Evaluation of Multi-Model Ensemble System for Monthly and Seasonal Prediction

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Acknowledgement: the entire NMME Team

NMME Forecast Models

(Real-time August 2012-April 2014)

NMME Forecast providers YEAR 2&3

Model name	Period	Members	Arrangement of Members	Lead (months)	Model resident Resolution: Atmosphere	Model resident Resolution: Ocean	Reference
NCEP-CFSv2	1982-2010	24(28)	4 members (0,6,12,18Z) every 5th day	0-9	T126L64	MOM4 L40 0.25 deg Eq	Saha et al. (2010)
GFDL-CM2.1	1982-2010	10	All 1st of the month 0Z	0-11	2x2.5deg L24	MOM4 L50 0.30 deg Eq	Delworth et al. (2006)
CMC1-CanCM3	1981-2010	10	All 1st of the month 0Z	0-11	CanAM3 T63L31	CanOM4 L40 0.94 deg Eq	Merryfield et al. (2012)
CMC2-CanCM4	1981-2010	10	All 1st of the month 0Z	0-11	CanAM4 T63L35	CanOM4 L40 0.94 deg Eq	Merryfield et al. (2012)
NCAR-CCSM3.0	1982-2010	6	All 1st of the month**	0-11	T85L26	POP L40 0.3 deg Eq	Kirtman and Min (2009)
NASA	1981-2010	11	1 member every 5th day and 6 additional member by pertrubation	0-8	1x1.25deg L72	MOM4 L40 1/4 deg at Eq	Rienecker et al. (2008)

Evaluation of NMME Hindcast

- Initial Conditions: All months of 1982-2010
- Verify variables: Precipitation, SST and T2m
- Equal weight for six models: CFSv2/NCEP, CM2.1, CCSM3.0, CanCM3 and CanCM4, GEOS5/NASA
- Bias correction by model climatology
- Verification observation:

  SST: OISST-QD (1982-2010)

  Prate.: CMAP (1982-2010)

  T2m:GHCN_CAMS (1982-2010)

NMME Systematic Error

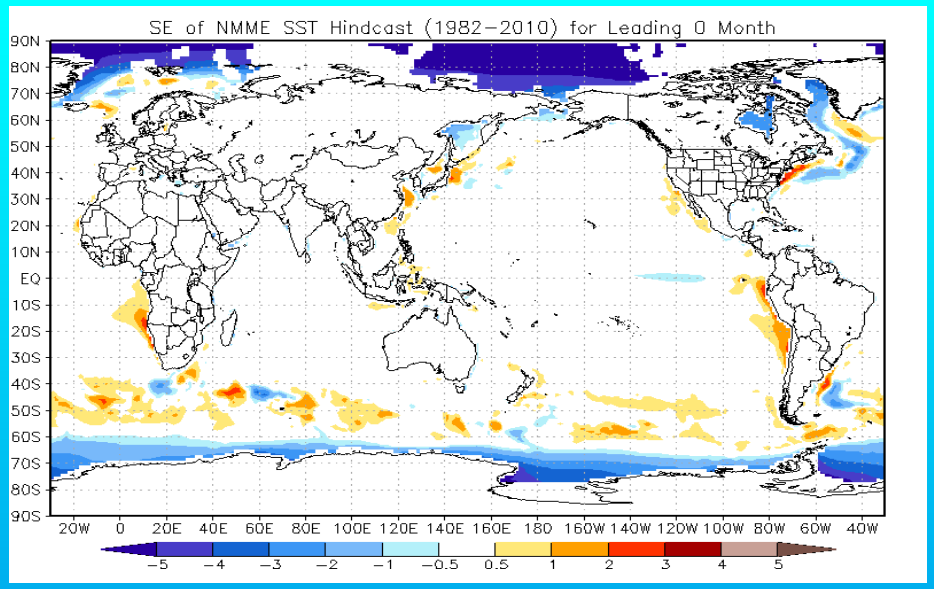
Systematic Error (SE) is estimated as the difference between NMME forecast and observation climatologies:

$SE = F^c - O^c$

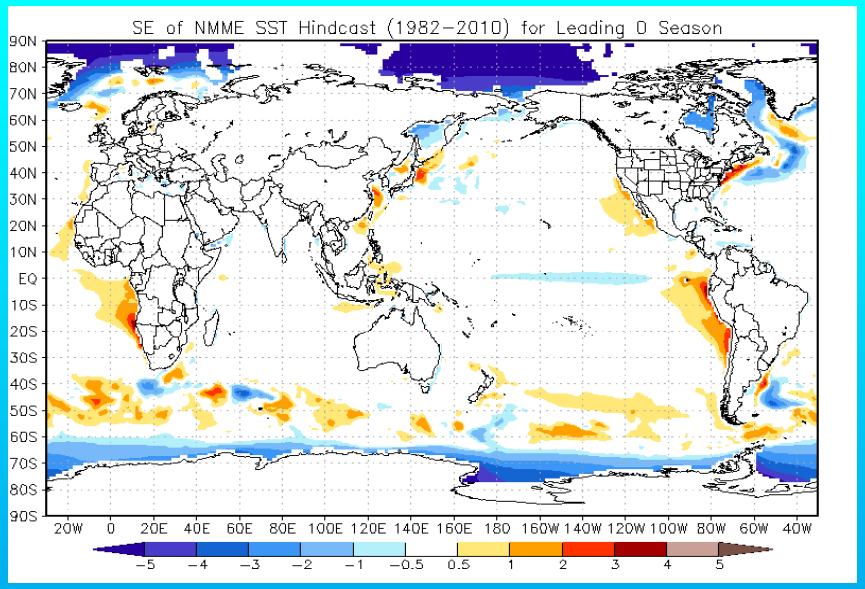
Note: NMME has an implicit SE correction as follows: $F' = F - F^c = F - O^c - SE$.

SST Systematic Error

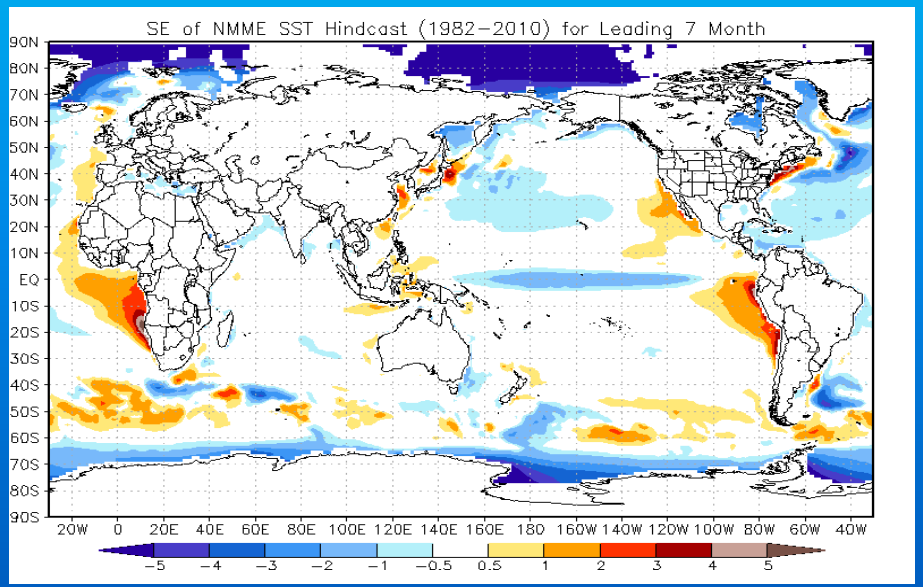
0 month lead



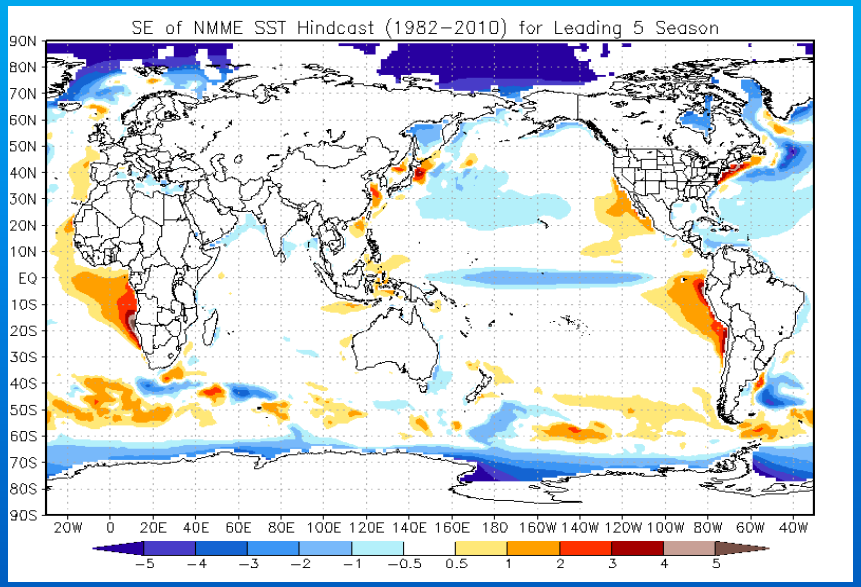
0 season lead



7 month lead

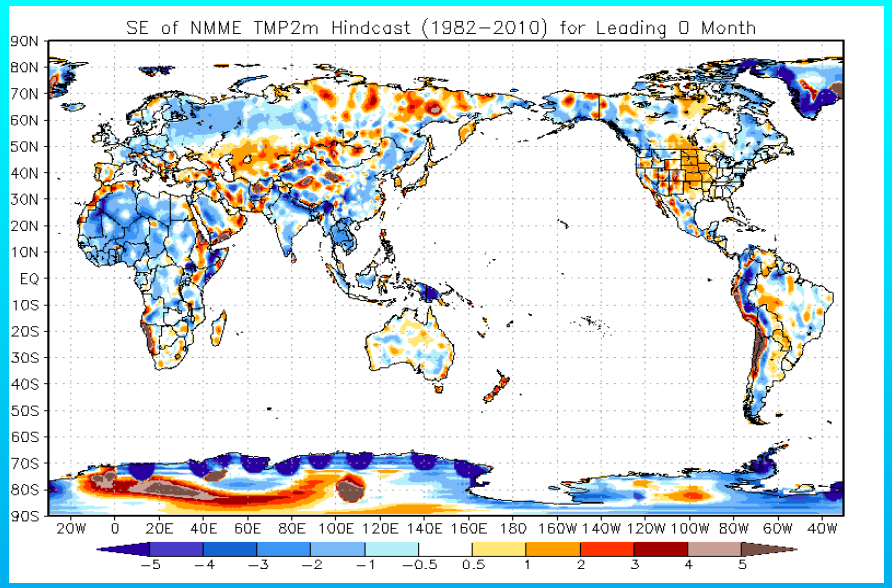


5 season lead

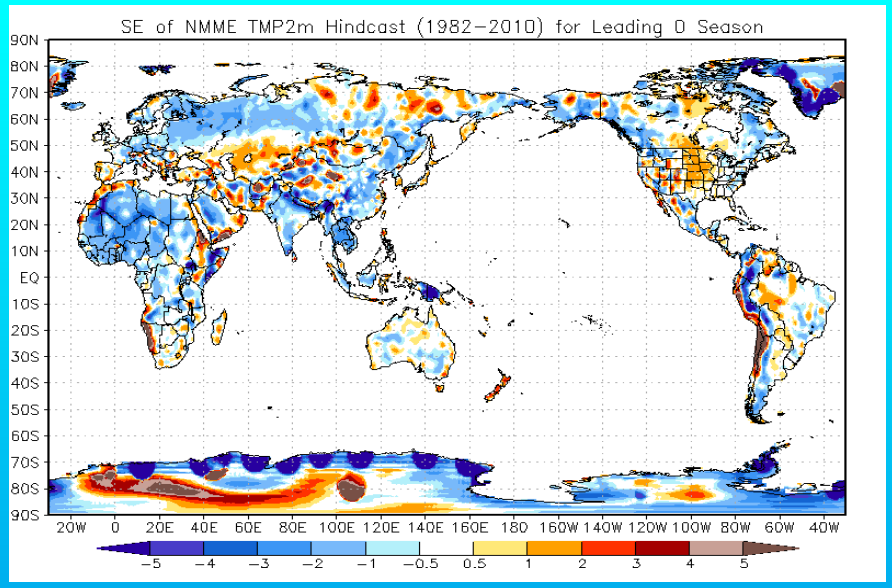


TMP2m Systematic Error

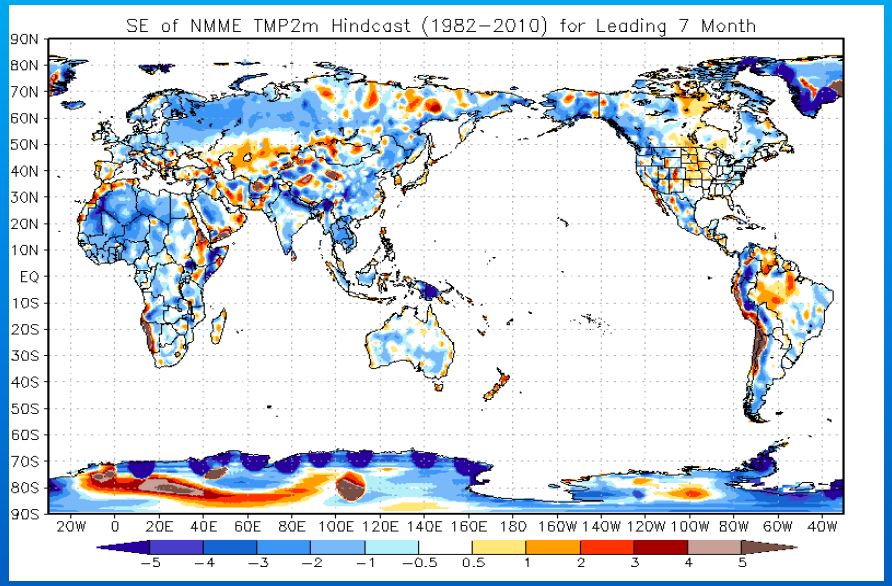
0 month lead



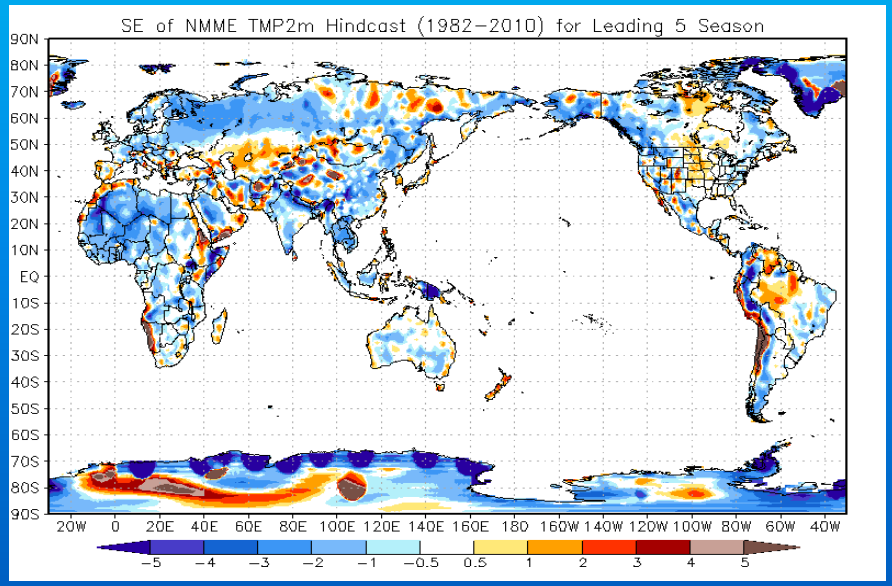
0 season lead



7 month lead

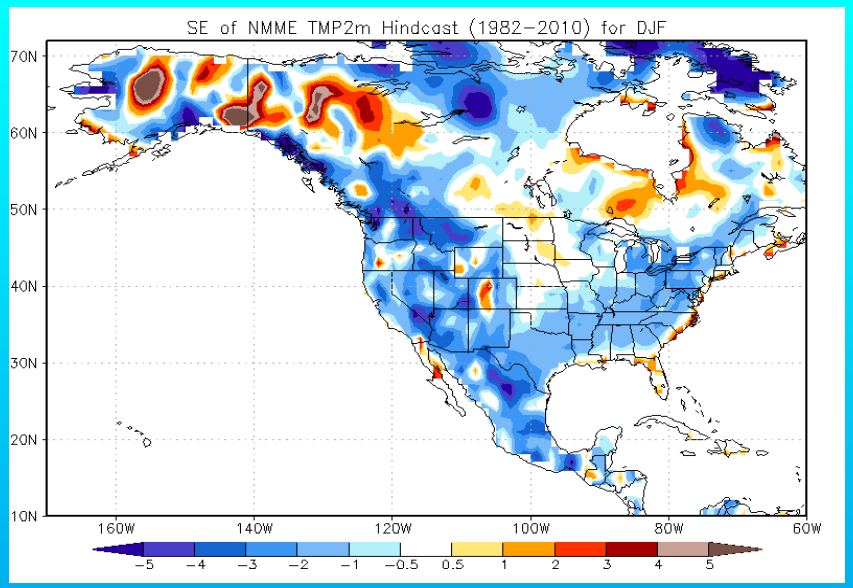


5 season lead

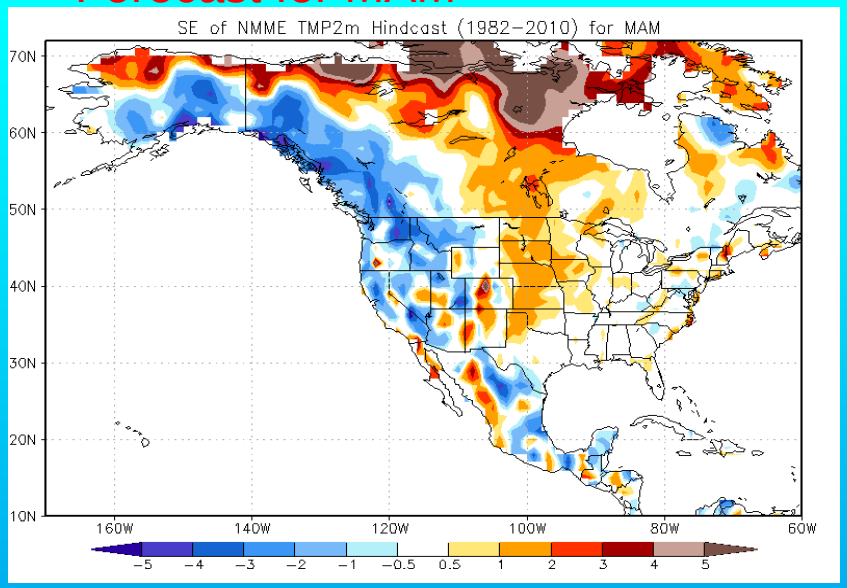


TMP2m Systematic Error

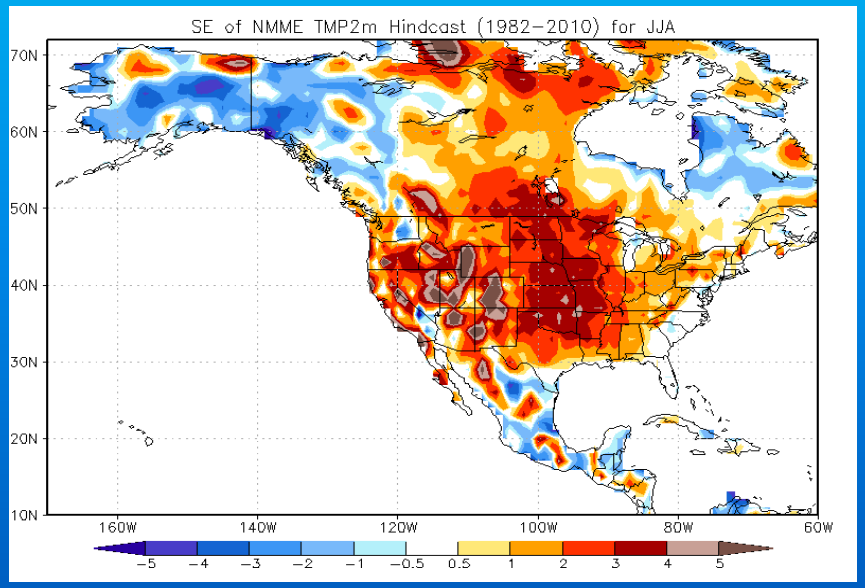
Forecast for DJF



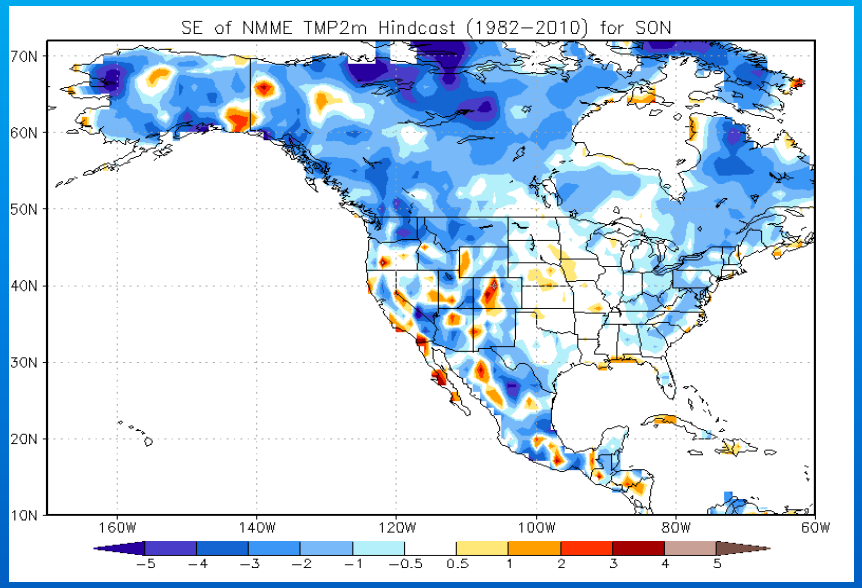
Forecast for MAM



Forecast for JJA

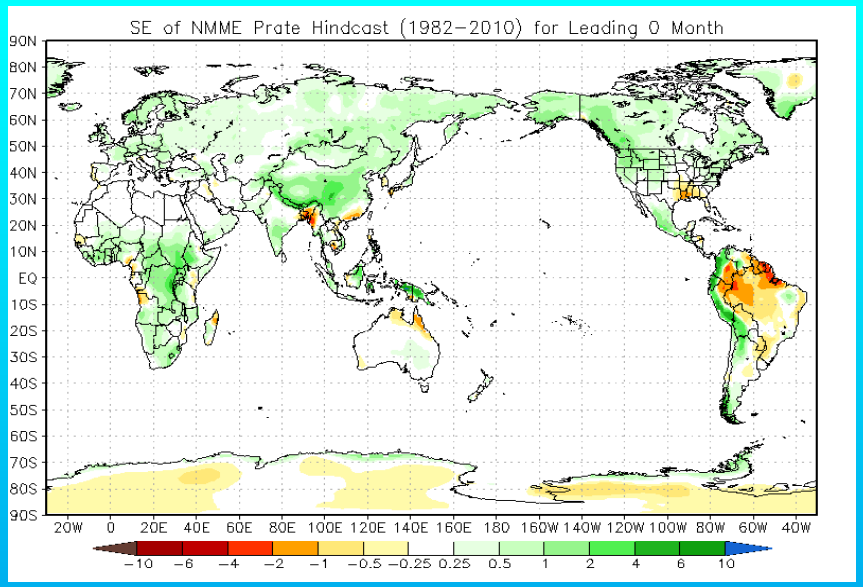


Forecast for SON

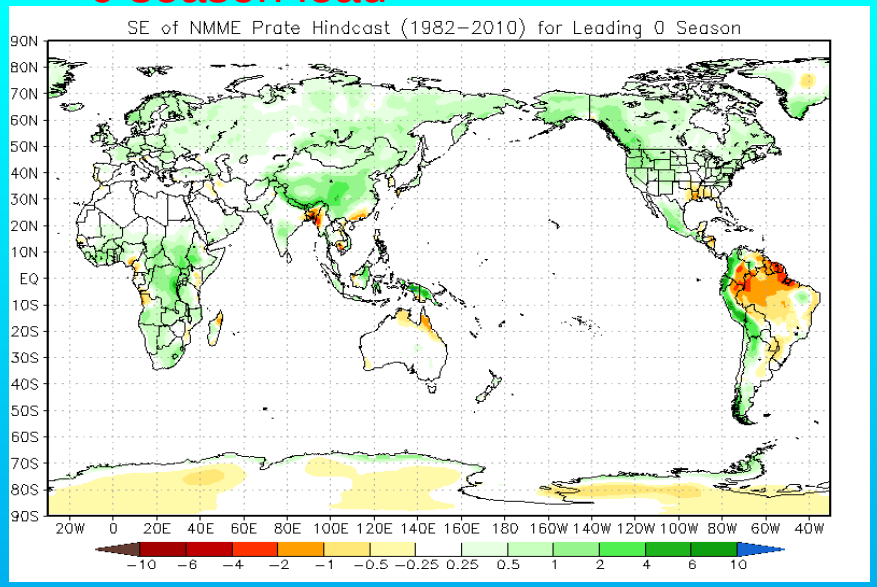


Precipitation Systematic Error

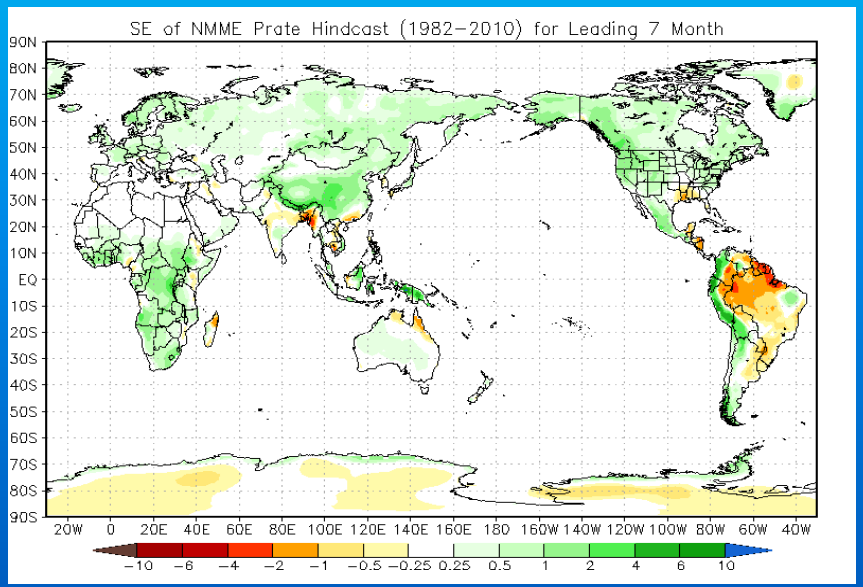
0 month lead



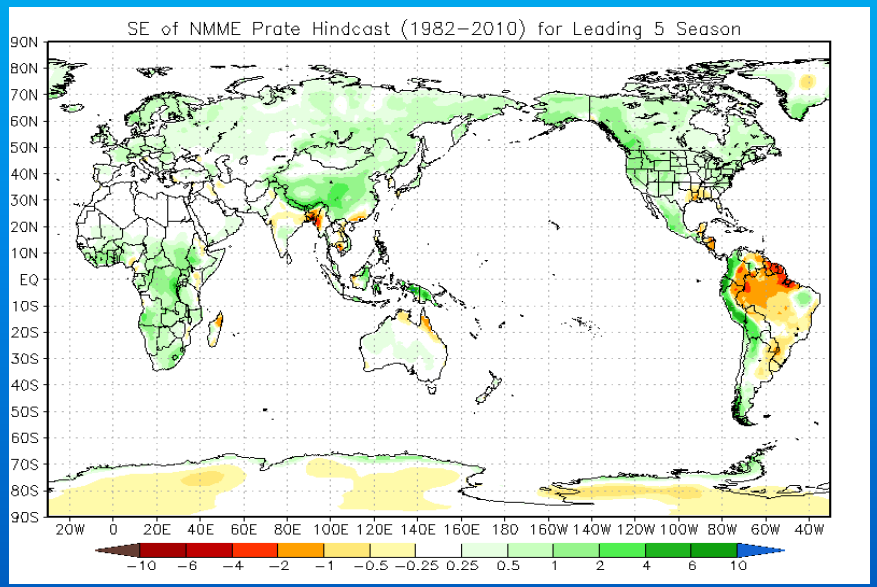
0 season lead



7 month lead

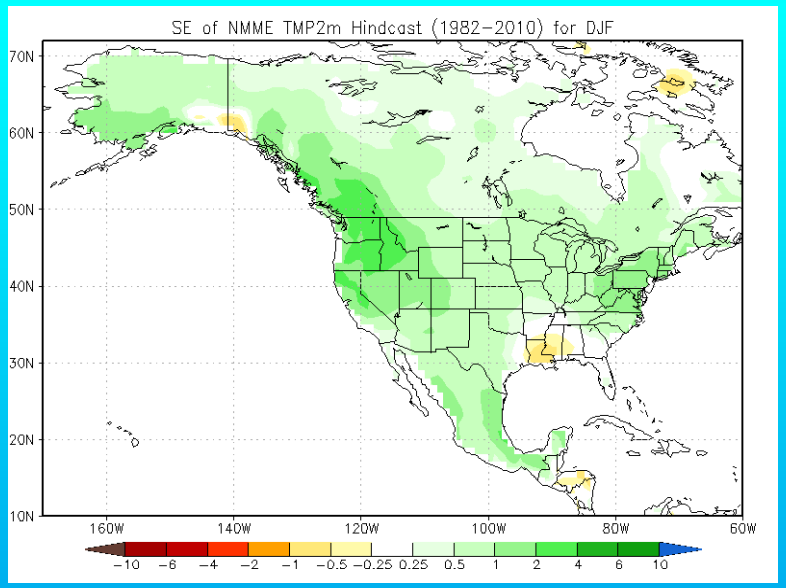


5 season lead

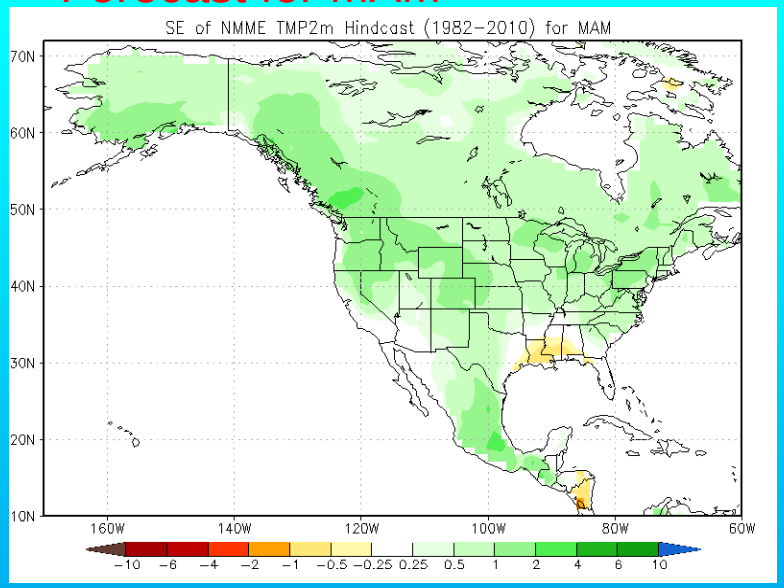


Precipitation Systematic Error

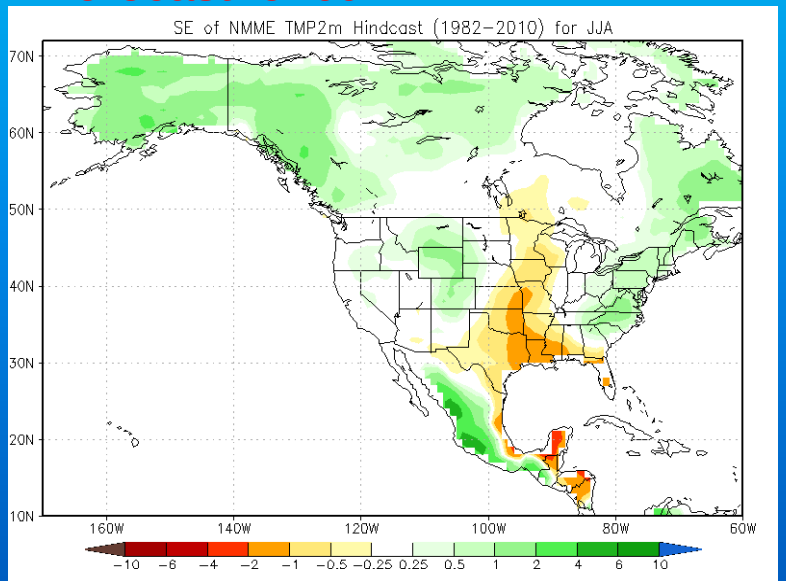
Forecast for DJF



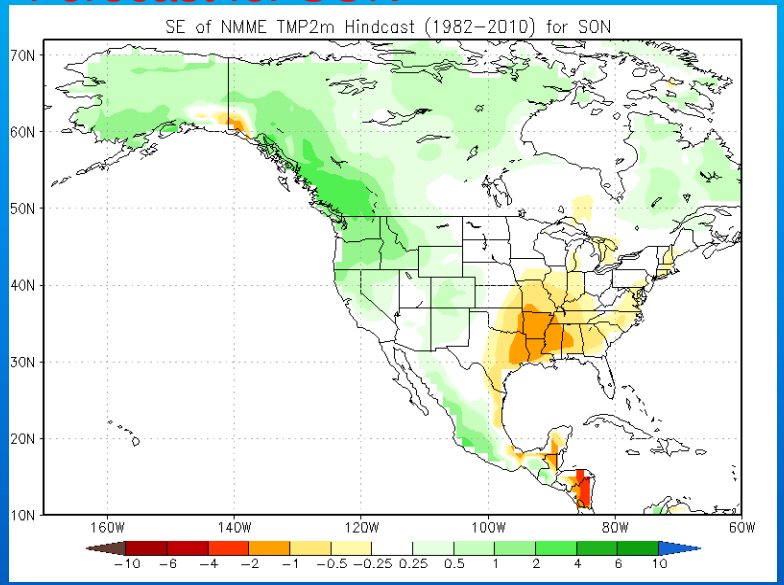
Forecast for MAM



Forecast for JJA



Forecast for SON



NMME RMSE

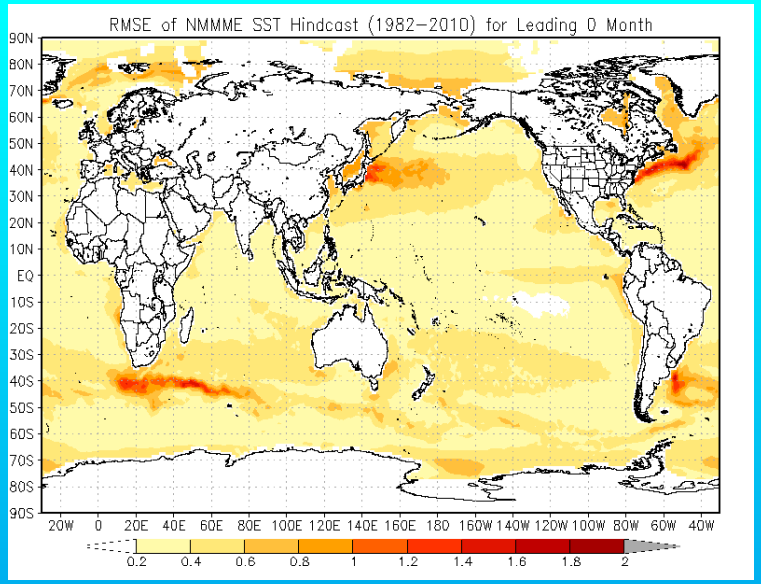
The Root Mean Square Error (**RMSE**) is a frequently used measure of the difference between values predicted by a model and the values actually observed from the environment.

The RMSE of a model prediction with respect to the observation is defined as the square root of the mean squared error:

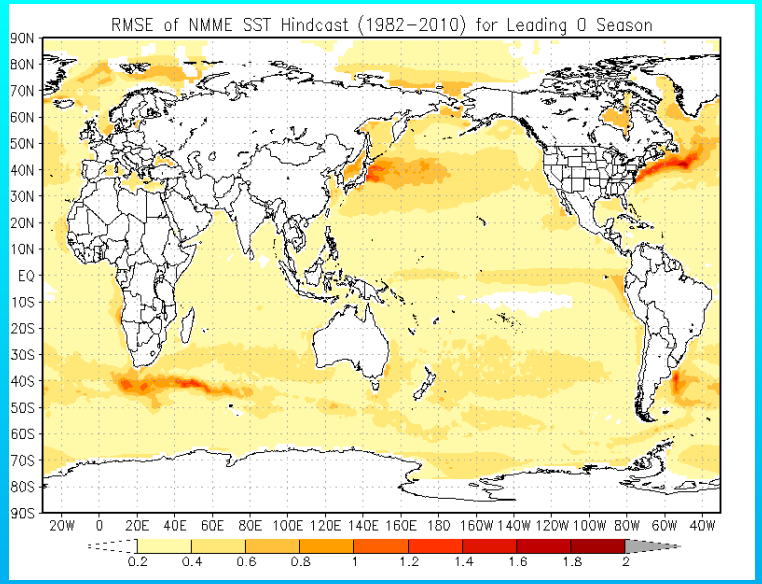
$$RMSE = \sqrt{\frac{\sum_{n=1}^{N} (F' - O')^2}{N}}$$

SST RMSE

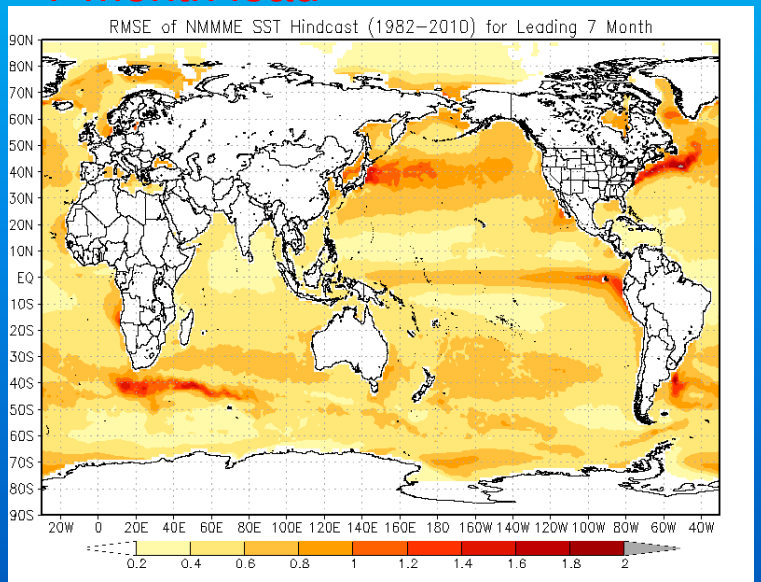
0 month lead



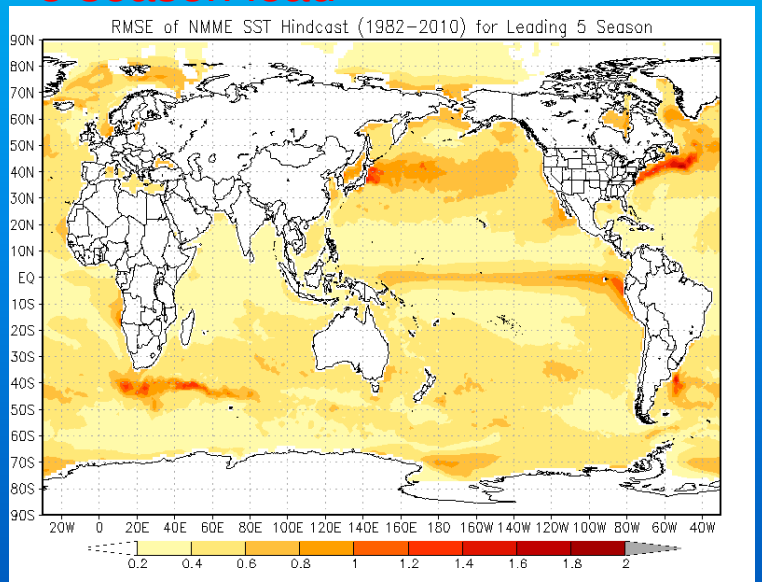
0 season lead



7 month lead

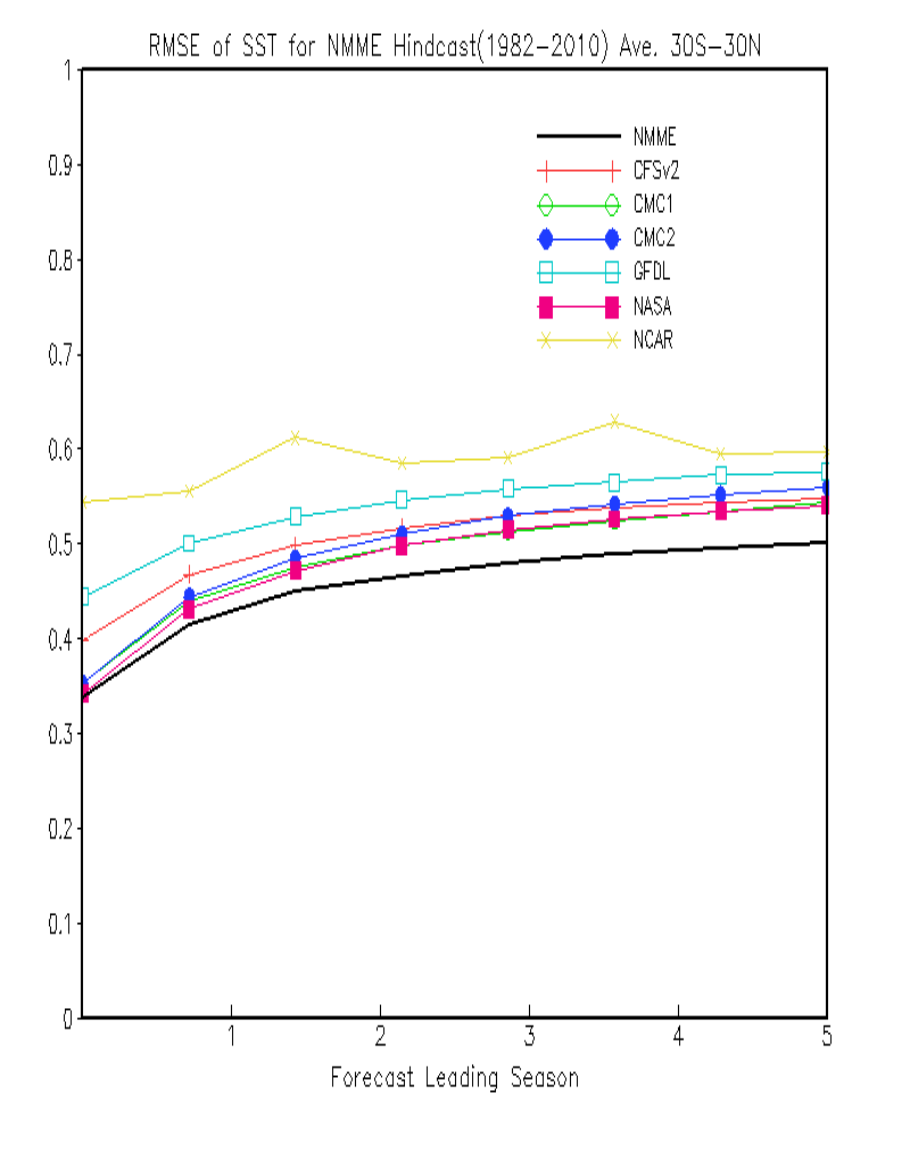


5 season lead

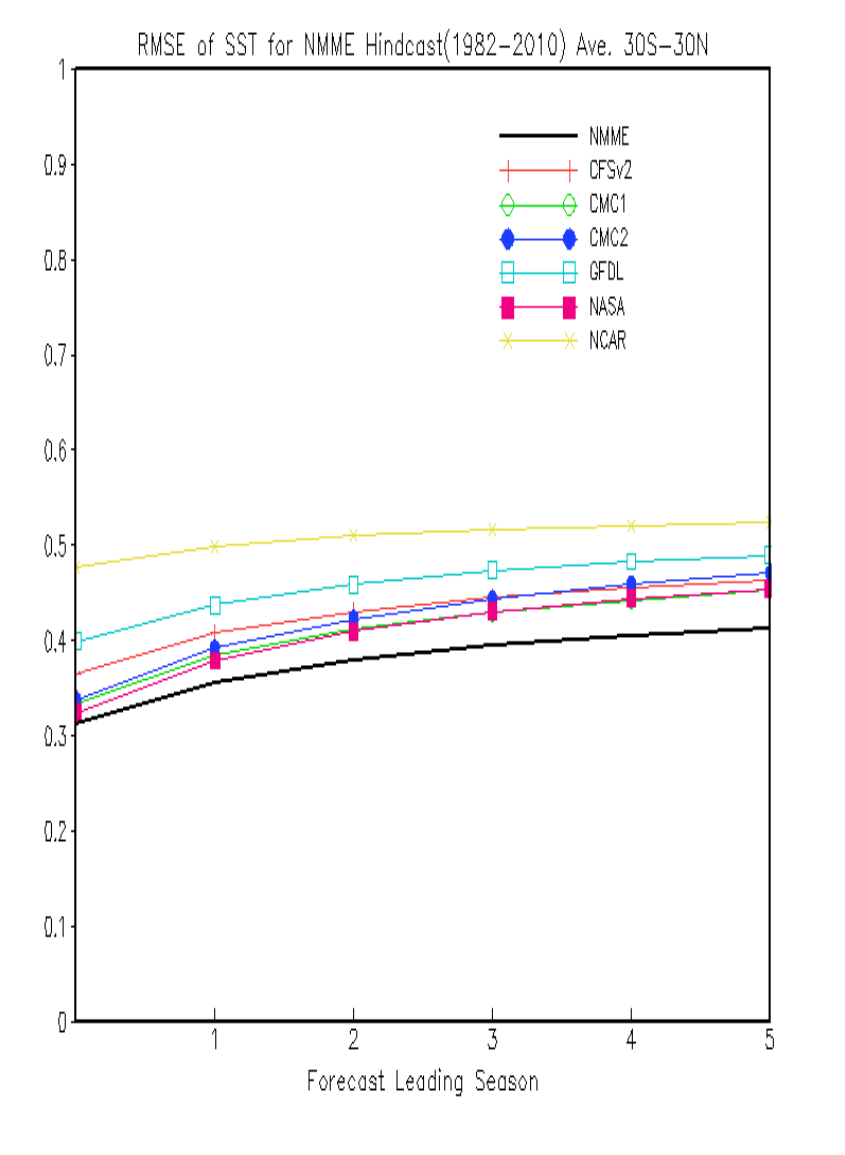


SST RMSE

Month Forecast

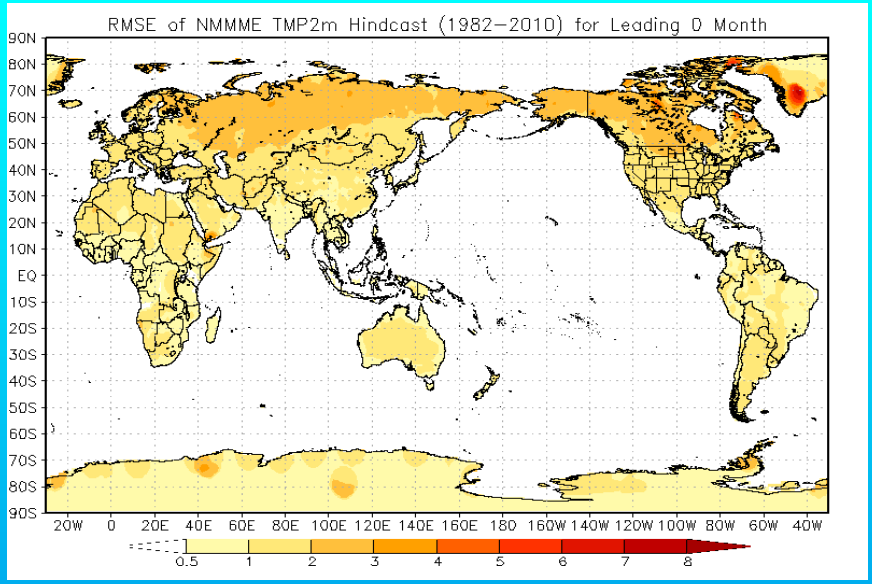


Season Forecast

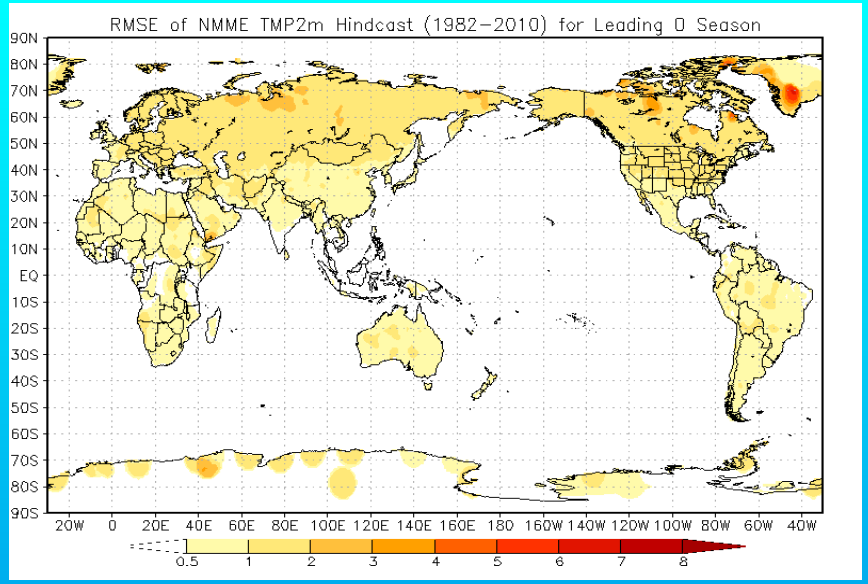


TMP2m RMSE

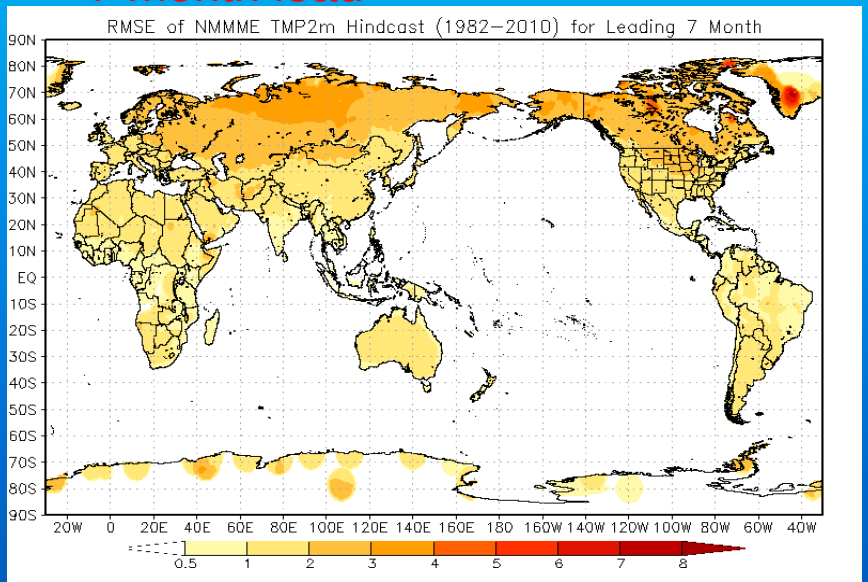
0 month lead



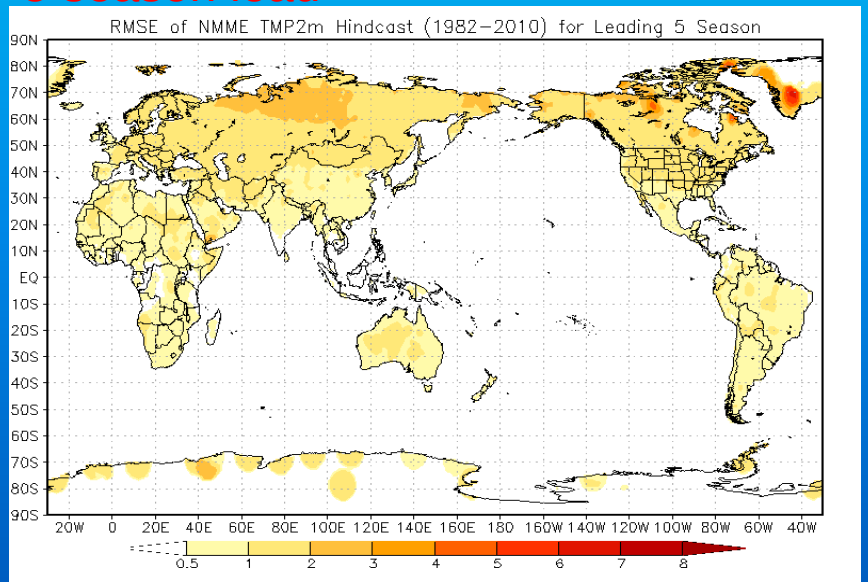
0 season lead



7 month lead

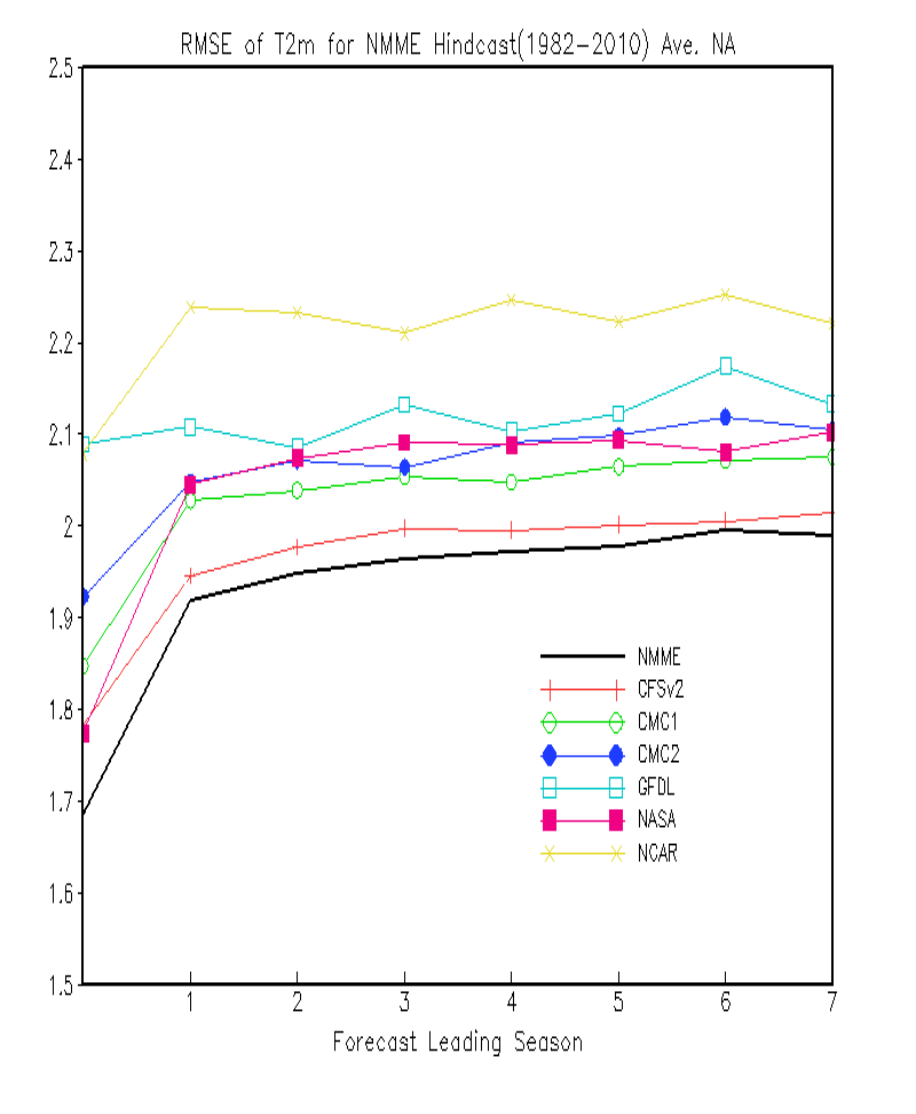


5 season lead

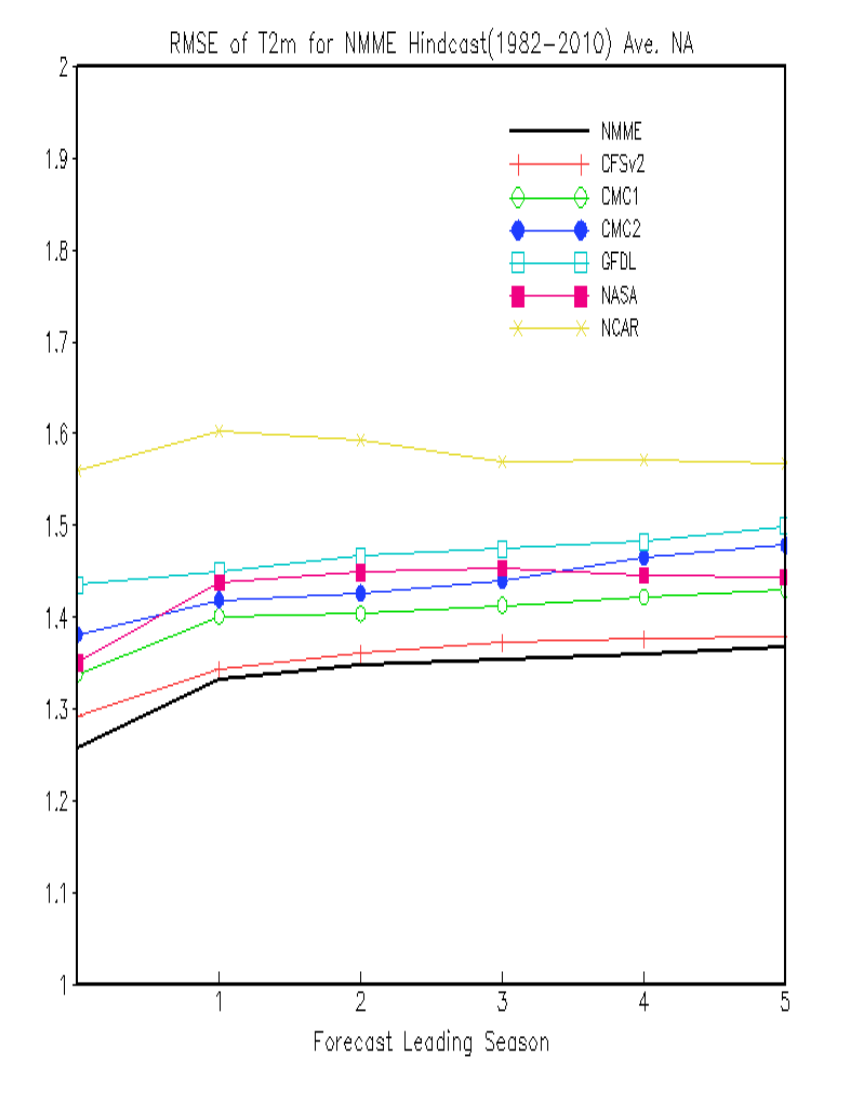


TMP2m RMSE

Monthly Forecast for NA

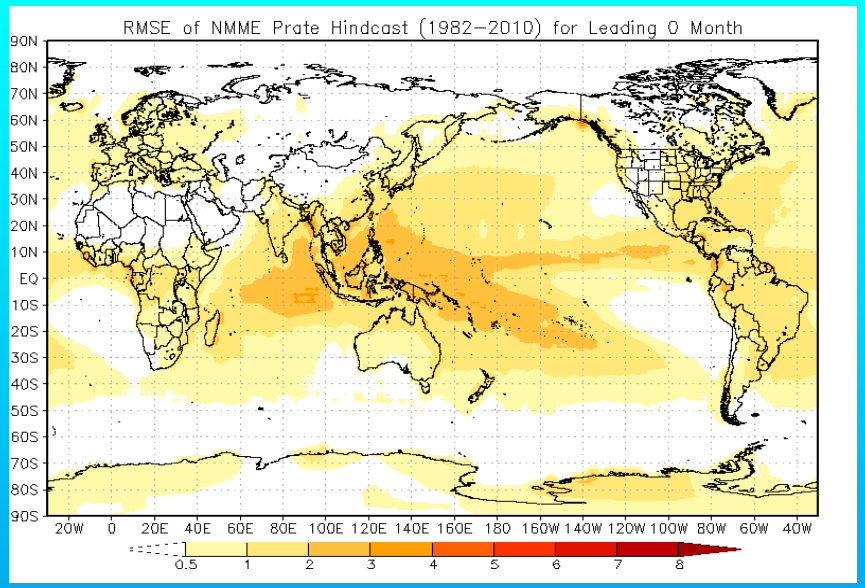


Seasonal Forecast for NA

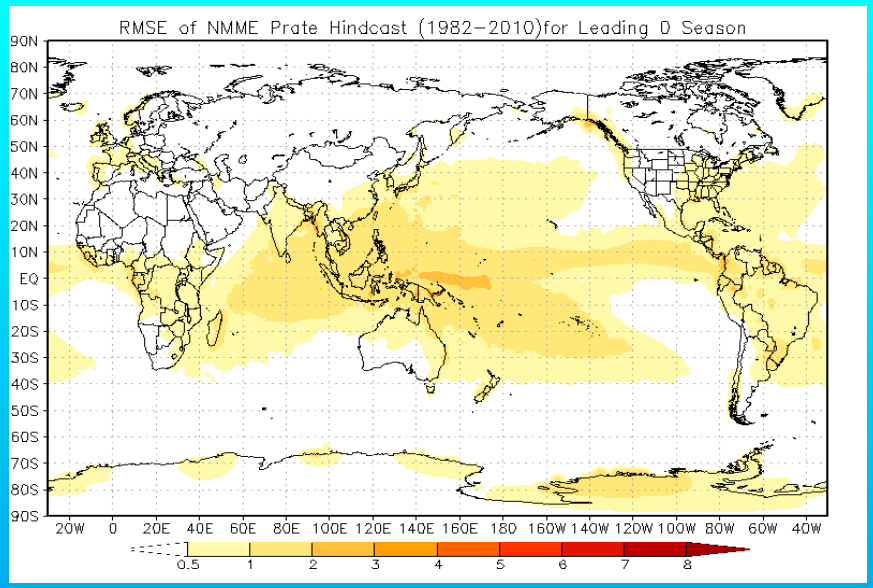


Precipitation RMSE

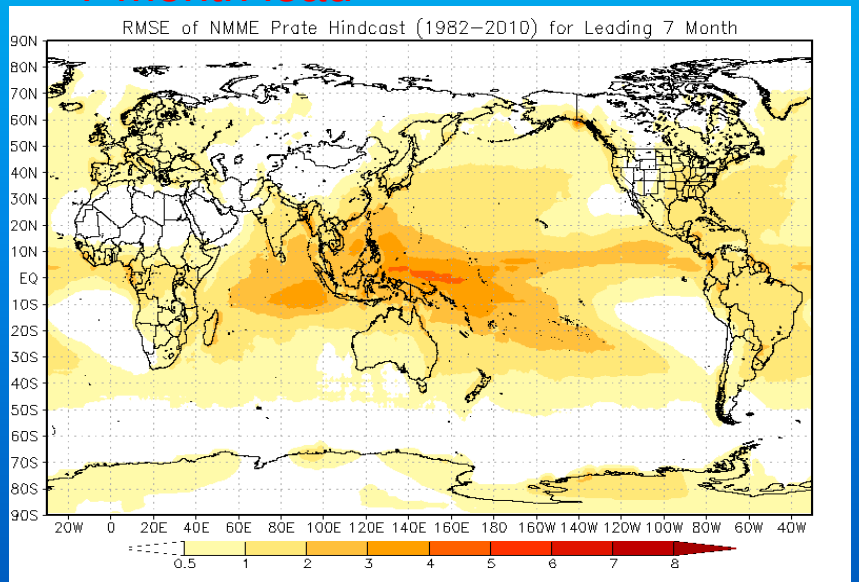
0 month lead



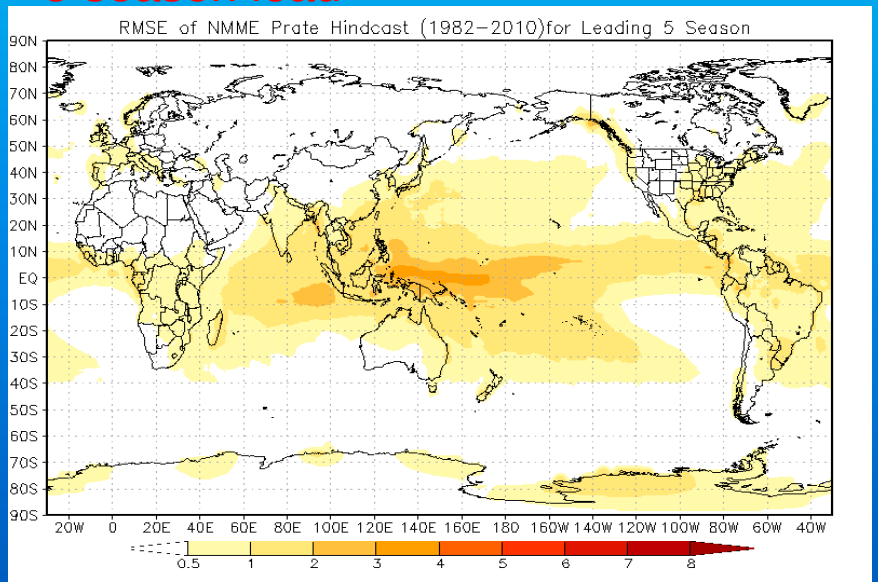
0 season lead



7 month lead

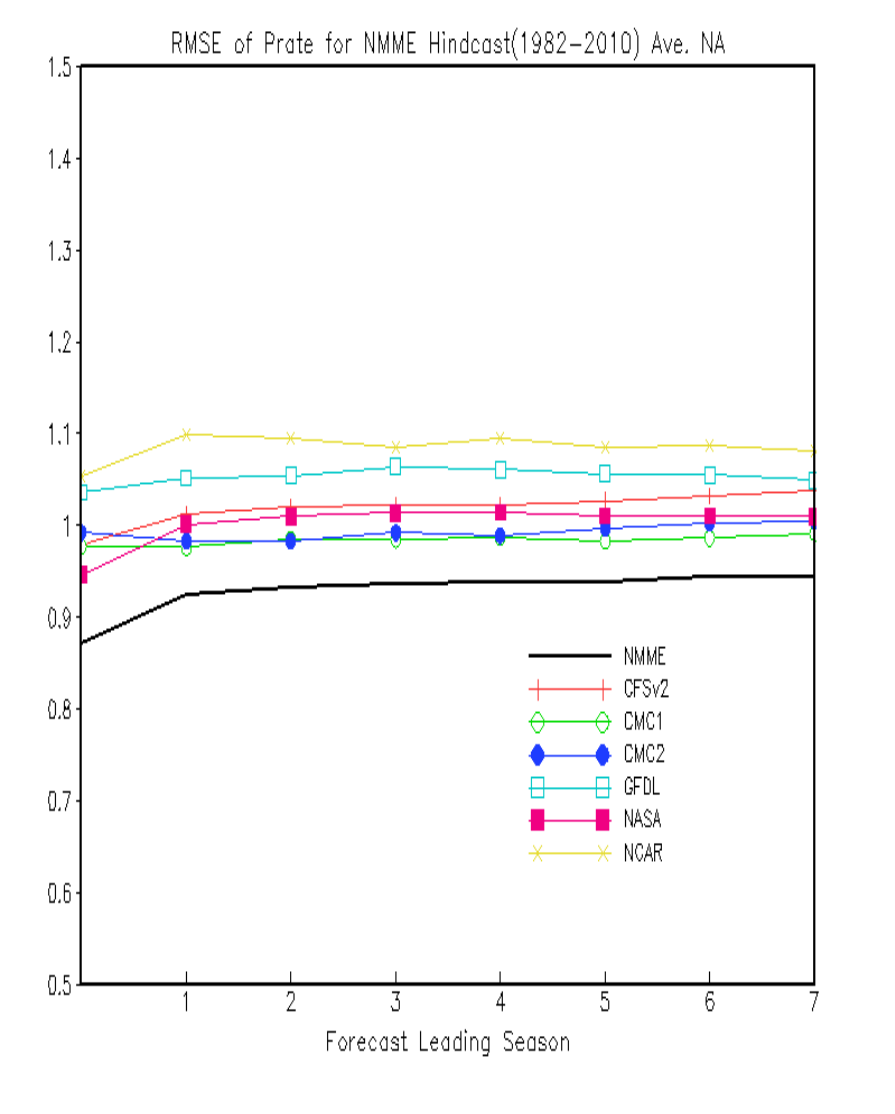


5 season lead

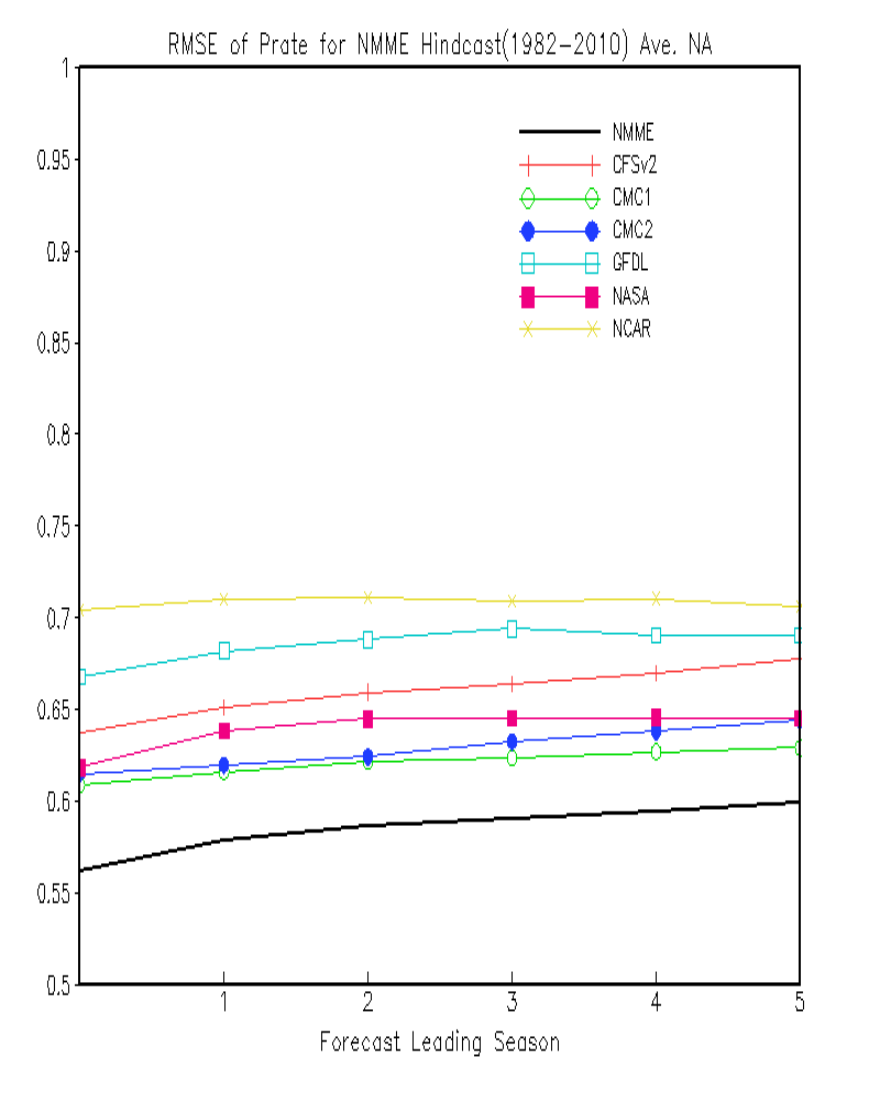


Precipitation RMSE

Monthly Forecast for NA



Seasonal Forecast for NA



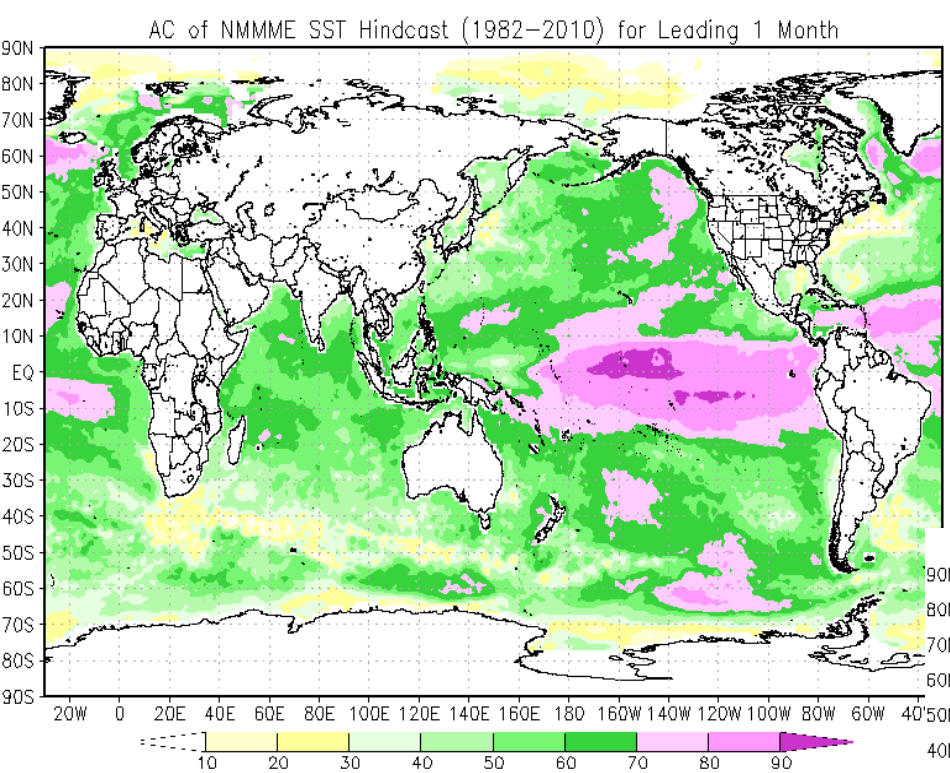
NMME Forecast Skills (AC)

The maps of the anomaly correlations are temporal correlation, calculated at each grid point, between observed and simulated anomalies for N years, such as,

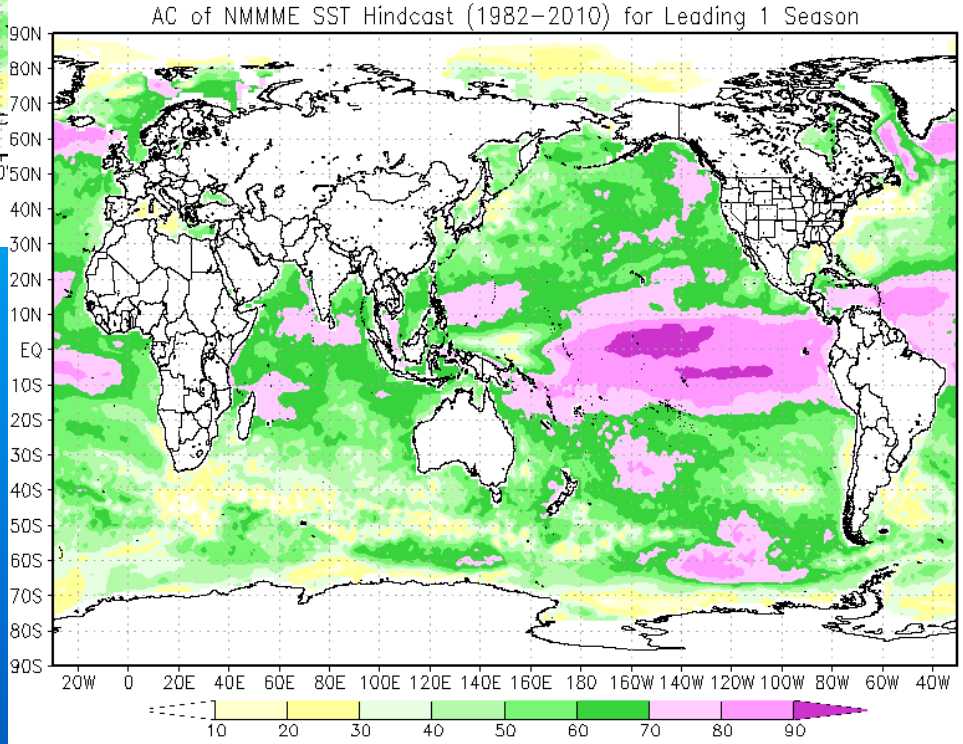
$$ACC = \frac{\sum_{n=1}^{N} F' O'}{\left[\sum_{n=1}^{N} (F')^2 \sum_{n=1}^{N} (O')^2 \right]^{1/2}}$$

The ACC usually also refers as a map of the forecast skills. The regions with high [positive] correlations indicate that the NMME predicted anomalies are mimicking the observed anomalies, with the right sign (positive or negative departures from average) and with the correct *relative* amplitudes.

SST Forecast Skills

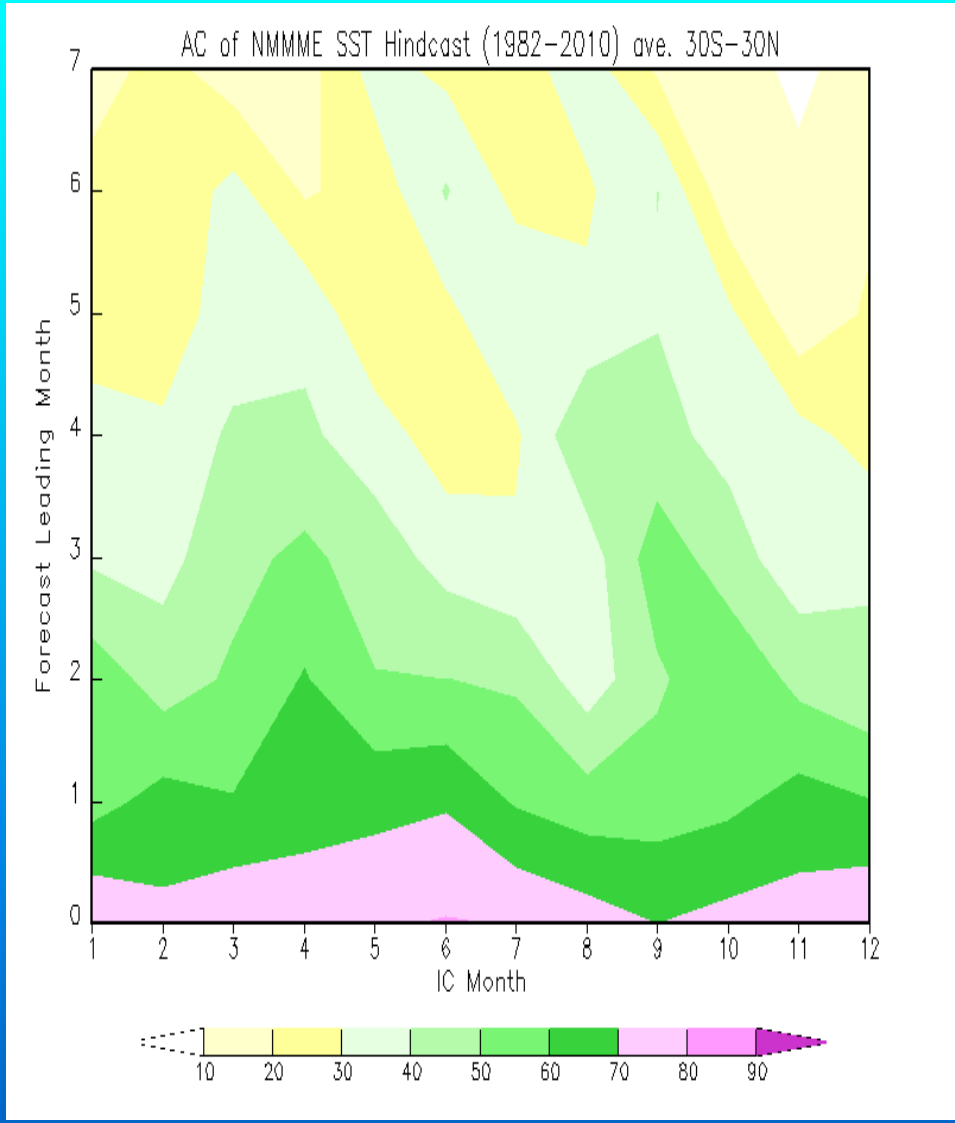


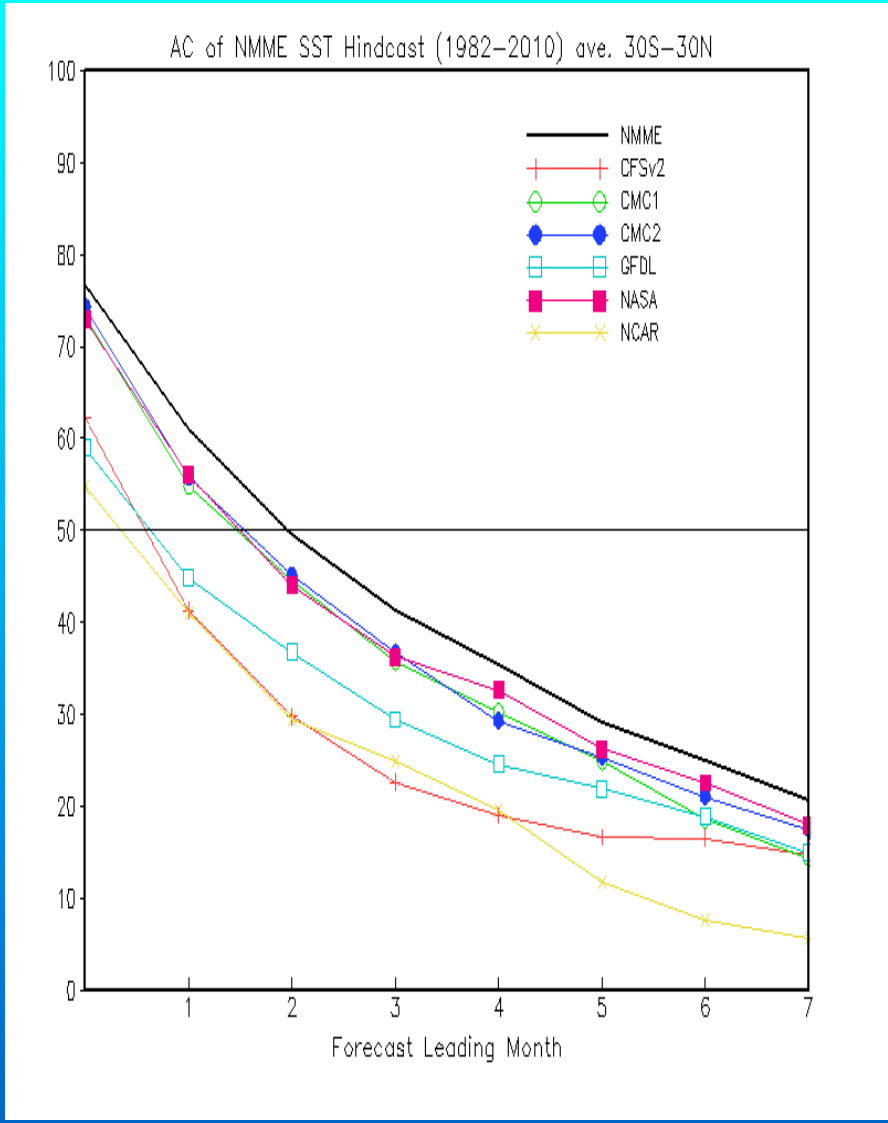
1 month lead



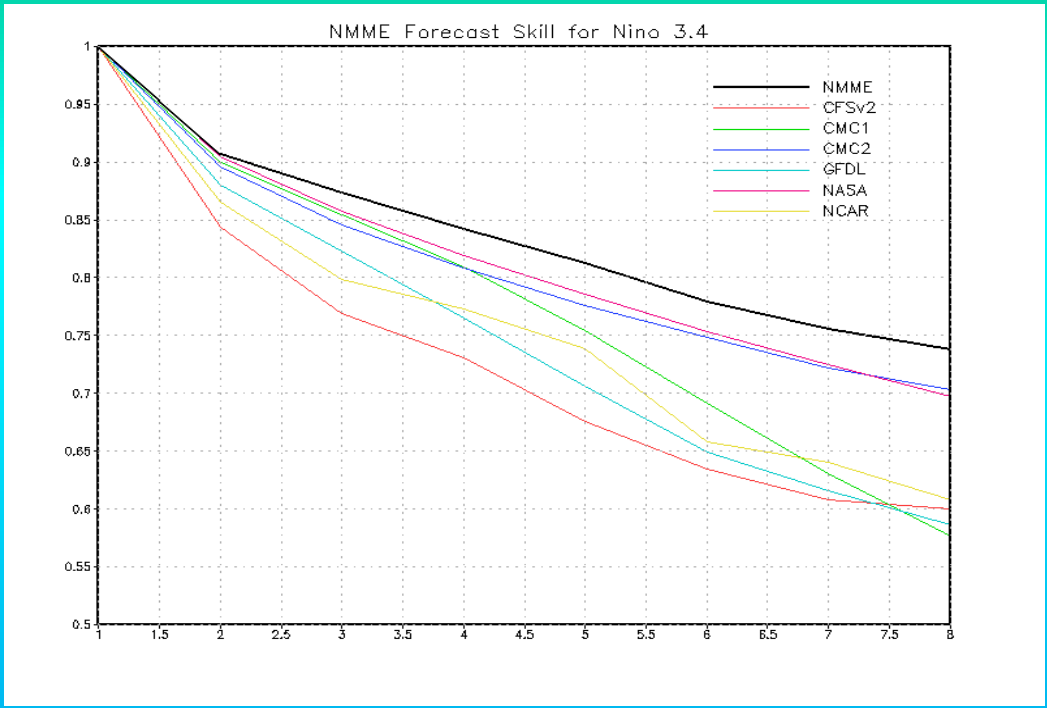
1 season lead

SST Forecast Skills

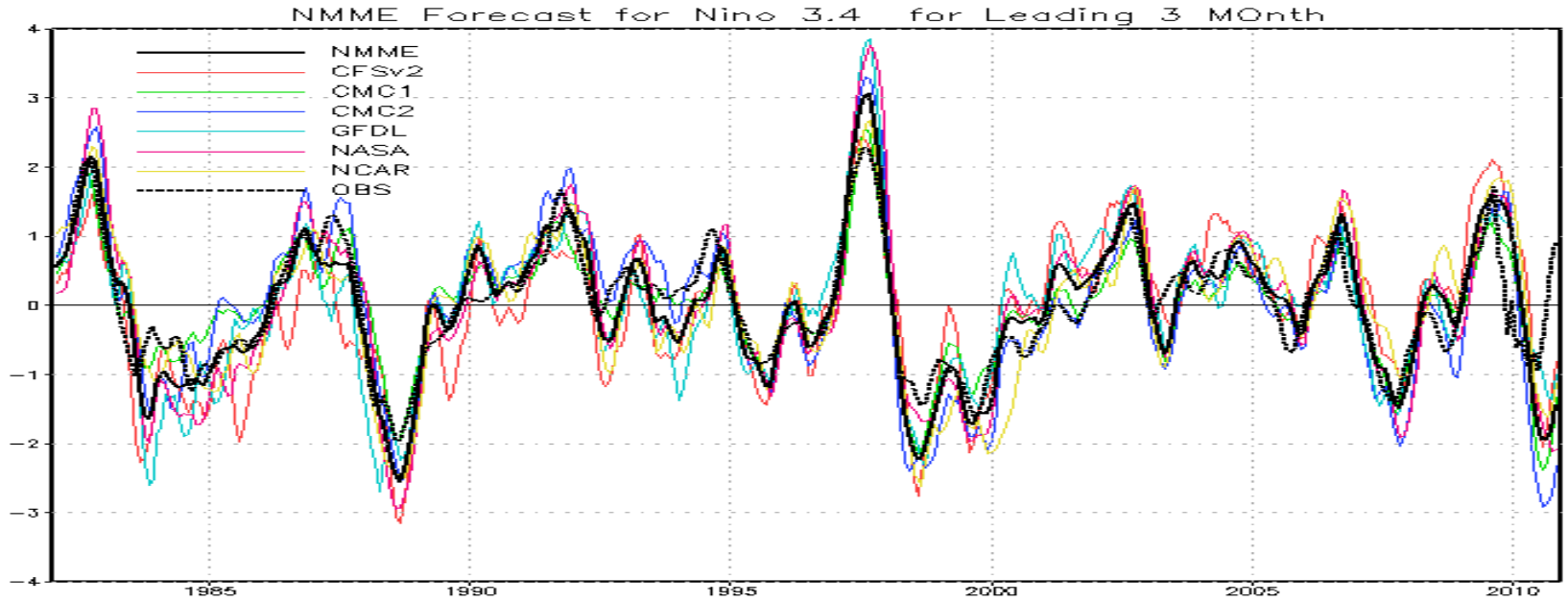




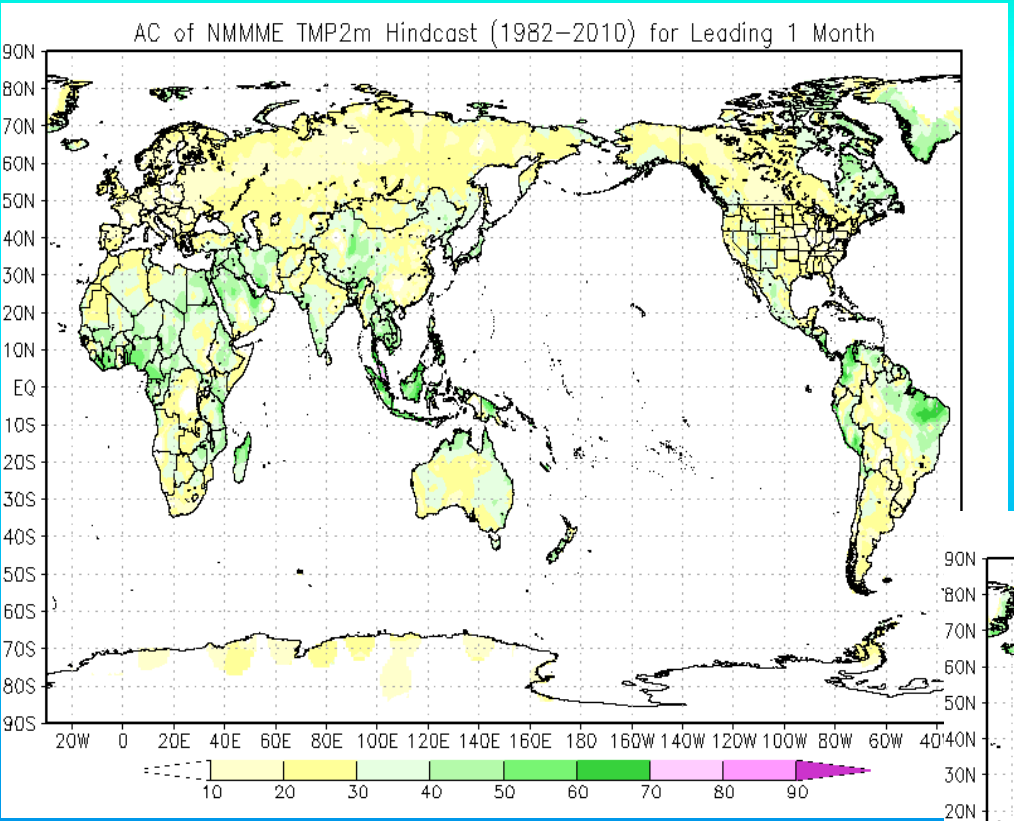
NINO3.4 Forecast Skills



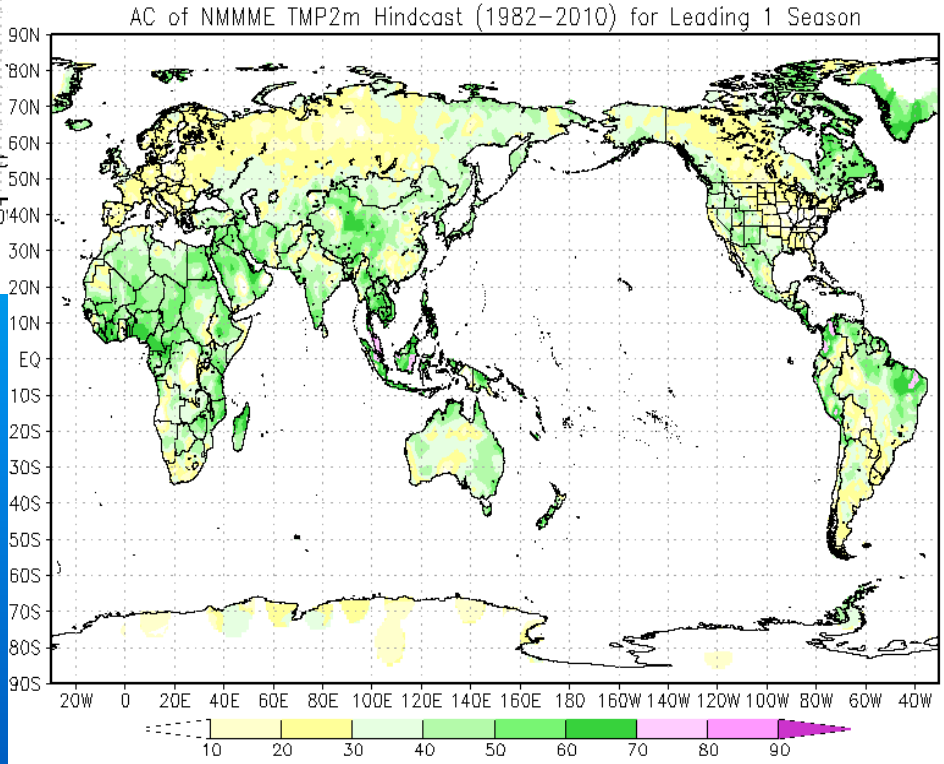
Model Forecast for Leading 3 Months



TMP2m Forecast Skills



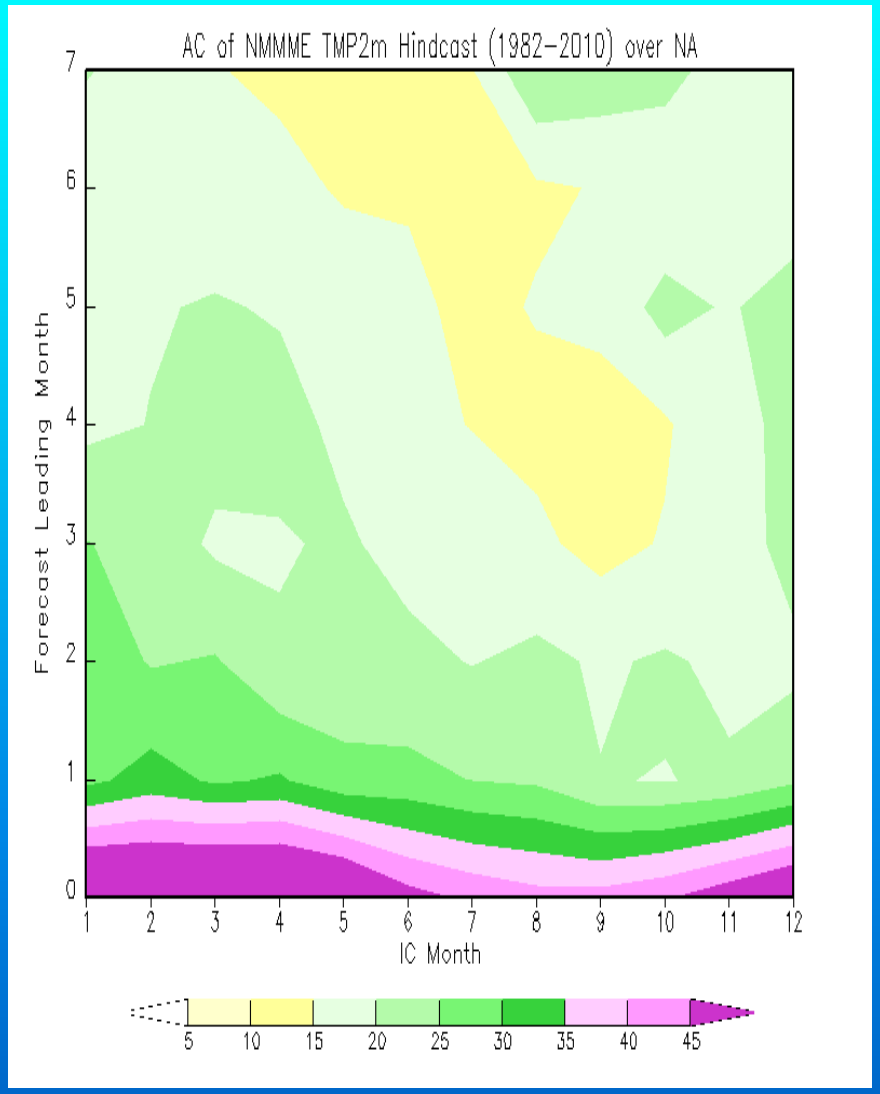
1 month lead



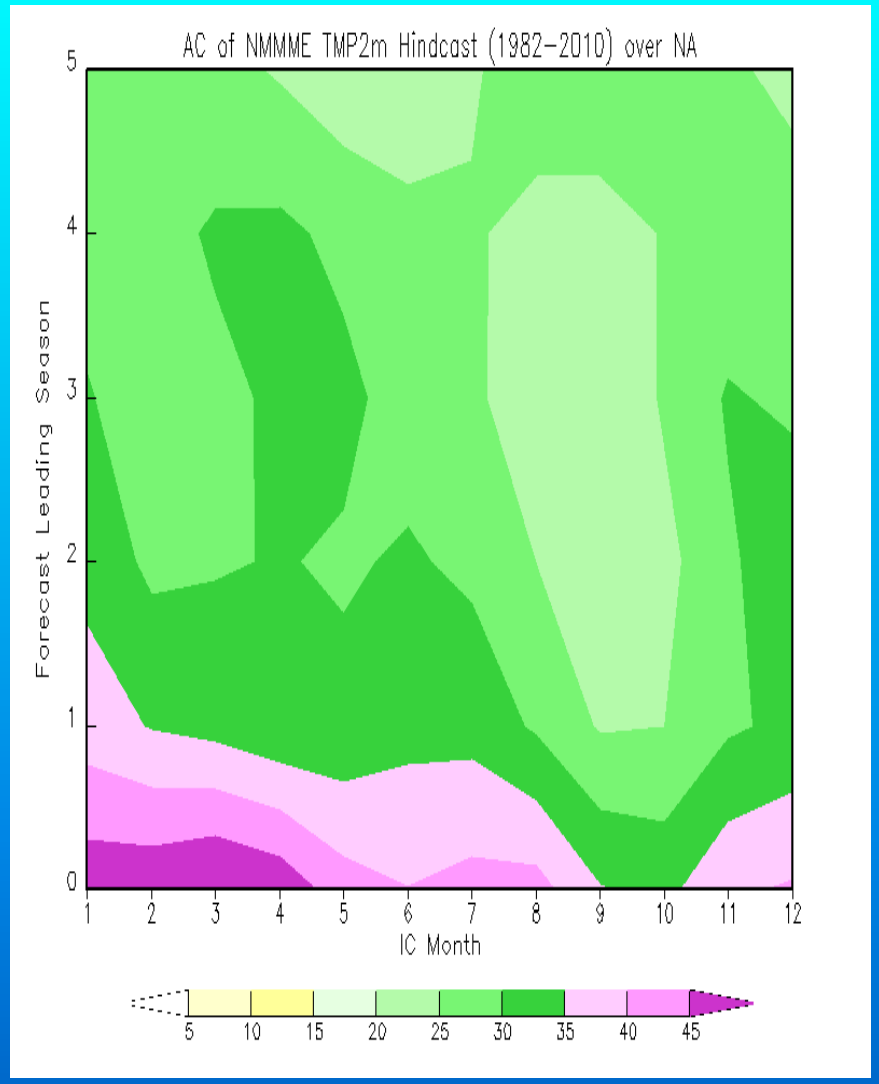
1 season lead

TMP2m Forecast Skills

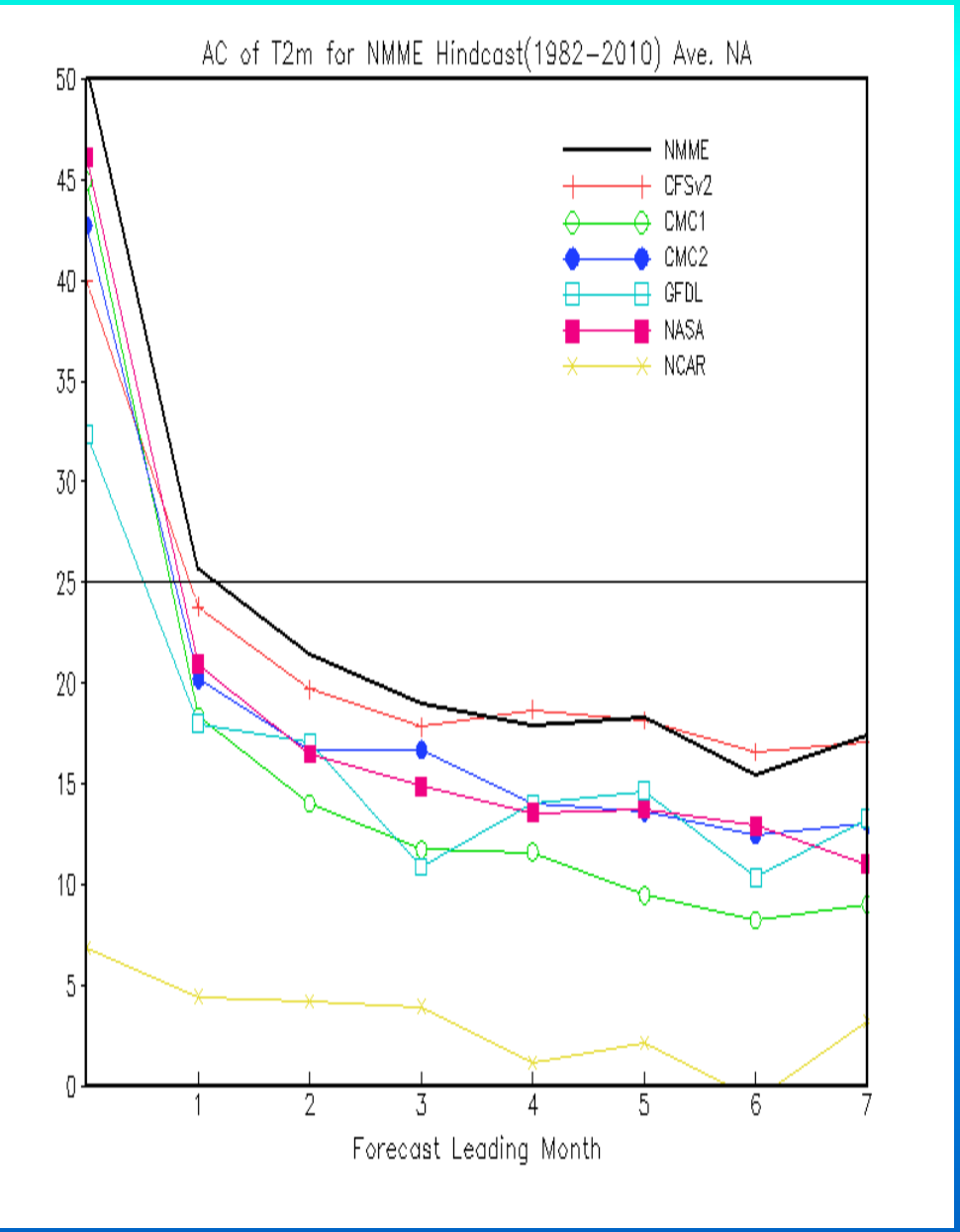
Monthly Forecast

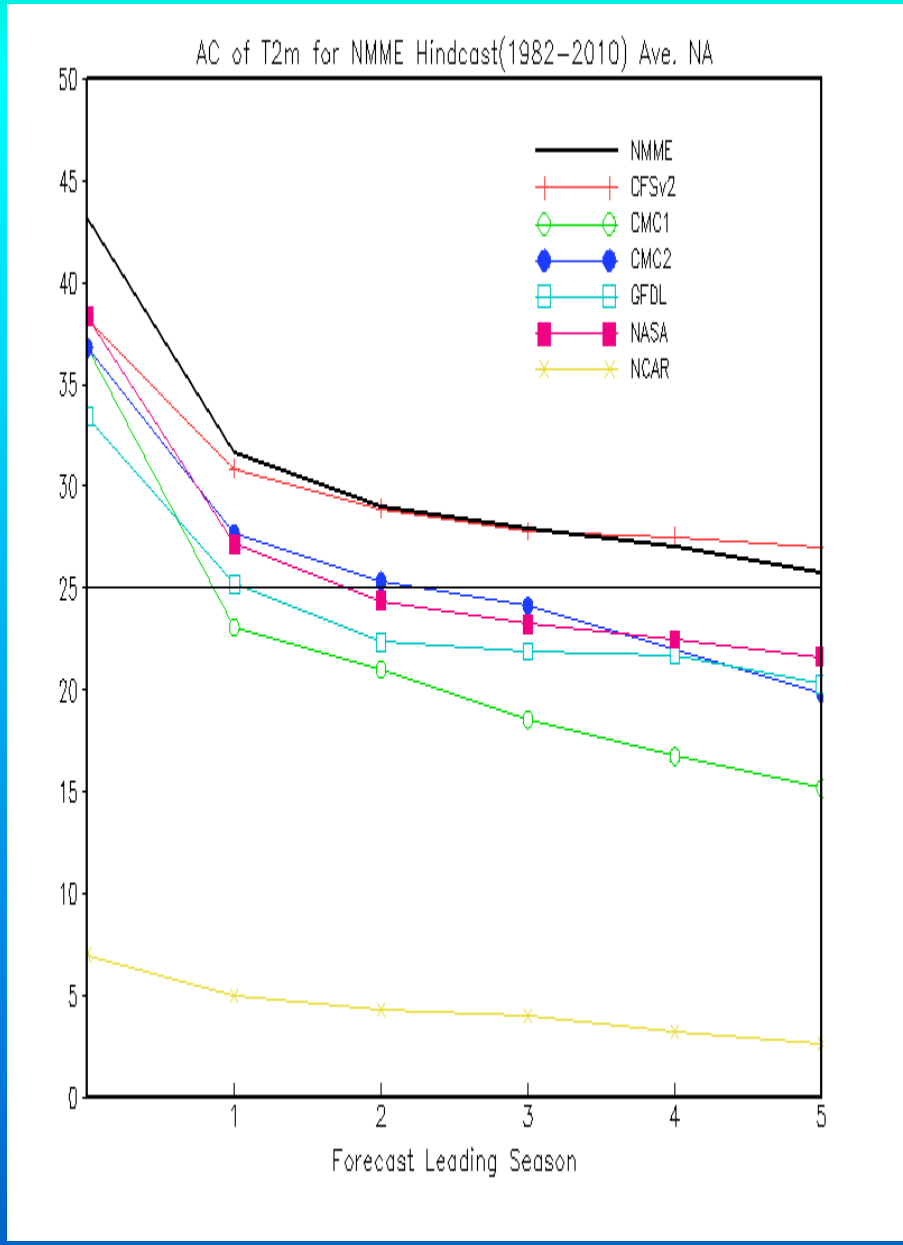


Seasonal Forecast

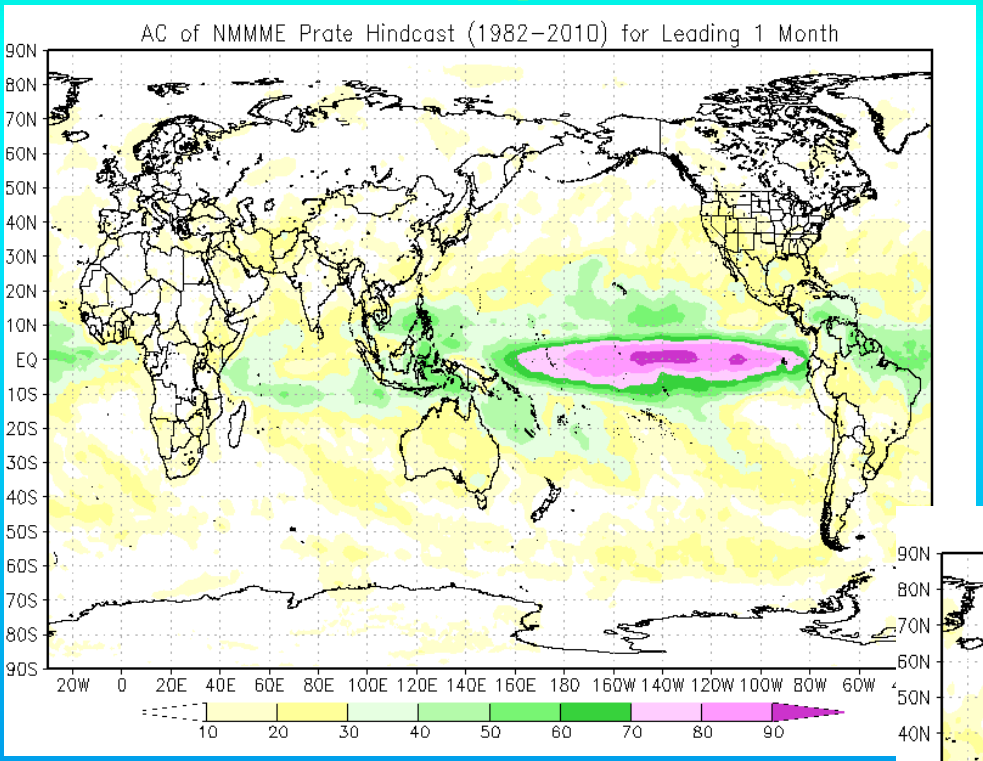


TMP2m Forecast Skills

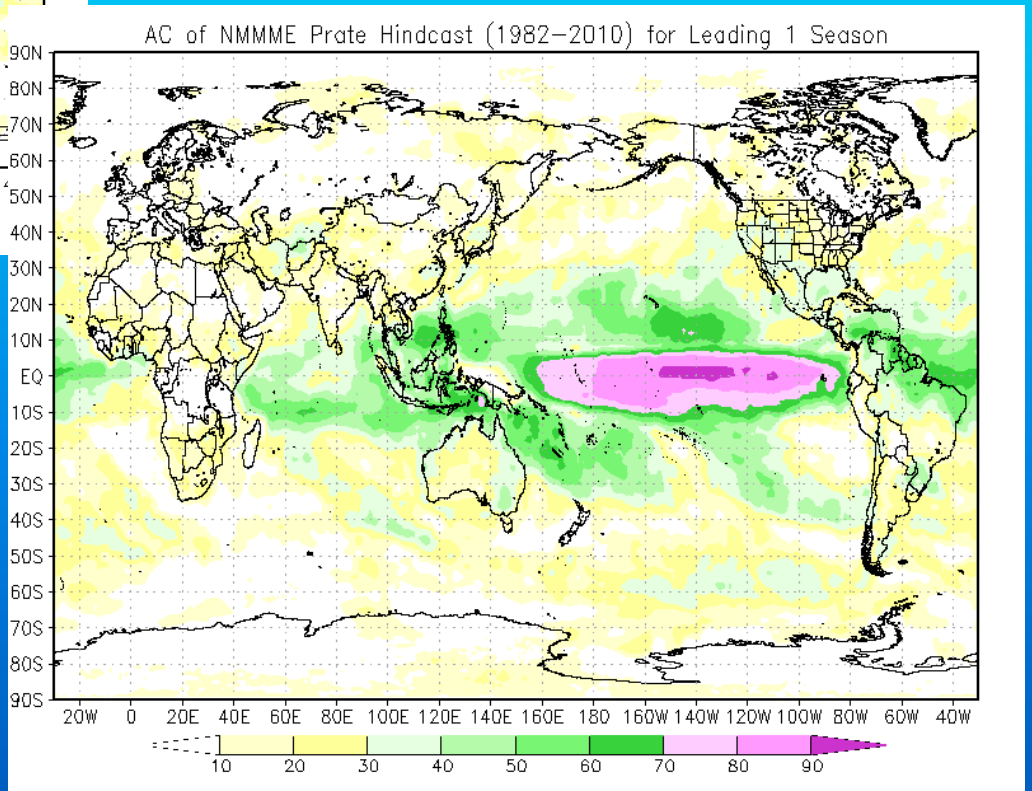




Precipitation Forecast Skills



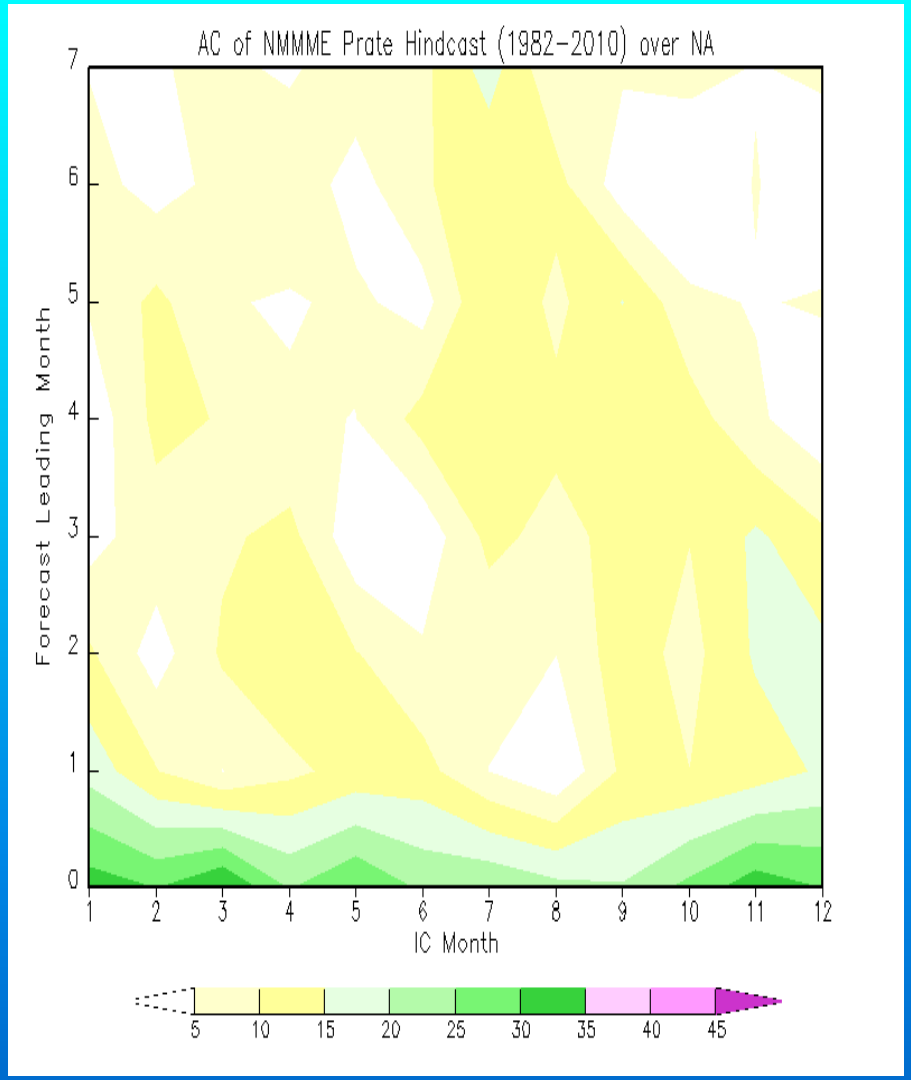
1 month lead



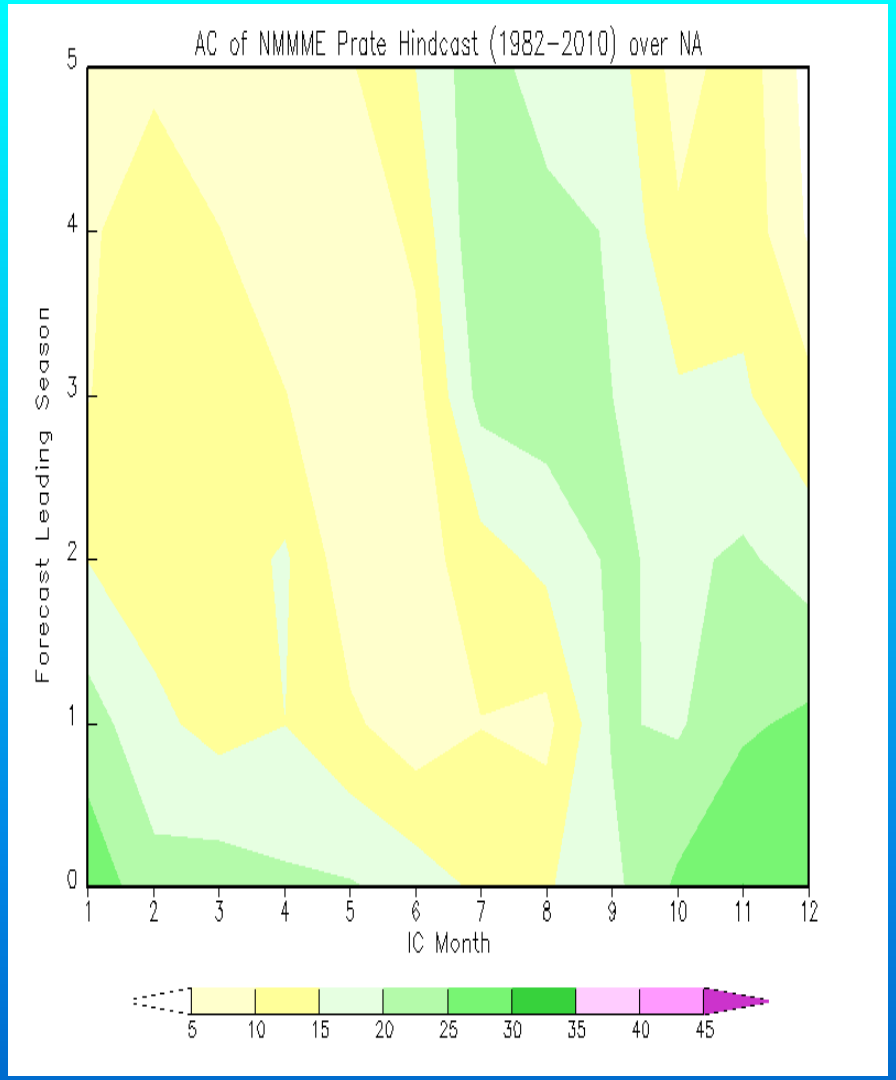
1 season lead

Precipitation Forecast Skills

Monthly Forecast



Season Forecast



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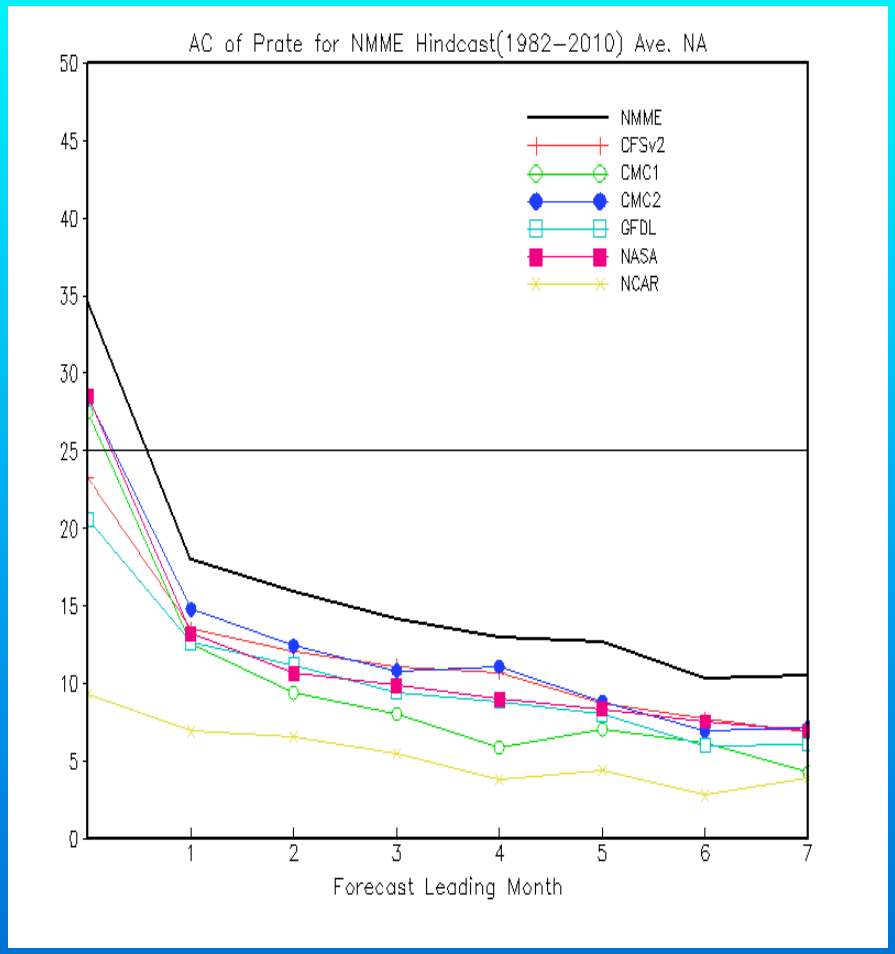
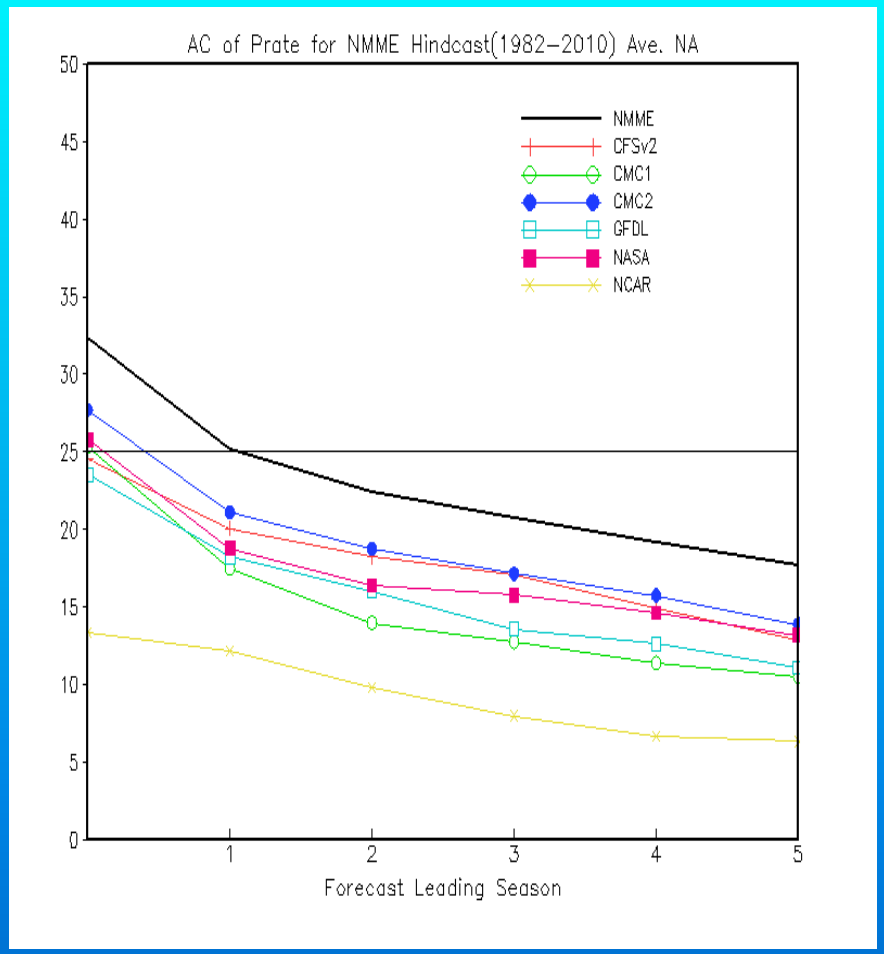


Seasonal Forecast



Summary

- **SE of NMME is small but varies with season. Monthly SE removed from NMME forecast system by using individual model climatology (bias correction) when we calculate the NMME forecast anomalies.**

- **RSME of NMME is lower for SST, T2m and prate than that of all constituent models and very slowly grows with leading time.**

- **AC of NMME shows higher forecast skills than that of all models for global tropical SST, especially for ENSO prediction, which is benefit from the models outside NCEP.**

- **AC of NMME for the Northern America is among the one of the best for T2m and prate prediction comparing to the individual models. The seasonal forecast skills are higher than that of monthly.**