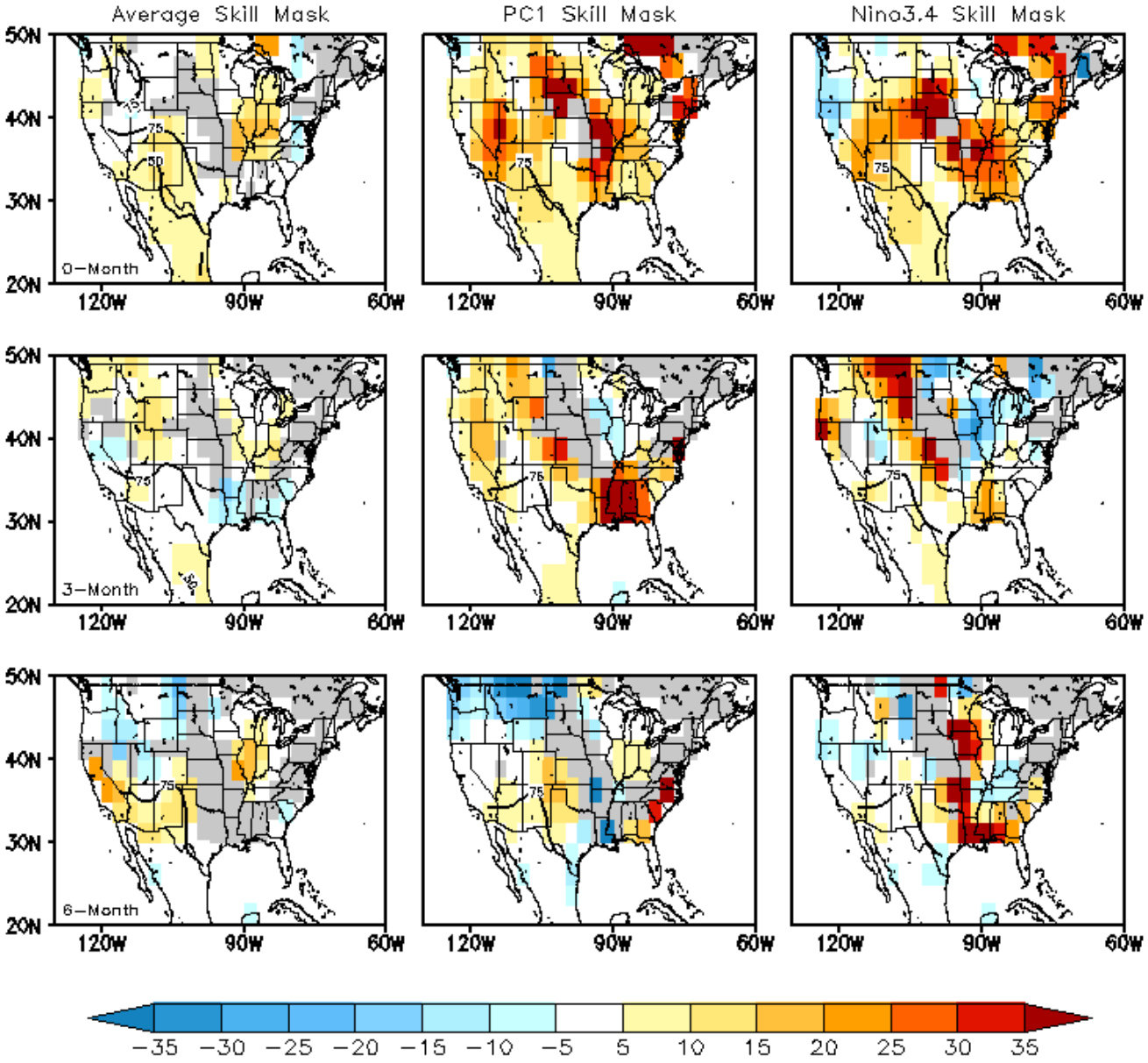
Non–EC Heidke Skill Score (shaded)

Percent of Forecasts that are EC (contours)



Real World Tercile Seasonal Forecasts (Precip)

Non-EC Heidke Skill Score (shaded)
Percent of Forecasts that are EC (contours)



Conclusions

1. Nino3.4 does not appear to be an ideal predictor of forecast skill for T2M because it cannot capture growing and decaying states of ENSO.

2. A seasonal EOF-based ENSO predictor is slightly better than Nino3.4 at predicting T2M and Precip perfect model skill for some seasons.

3. An average model is as good as or better than an ENSO-based regression model in predicting perfect model forecast skill.

4. Including higher PCs does not improve the regression model's ability to forecast forecast skill.

1. When the average and conditional masks are applied to probabilistic seasonal tercile forecasts the ENSO-based skill masks appear to offer some benefit over an average skill mask, although this varies with lead-time and region (and maybe season?).

2. At longer leads the ENSO-based masks have regions of both large forecast skill improvement and large forecast busts when compared to the average skill mask. It is not clear if this would be beneficial in an operational forecast environment.