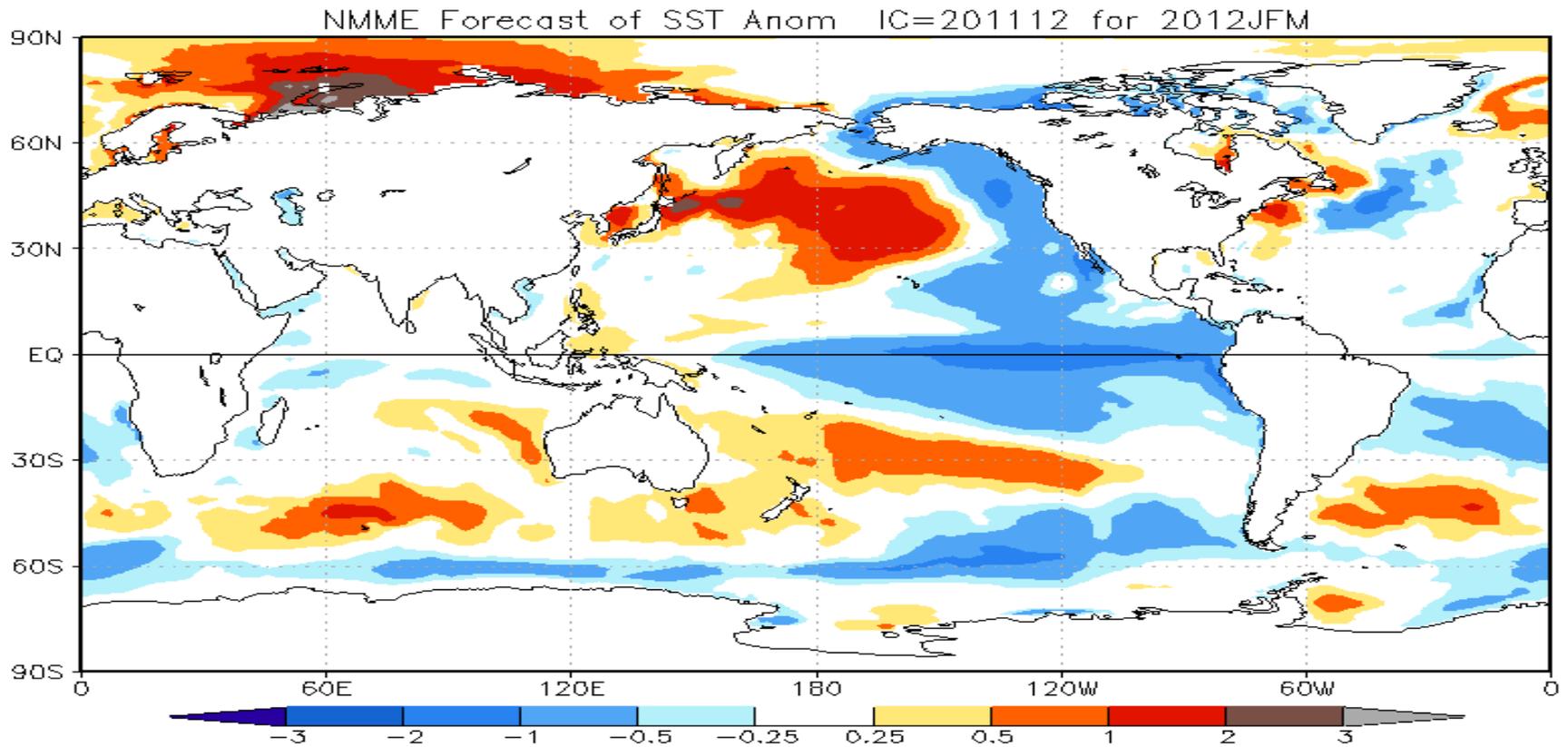


US National Multi-Model (NMME) Intra-Seasonal to Inter-Annual (ISI) Prediction System



Why Multi-Model?

- Multi-Model Methodologies Are a Practical Approach to Quantifying Forecast Uncertainty Due to Uncertainty in Model Formulation
 - And, Apparently Improve Forecast Quality
- Larger Ensembles Yield Better Resolved Uncertainty Due to Initial Condition Uncertainty
- Multi-Model is also Multi-Institutional Bringing More Resources to the Effort
 - And, More Frequent Prediction System Updates

Phase 1 NMME

- **CTB NMME Workshops February 18, April 8, 2011**
 - Establish Collaboration and Protocol for Experimental Real-time Multi-Model Prediction
- **Protocol Developed**
- **Distributing Hindcast Data to CPC**
 - Public Dissemination via IRI Data Library
- **Became Real-Time in August 2011**
 - Adhering to CPC Operational Schedule

NMME Partners

- **University of Miami – RSMAS**
- **Nation Center for Atmospheric Research (NCAR)**
- **Center for Ocean-Land-Atmosphere Studies (COLA)**
- **International Research Institute for Climate and Society (IRI)**
- **University of Colorado – CIRES**
- **NASA – GMAO**
- **NOAA/NCEP/EMC/CPC**
- **NOAA/GFDL**
- **Canadian Meteorological Centre (Soon)**
- **Princeton University**

Phase-1 NMME Data Time Line

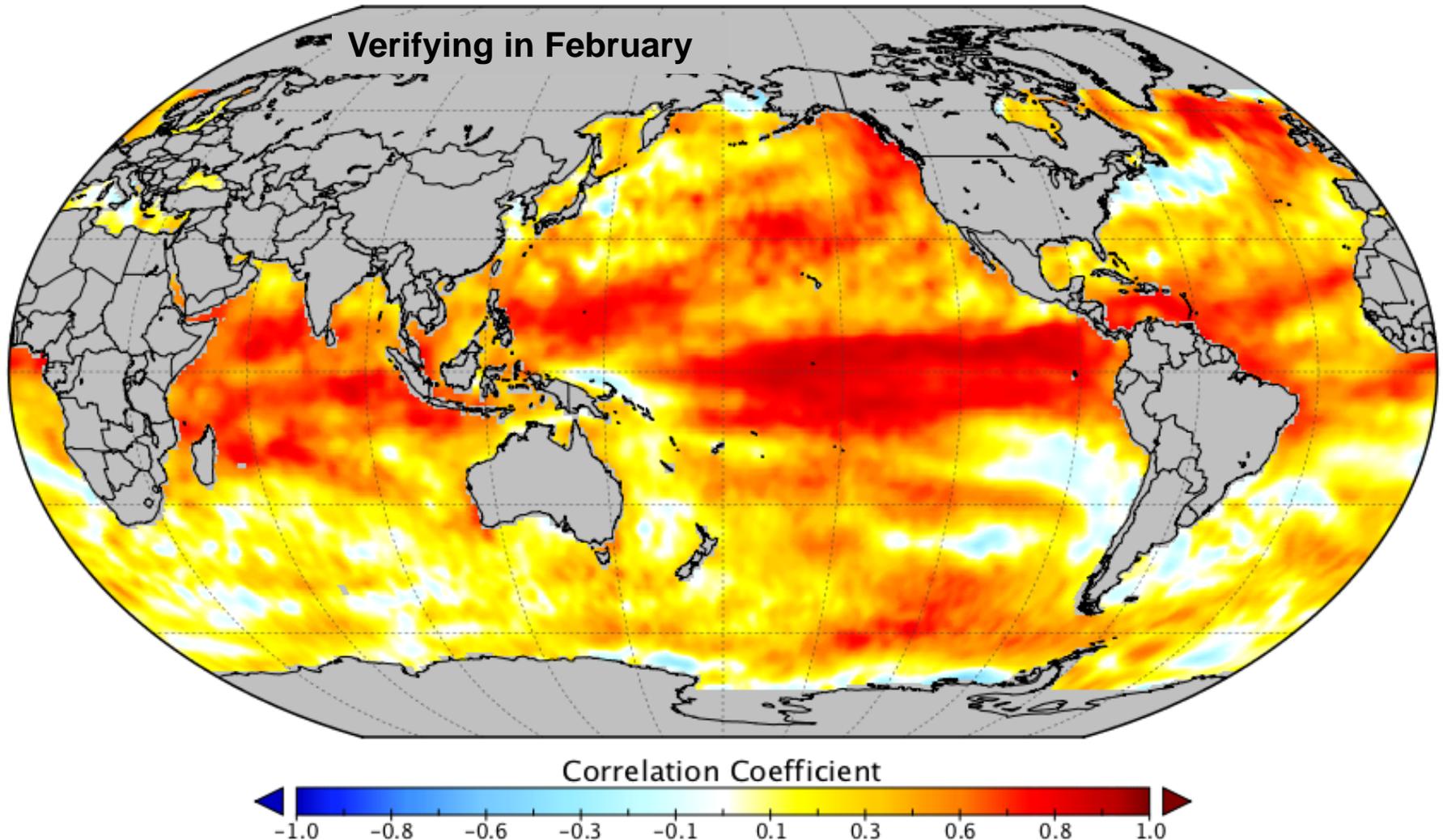
Data	End October 2011	End January 2012	End April 2012	End of July 2012
Monthly Means of T2m, SST Precipitation for all models, all ensemble members and all lead times. Data will be made available in a common format on a common 1x1 grid.	August, September and October 1982-2010 Hindcasts Available	November, December and January 1982-2010 Hindcasts Available	February, March, and April 1982-2010 Hindcasts Available	May, June and July 1982-2010 Hindcasts Available
	August, September and October 2011 Real-time Forecast Data Available	November and December 2011 and January 2012 Real-time Forecast Data Available	February, March and April 2011 Real-time Forecast Data Available	May, June and July 2011 Real-time Forecast Data Available

Graphical Output Available From CPC for Each Model and MME at <http://origin.cpc.ncep.noaa.gov/products/people/wd51yf/NMME/>

Numerical Output for Aug-Jan Starts Available at <http://iridl.ideo.columbia.edu/SOURCES/.Models/.NMME/>

(Preliminary) Hindcast Quality Assessment

US NMME SSTA Correlation Coefficient
6 Month Lead August Initial Conditions (1982-2010)



Each Ensemble Member from Each Model Weighted Equally – 83 Ensemble Members 8

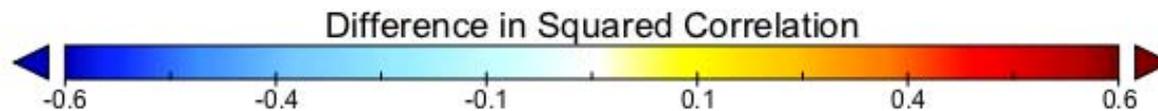
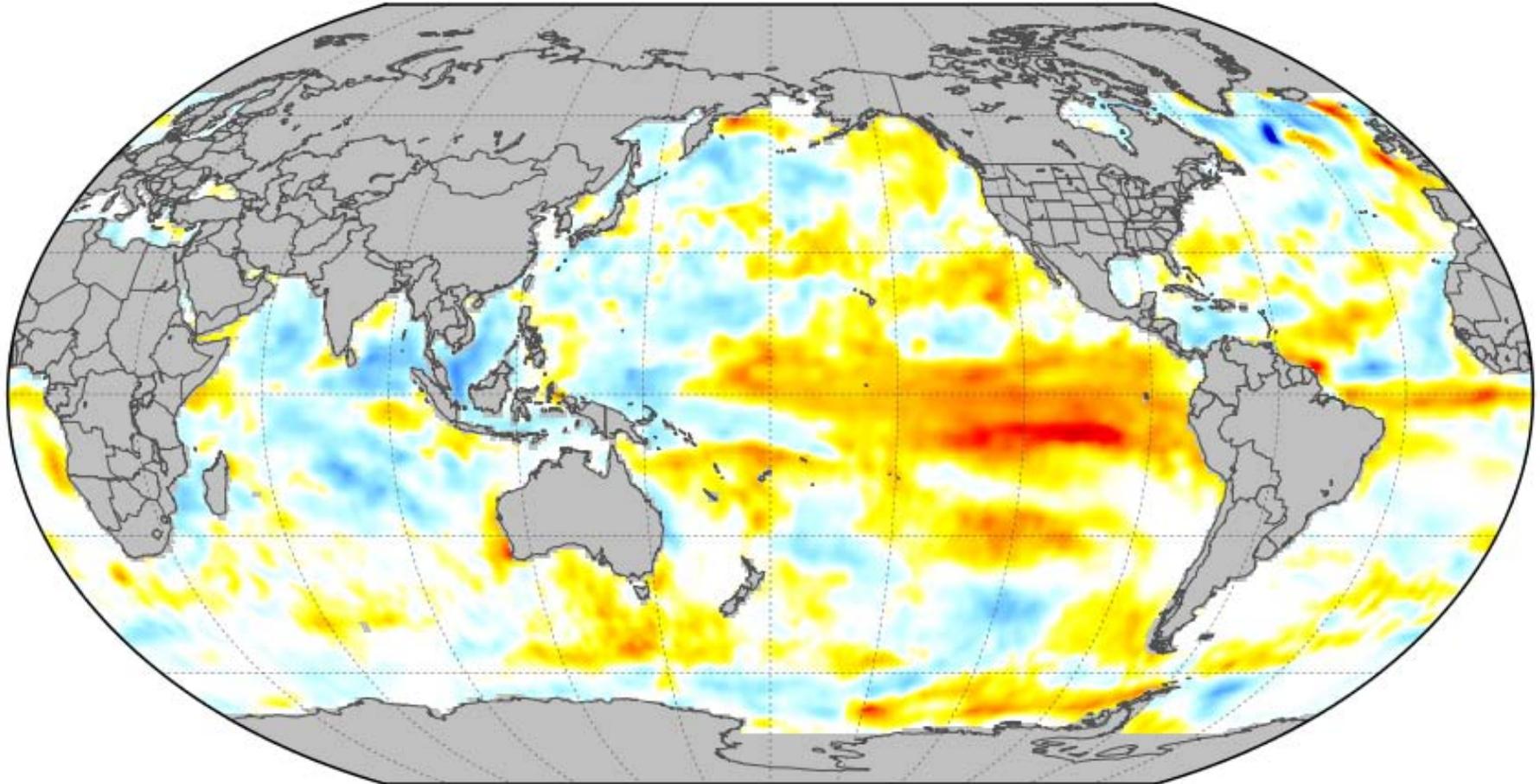
Complementary Skill

- **What is the NMME Benefit?**
 - **What Does Each Model Bring to the NMME?**
- **Compare Each Model to the NMME***
 - **Use Ensembles of the Same Size**
 - **NMME*: All Other Models**

Complementary Correlation

All Others (24 Member Ensemble) vs. CFSv2

Lead Time 6 Months (August Initial Conditions)

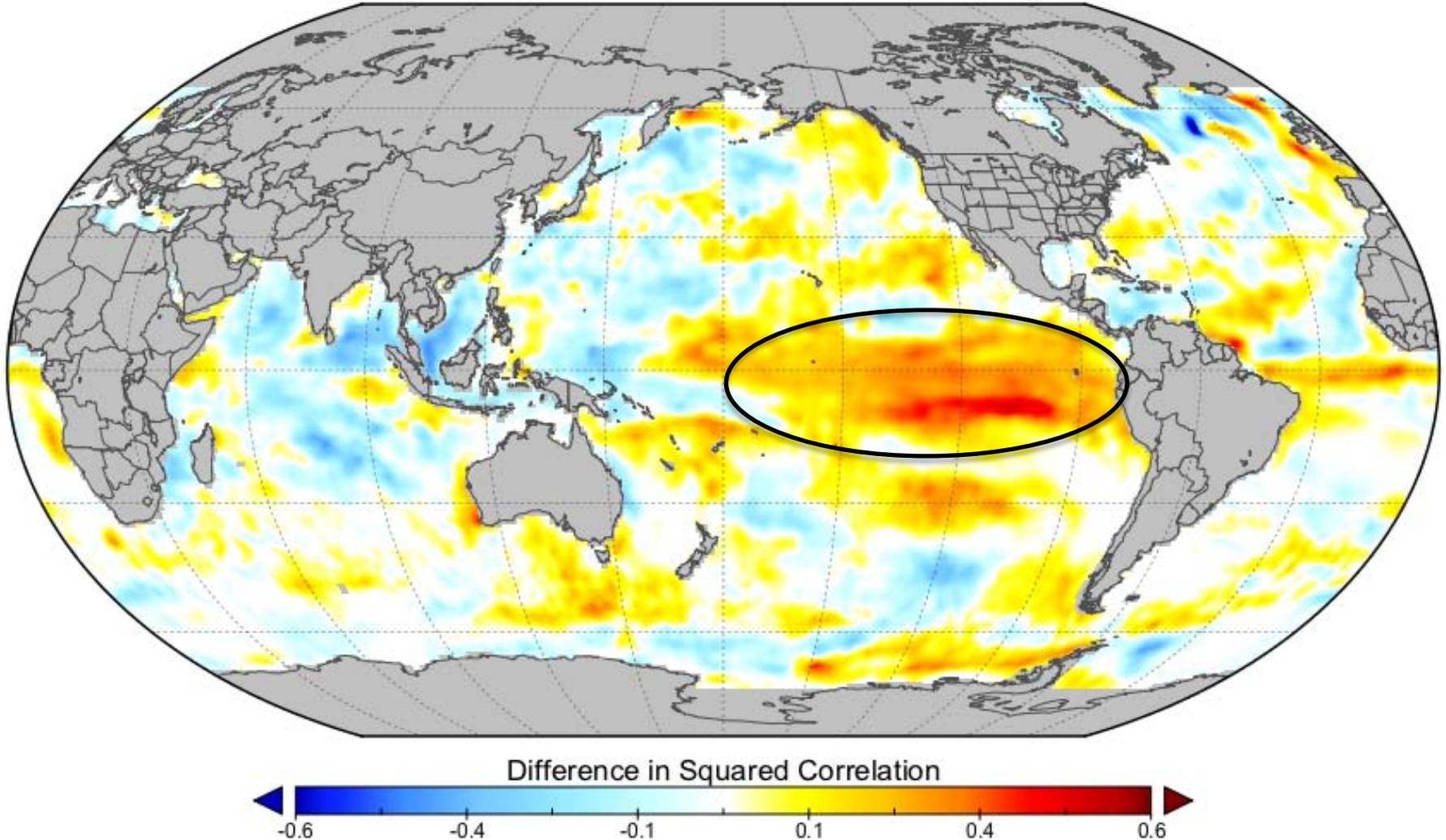


CCSM3(4)+IRIa(4)+IRId(4)+CM2.1(4)+GEOS5(4)+CFSv1(4) vs. CFSv2(24)¹⁰

Complementary Correlation

All Others (24 Member Ensemble) vs. CFSv2

Lead Time 6 Months (August Initial Conditions)

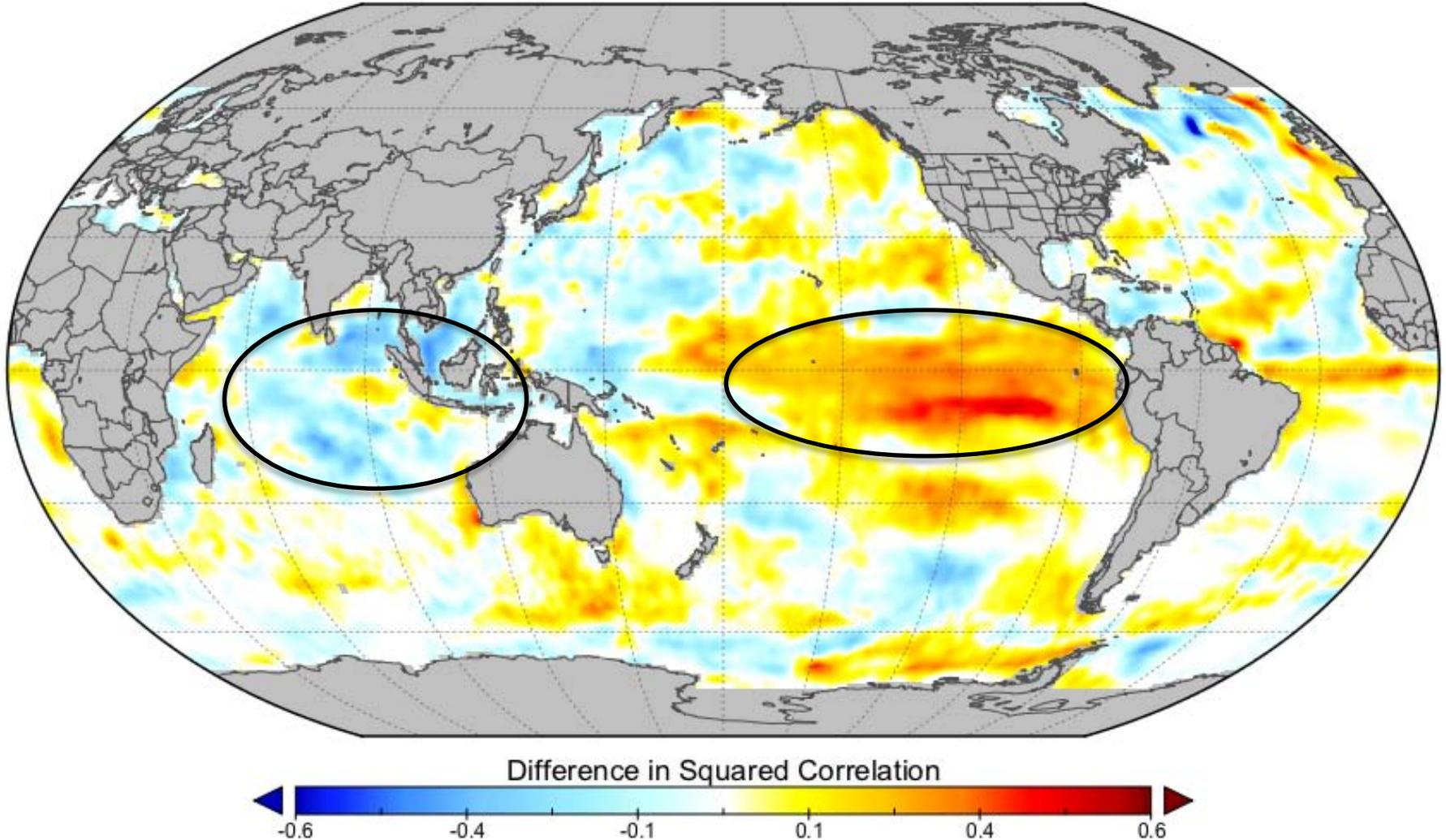


CCSM3(4)+IRIa(4)+IRId(4)+CM2.1(4)+GEOS5(4)+CFSv1(4) vs. CFSv2(24)¹¹

Complementary Correlation

All Others (24 Member Ensemble) vs. CFSv2

Lead Time 6 Months (August Initial Conditions)

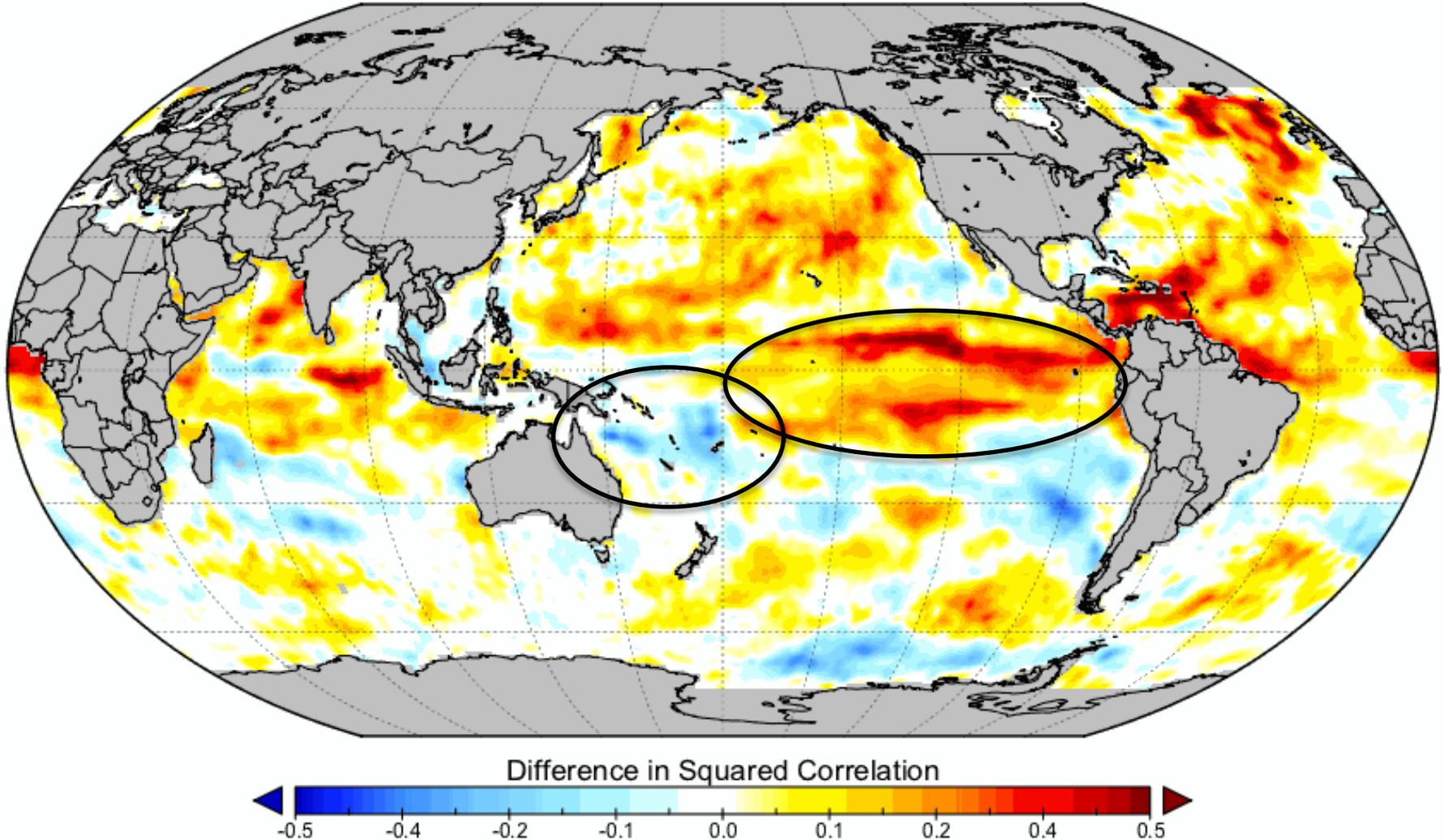


CCSM3(4)+IRIa(4)+IRId(4)+CM2.1(4)+GEOS5(4)+CFSv1(4) vs. CFSv2(24)¹²

Complementary Correlation

All Others (24 Member Ensemble) vs. CCSM3

Lead time 6 Months (August Initial Conditions)

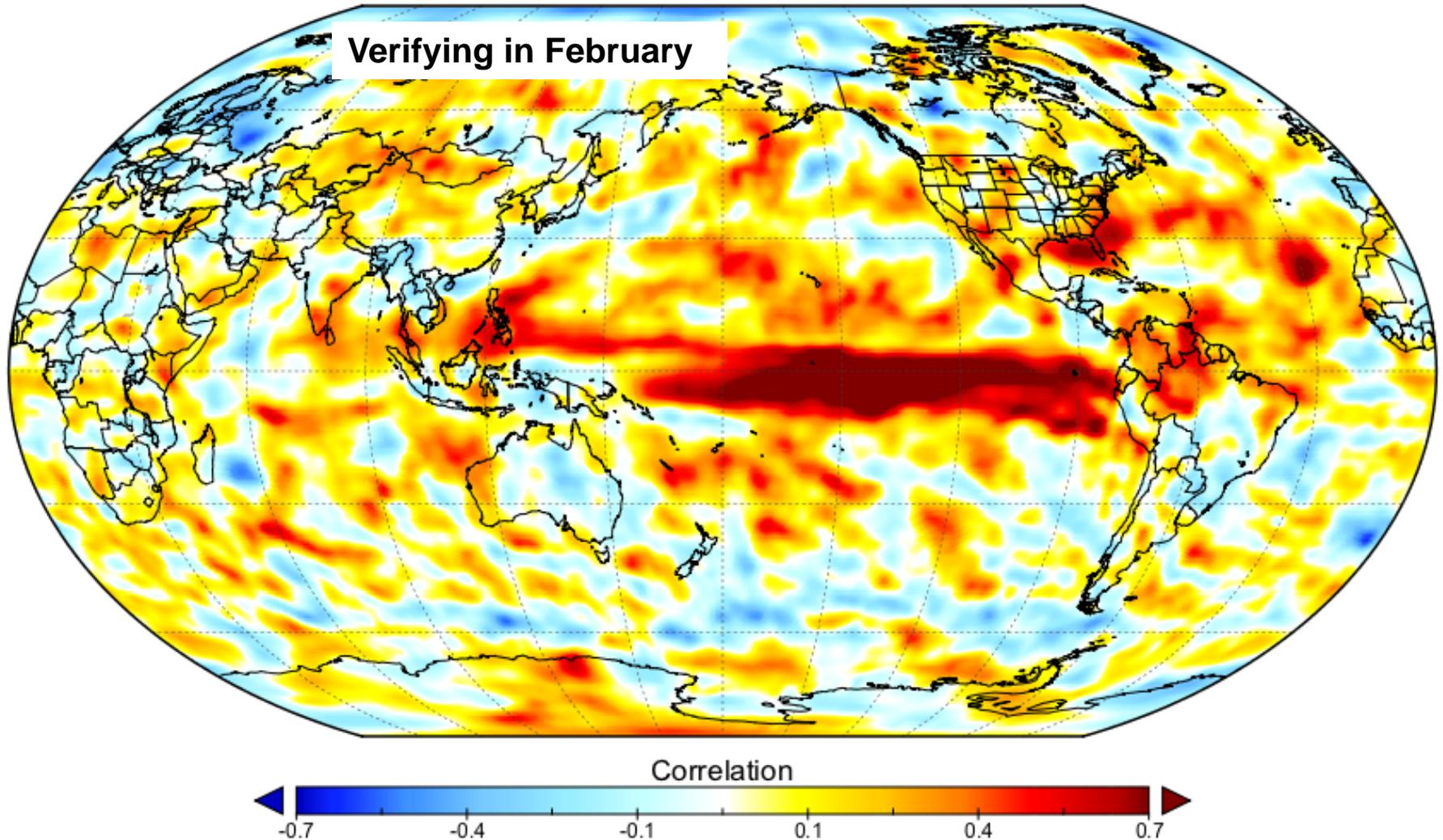


CFSv1(1)+IRIa(1)+IRId(1)+CM2.1(1)+GEOS5(1)+CFSv1(1) vs. CCSM3(6) 13

(Preliminary) Hindcast Quality Assessment

NMME Precipitation Correlation 6 Month Lead (August IC)

Each ensemble member weighted equally

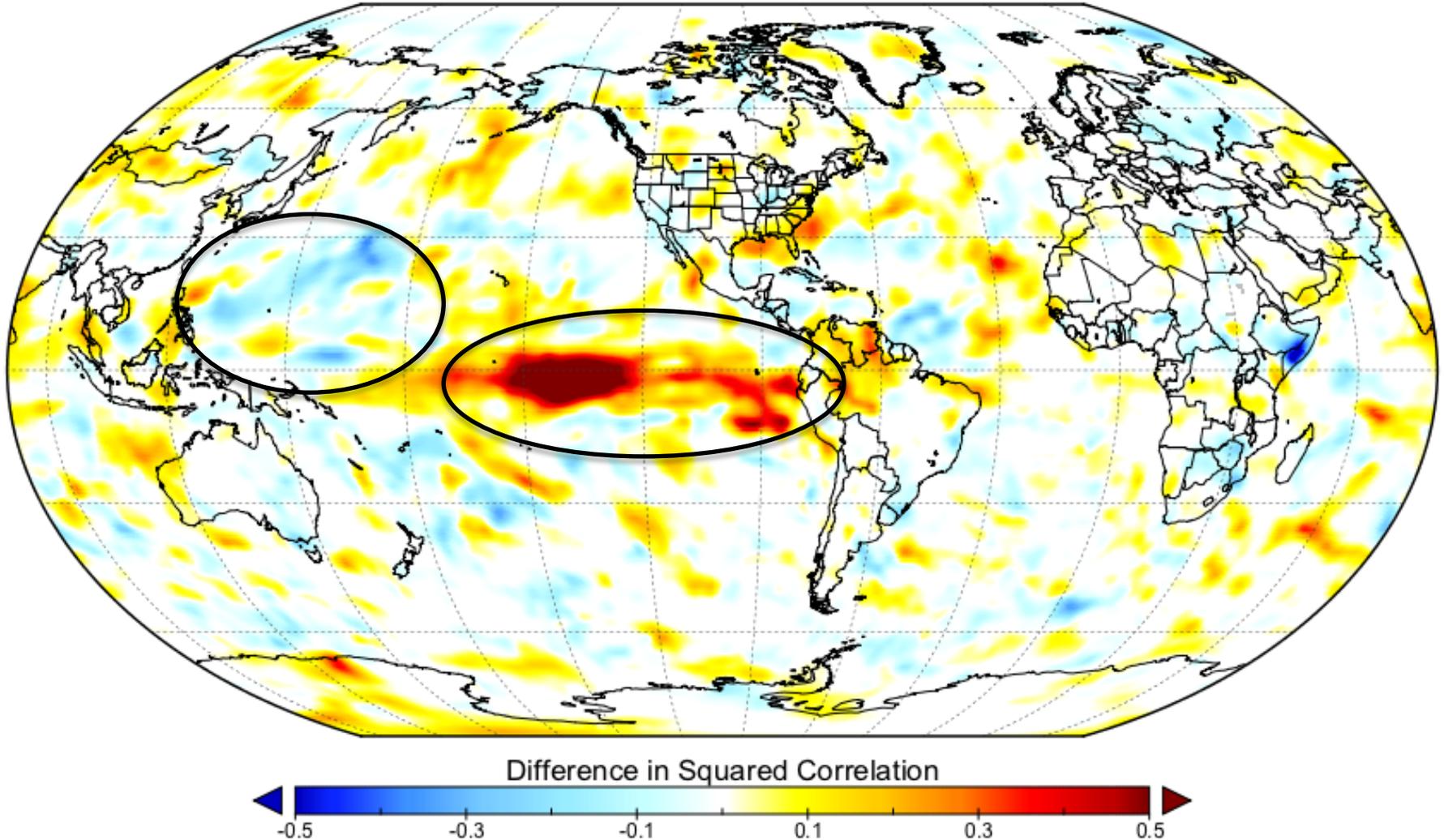


Each Ensemble Member from Each Model Weighted Equally – 83 Ensemble Members¹⁴

Complementary Correlation

All Others (24 Member Ensemble) vs. CFSv2

Lead Time 6 Months

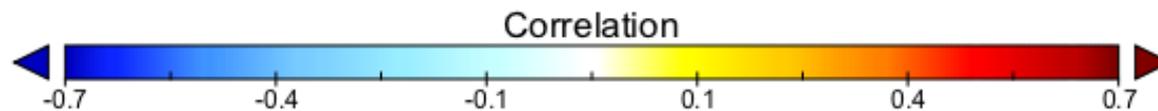
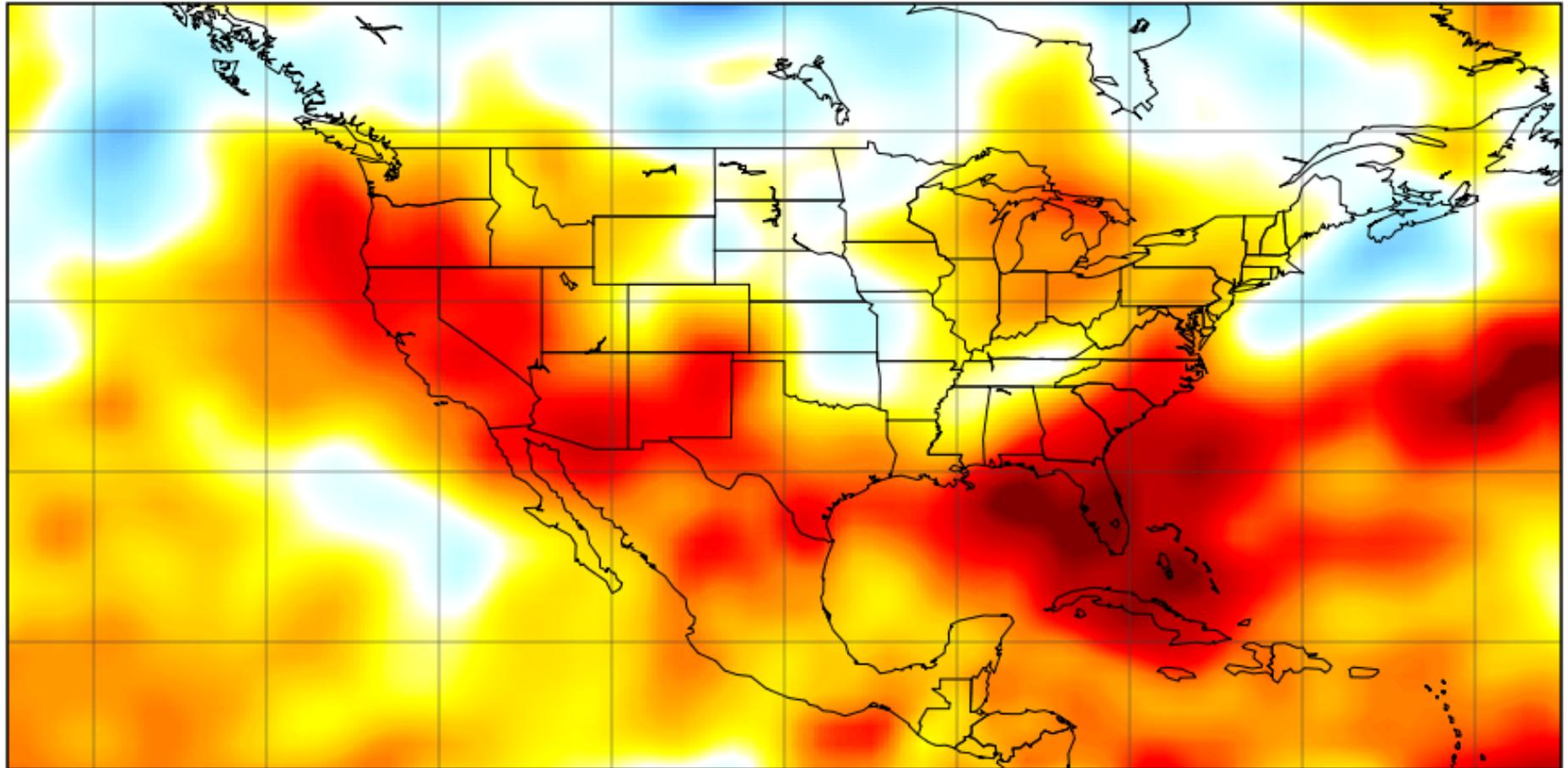


CCSM3(4)+IRIa(4)+IRId(4)+CM2.1(4)+GEOS5(4)+CFSv1(4) vs. CFSv2(24)¹⁵

(Preliminary) Hindcast Quality Assessment

NMME Precipitation Correlation 2 Month Lead (December IC)

Each ensemble member weighted equally



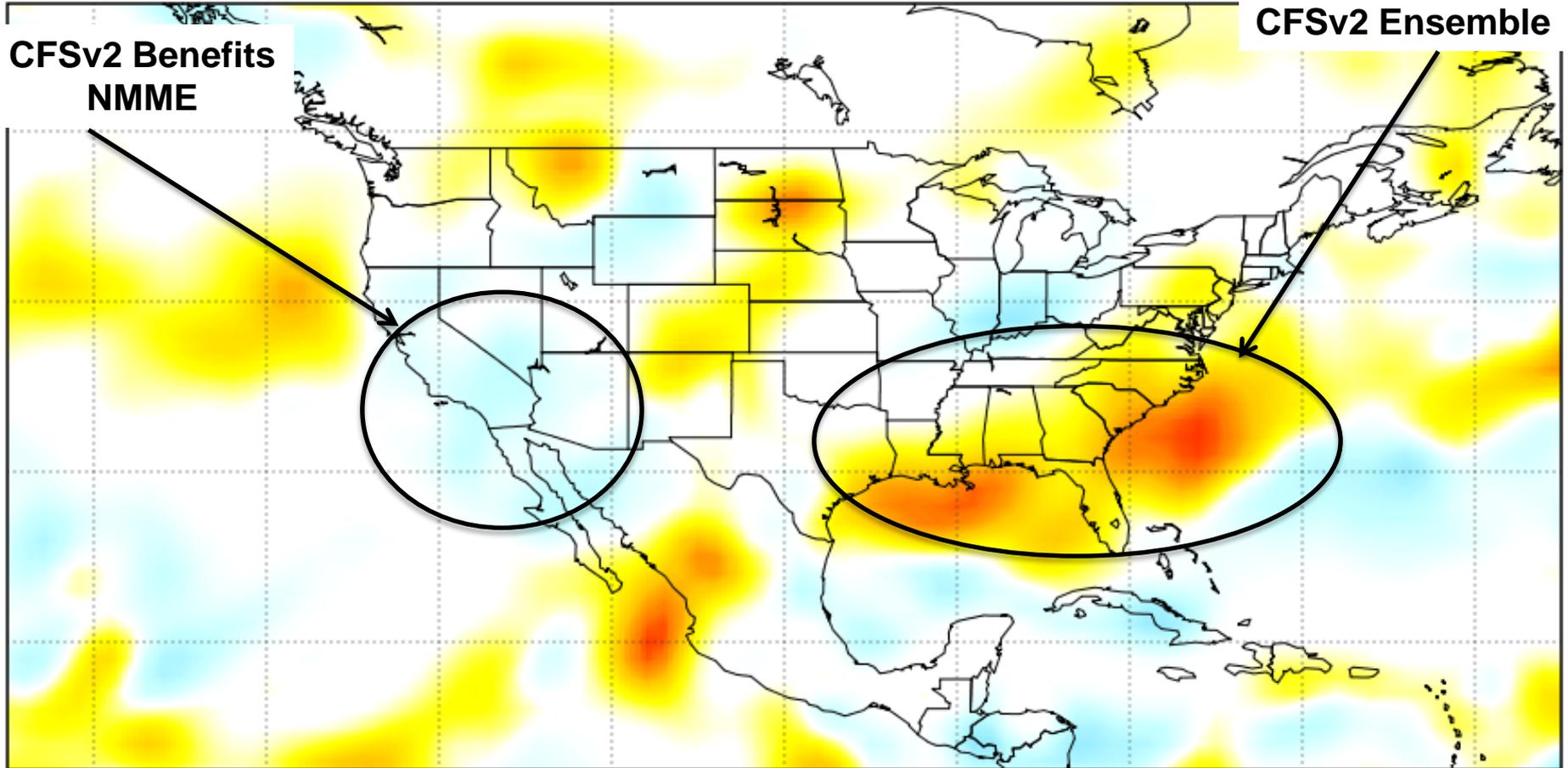
Each Ensemble Member from Each Model Weighted Equally – 83 Ensemble Members₁₆

All Others (24 Member Ensemble) vs. CFSv2

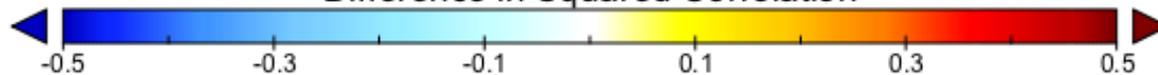
Lead Time 6 Months (August Initial Conditions)

**NMME Benefits
CFSv2 Ensemble**

**CFSv2 Benefits
NMME**



Difference in Squared Correlation



CCSM3(4)+IRIa(4)+IRId(4)+CM2.1(4)+GEOS5(4)+CFSv1(4) vs. CFSv2(24)¹⁷

Area Averaged Correlation (R^2) Over North America: Model Ranks

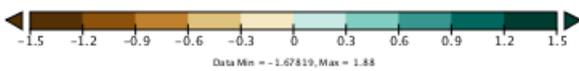
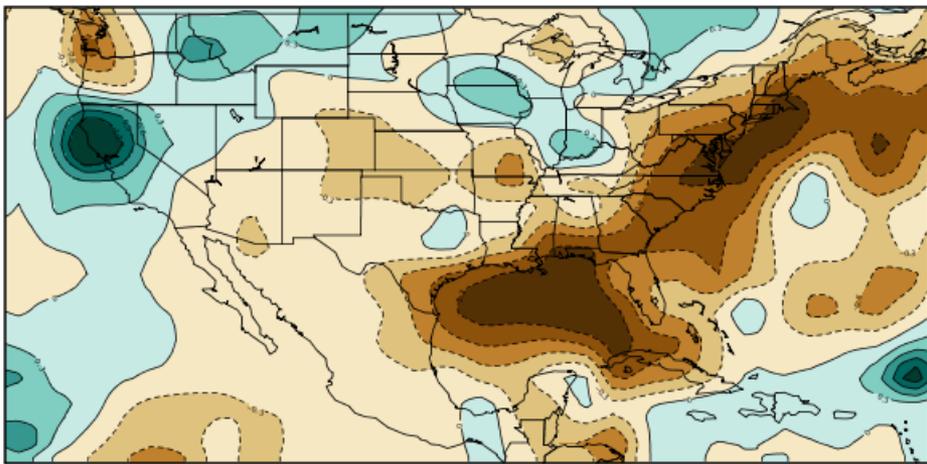
	Mod A	Mod B	Mod C	Mod D	Mod E	Mod F	Mod G	NMME
JFM P (August IC)	4	6	5	8	7	3	2	1
JFM T2m (August IC)	3	1	5	6	7	4	8	2
MJJ P (December IC)	5	7	1	2	8	6	3	4
MJJ T2m (December IC)	6	1	3	4	8	7	5	2
Mean Rank	4.5	3.75	3.5	5.0	7.5	5.0	4.5	2.2

“Best Model” Depends on Lead-Time, Domain, Variable, State: NMME Is Reliable One of the Best

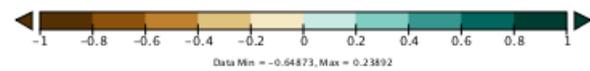
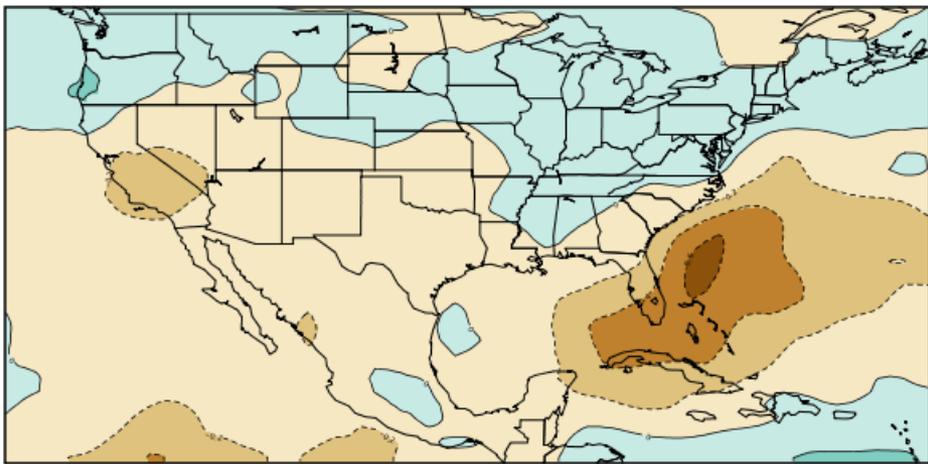
2006-2007 South East US Drought Case Study

FMA2006 CMAP Precipitation Anomaly vs. All Model, All Ensemble Average FMA2006 (Aug2005 and Dec2005 IC) Precipitation Anomaly (*note color scale change for model images)

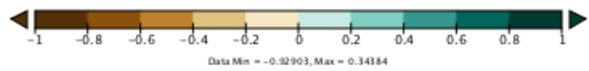
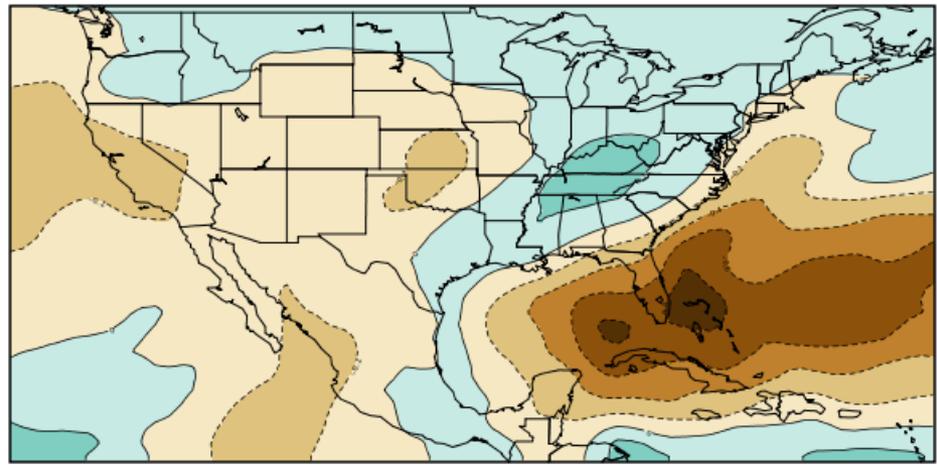
CMAP Precipitation Anomaly for FMA 2006



All Model, All Ensemble Average of Aug2005 IC, FMA 2006 Seasonal Average of Precip Anomalies

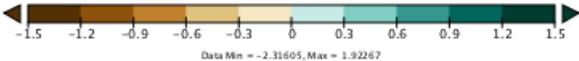
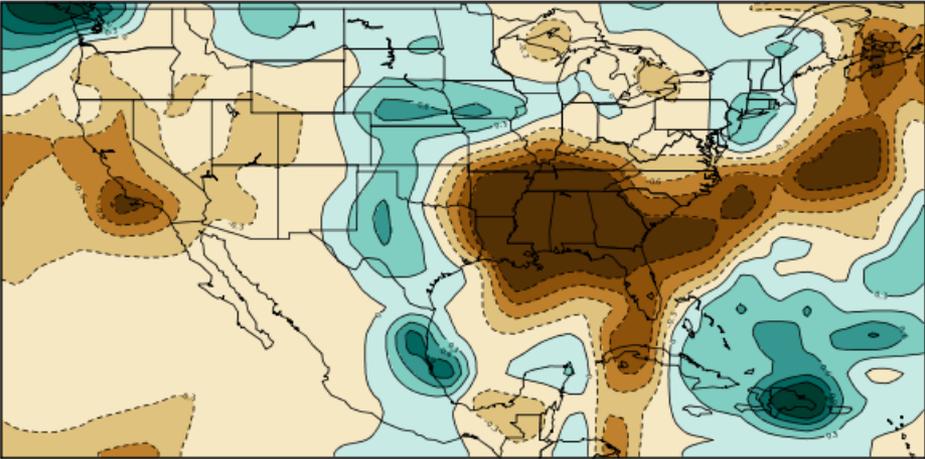


All Model, All Ensemble Average of Dec2005 IC, FMA 2006 Seasonal Average of Precip Anomalies

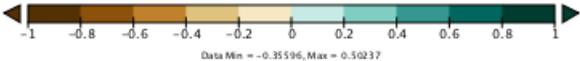
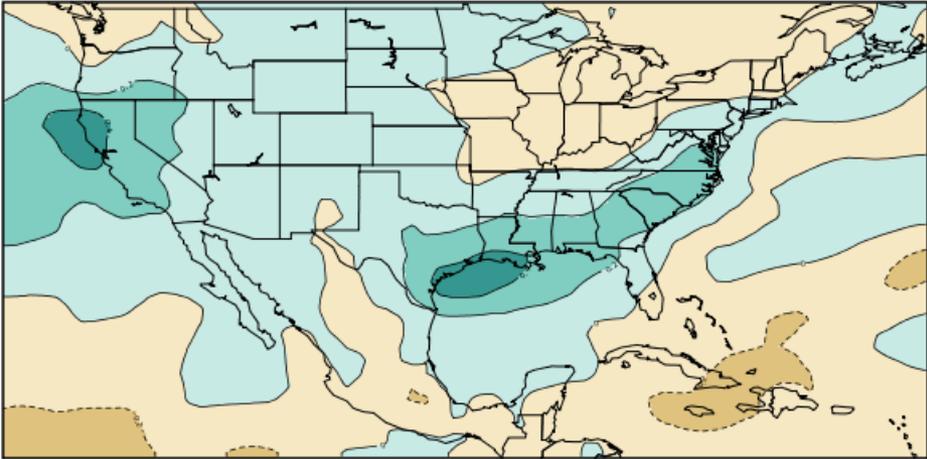


FMA2007 CMAP Precipitation Anomaly vs. All Model, All Ensemble Average FMA2007 (Aug2006 and Dec2006 IC) Precipitation Anomaly (*note color scale change for model images)

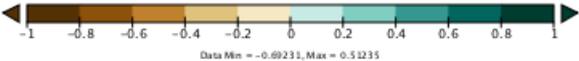
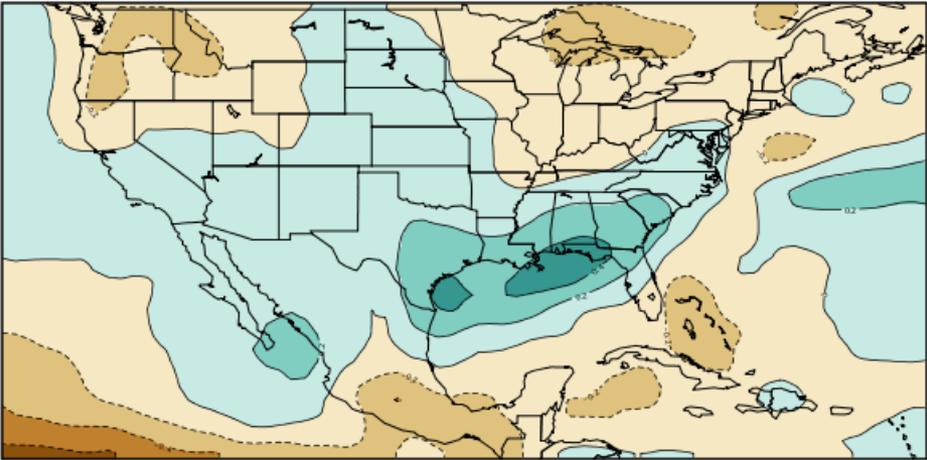
CMAP Precipitation Anomaly for FMA 2007



All Model, All Ensemble Average of Aug2006 IC, FMA 2007 Seasonal Average of Precip Anomalies

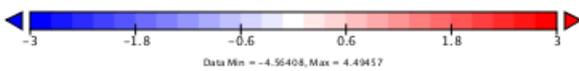
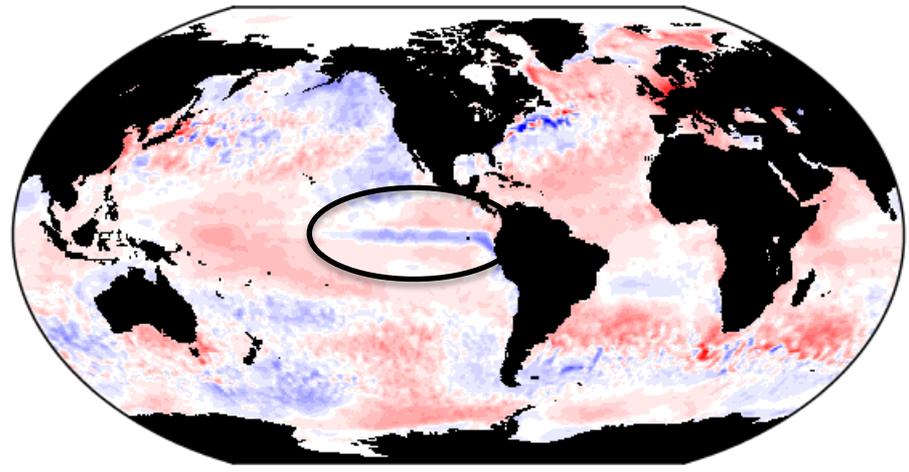


All Model, All Ensemble Average of Dec2006 IC, FMA 2007 Seasonal Average of Precip Anomalies

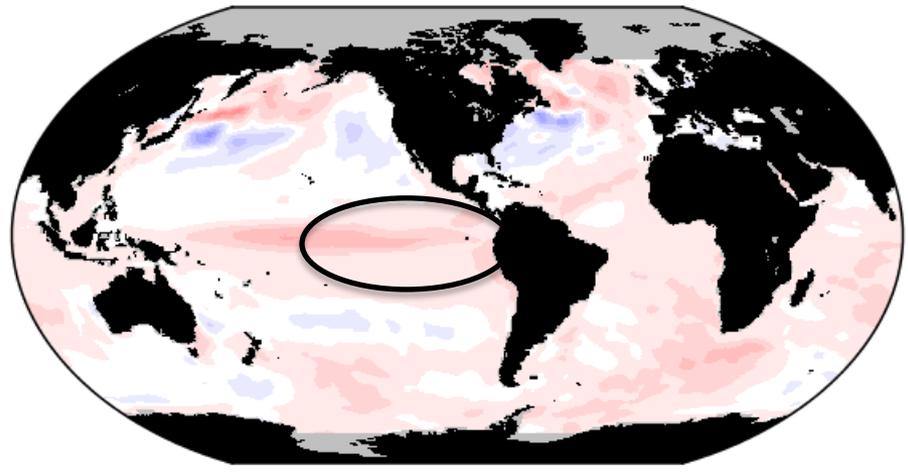


FMA2007 NCDC SST Anomaly vs. All Model, All Ensemble Average FMA2007 (Aug2006 and Dec2006 IC) SST Anomaly

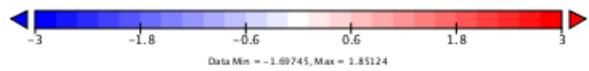
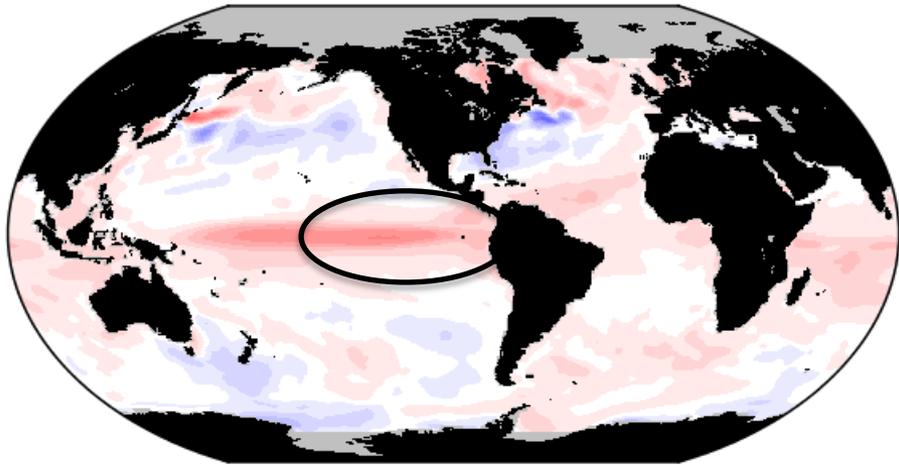
NCDC SST Anomaly, FMA2007 Seasonal Average



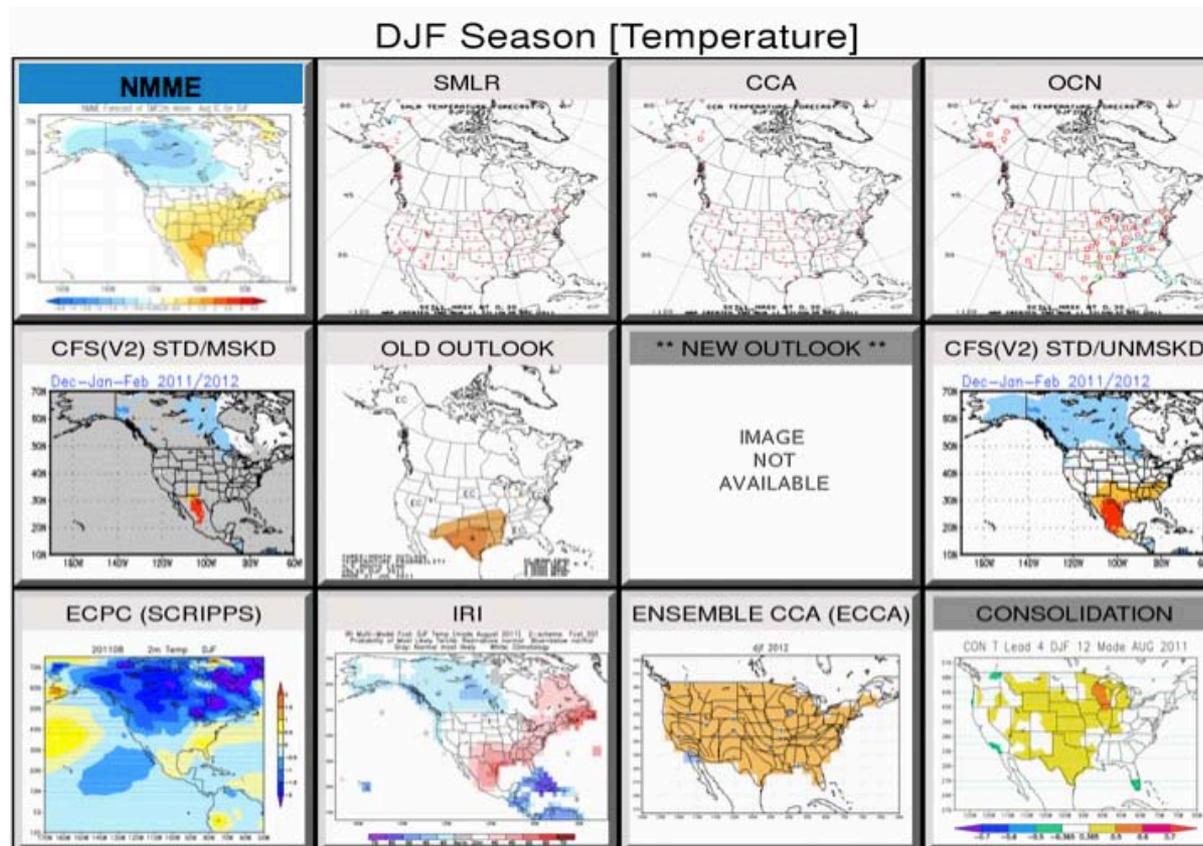
All Model, All Ensemble Average; August 2006 IC, FMA 2007 Seasonal Average SST Anomaly



All Model, All Ensemble Average; December 2006 IC, FMA 2007 Seasonal Average SST Anomaly



CPC Real-Time Seasonal Forecasting Tools



Used in Monthly Ocean Briefing

Used for African Desk

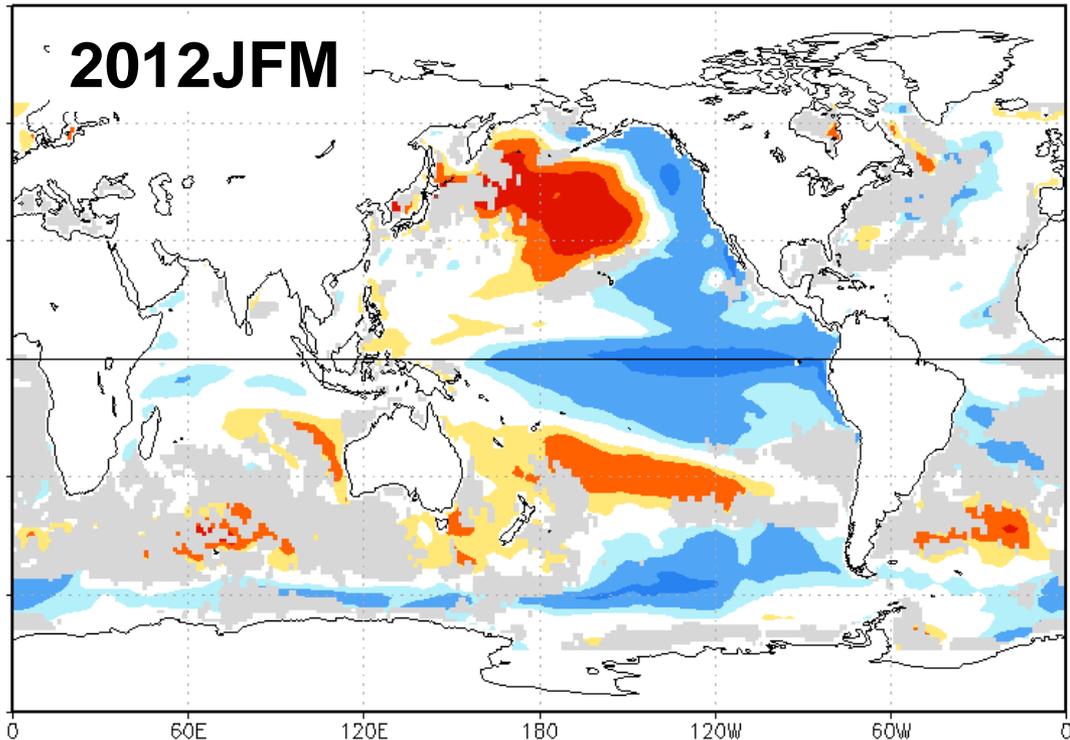
CPC Seasonal Prognostic Map Discussion (PMD):

“PROGNOSTIC TOOLS USED FOR U.S. TEMPERATURE AND PRECIPITATION OUTLOOKS FOR JFM THROUGH AMJ 2012 WERE PRIMARILY BASED ON THE NEW NATIONAL MULTI-MODEL ENSEMBLE MEAN FORECAST (NMME). THE FORECASTS STRONGLY AGREE WITH ...”

Phase 2 NMME

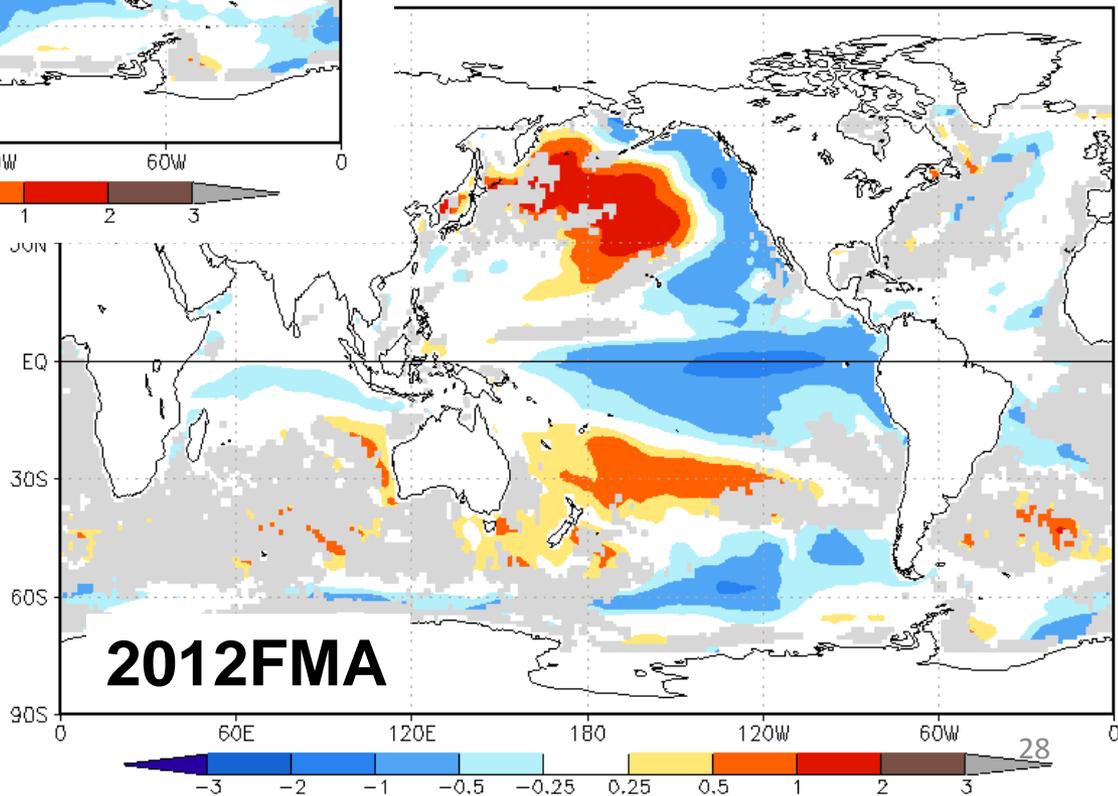
- **Continue Experimental Real-Time Predictions**
- **Enhancing Current NMME Capability**
 - Model Updates: GFDL-CM2.5 (20 km AGCM), IRI (T106), CCSM4, CESM1
- **Assess Forecast Quality**
 - MME Combinations, Model Independence
 - Drought Assessment
 - Include: soil moisture, runoff, evaporation
- **Sub-Seasonal Assessment**
 - Forecast Protocol
- **Initial Condition Sensitivity Experiments**
 - Ocean, Land
- **Improved Data Distribution**
 - Under Discussion with NCAR

2012JFM

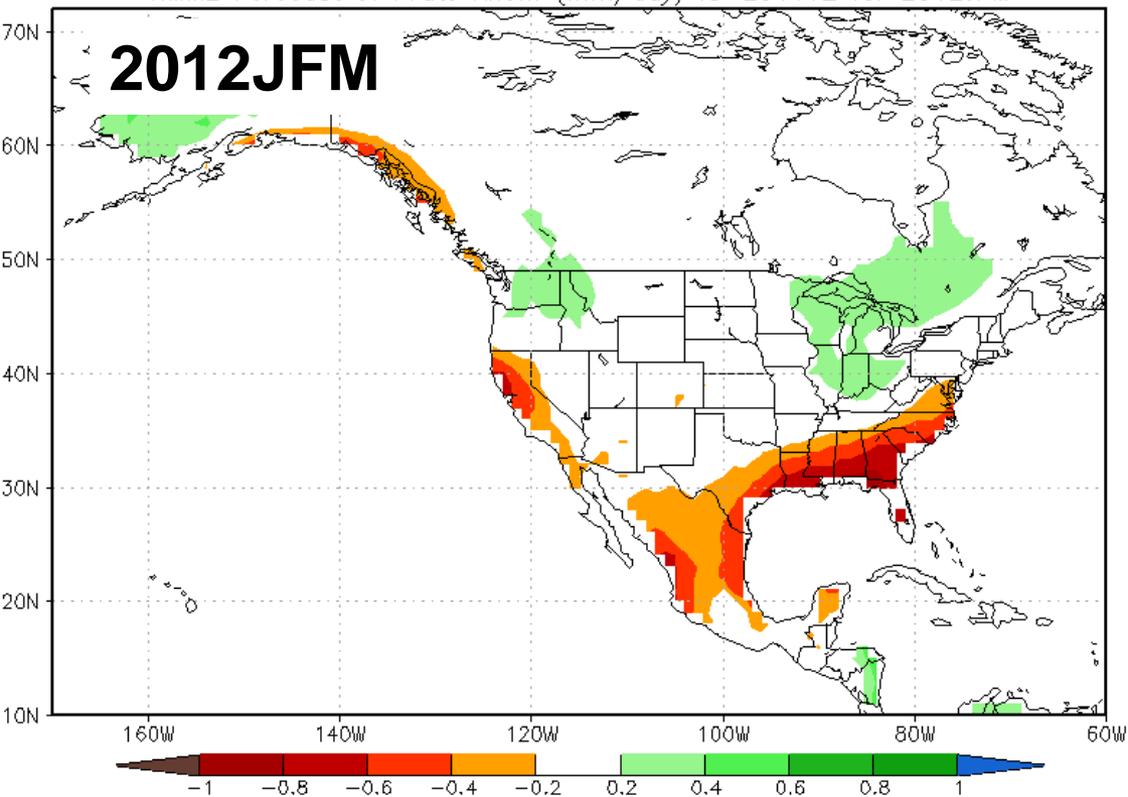


NMME SSTA Predictions December 2011 Initial Conditions

1st of SST Anom IC=201112 for 2012FMA

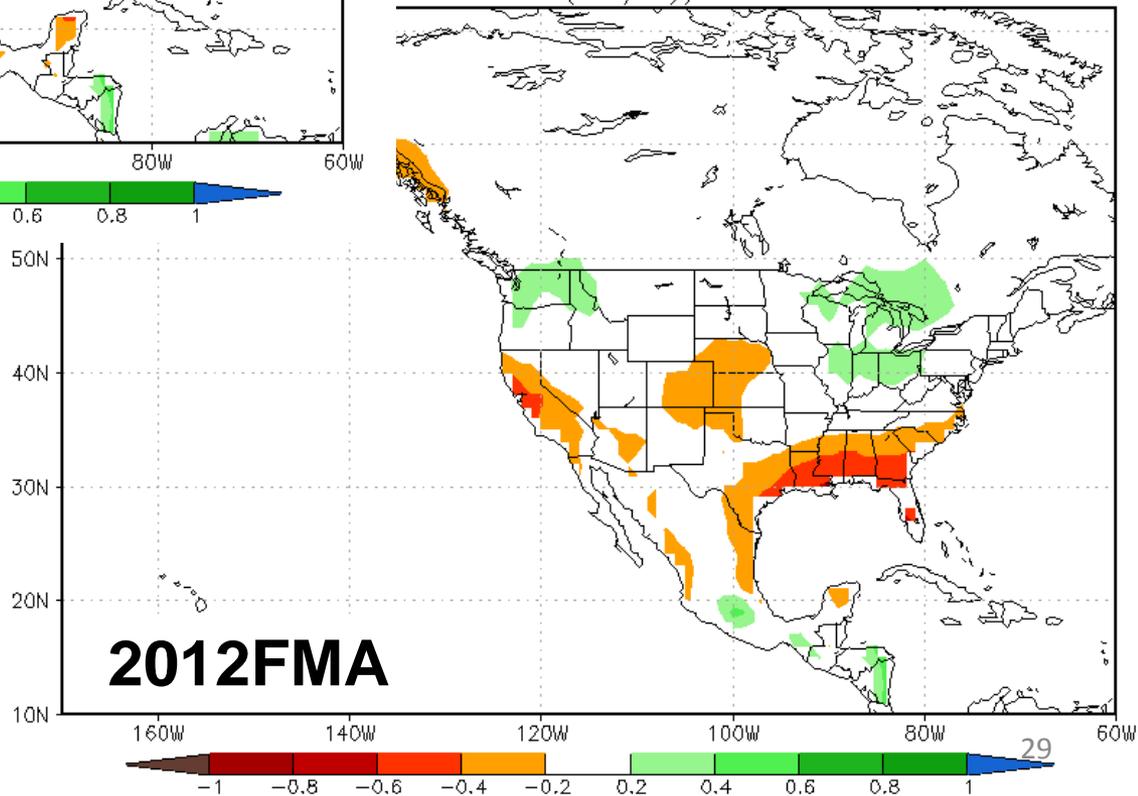


NMME Forecast of Prate Anom (mm/day) IC=201112 for 2012JFM



NMME Precip Predictions December 2011 Initial Conditions

Prate Anom (mm/day) IC=201112 for 2012FMA



Summary

- **All Participating Model Follow the Same Protocol**
- **Data (Hindcast and Forecasts) Readily Available to the Community (Now)**
- **Real-Time Forecasts Used by CPC Operational Forecasters**
- **NMME Contributes to the Forecast**
 - Many More Ensemble Members
 - Complementary Correlation
 - Reliably Among the Best
- **Leveraging Multi-Institutional Resources**
 - More Minds and Eyes
 - More Rapid Updates
- **NMME Contributes to Predictability Research**