Operational Use of NMME at CPC

David DeWitt
Director, Climate Prediction Center

Outline

- Background on Use of Multi-Model Ensembles and CPC Temperature and Precipitation Outlooks
- Sample CPC Products that use NMME
  - Monthly/Seasonal Temperature and Precipitation Outlooks
  - ENSO Diagnostic Discussion
  - Drought Outlook
  - International Desks
- Challenges/Gaps

Multi-Model Ensembles and the North-American Multi-Model Ensemble (NMME) Project

Why do use multi-model ensembles (MME) for forecasts?:

- **Allows representation of model uncertainty.**
- **Possibility of complementary skill between models.**
- **Skill of MME is frequently higher than that from the most skillful member in the ensemble (though if one model is dominantly better this is not always true).**

NMME is frequently our most skillful tool but there is still room for improvement.

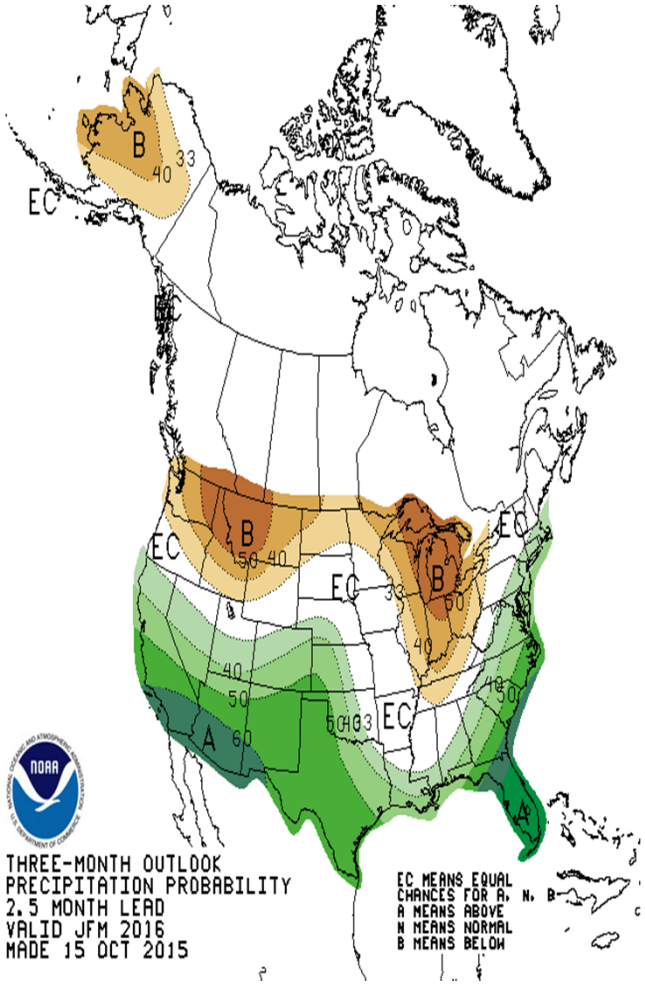
Generation of CPC Monthly/Seasonal Outlooks

Human Forecasters Use Various Tools To Develop Seasonal Predictions:

- Dynamical Models (including NMME)
- Statistical Models
- Historical Analogs
- Historical Composites

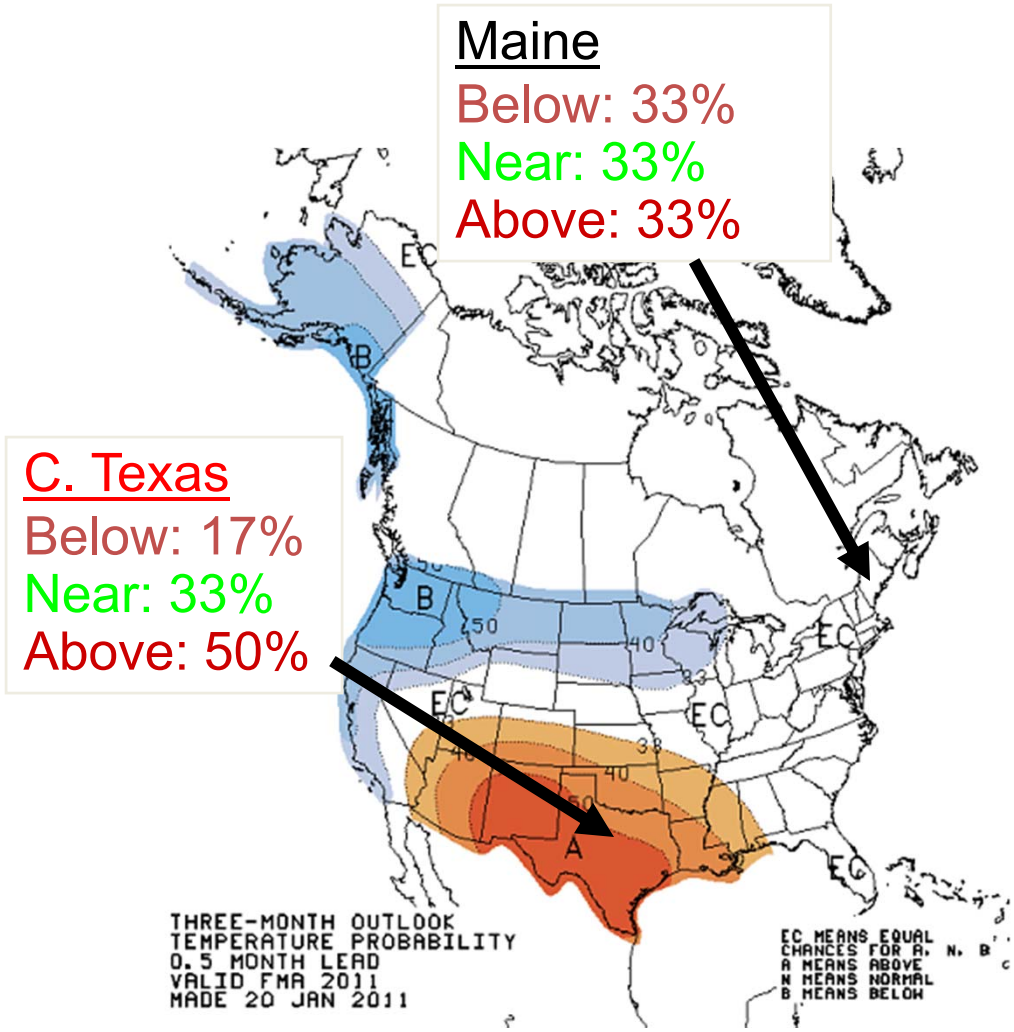
Goal is to leverage complementary skill between the tools.

Ultimately, skill of seasonal forecast depends on skill of tools made available to the forecaster. NMME is one of those tools



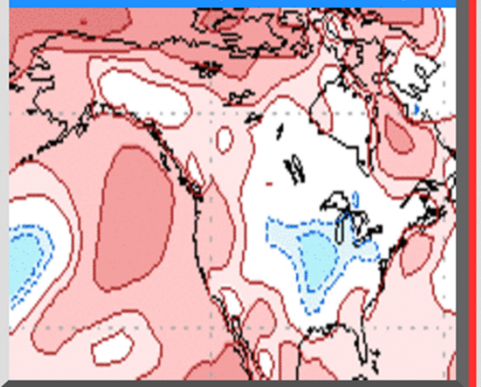
CPC Monthly/Seasonal Outlook

CPC Seasonal Outlooks:
- Tercile Class Probabilities
- Dominant category is given on map
- Probability of Exceedance information is available. New user-friendly graphical tool for POE to be released soon.
-

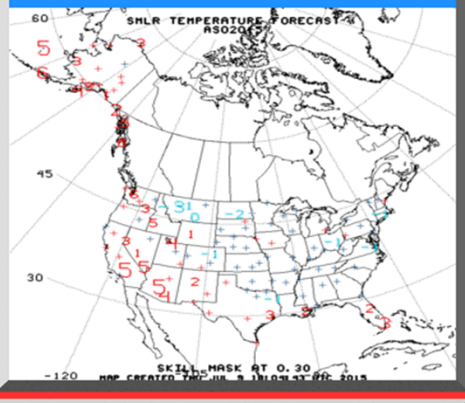


ASO 2015 [Temperature]

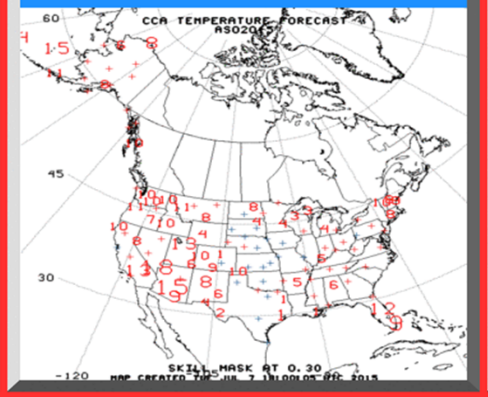
SST CA (ASO 2015)



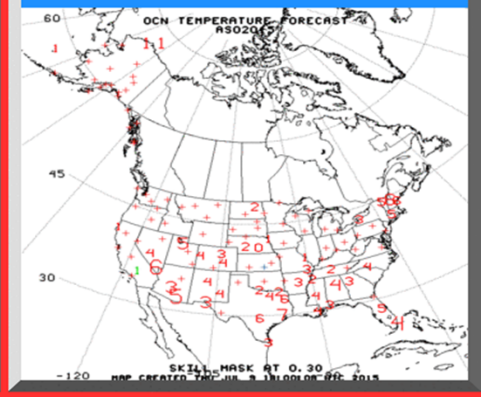
SMLR



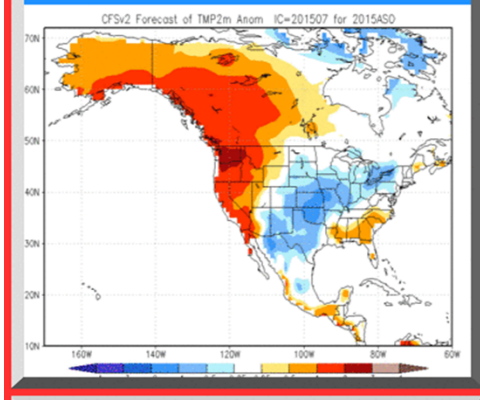
CCA



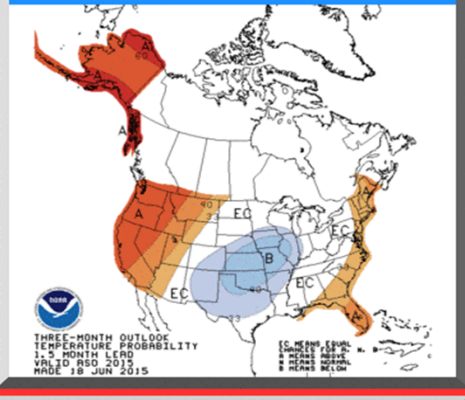
OCN



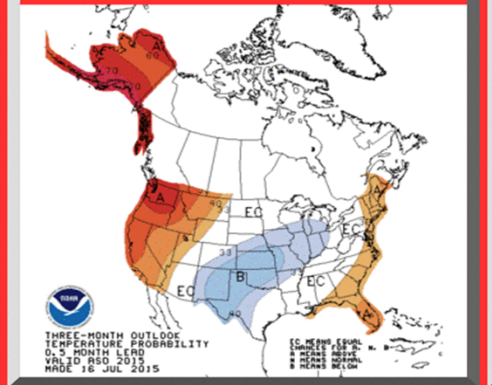
CFSv2



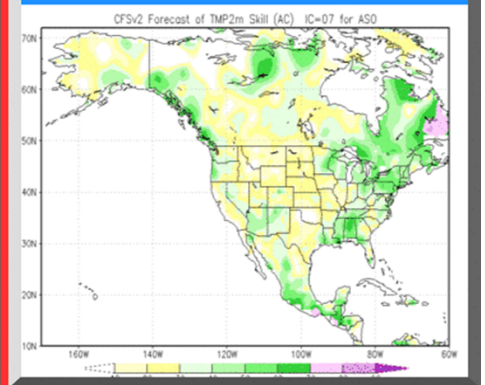
OLD OUTLOOK



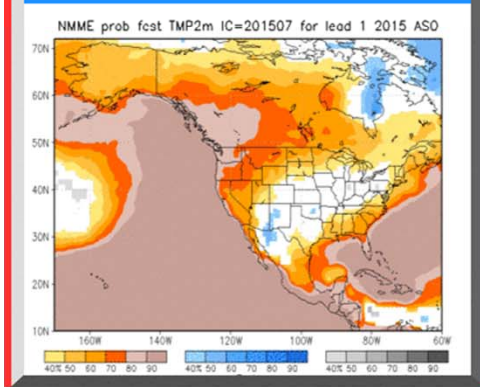
** NEW OUTLOOK **



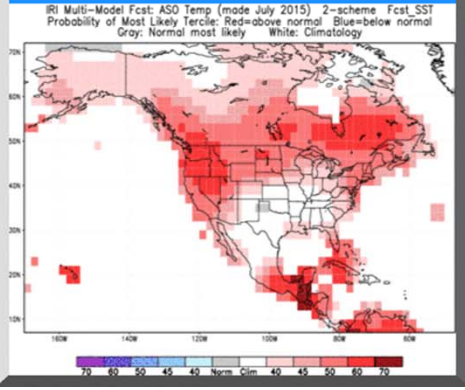
CFSv2 (skill)



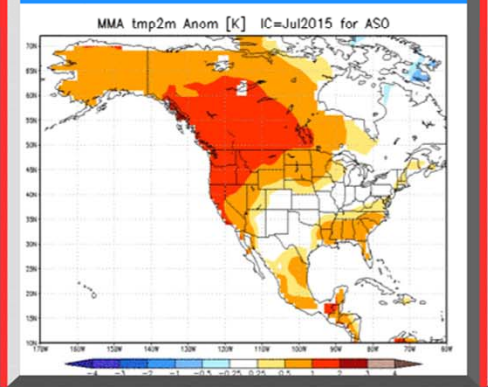
NMME (Probs)



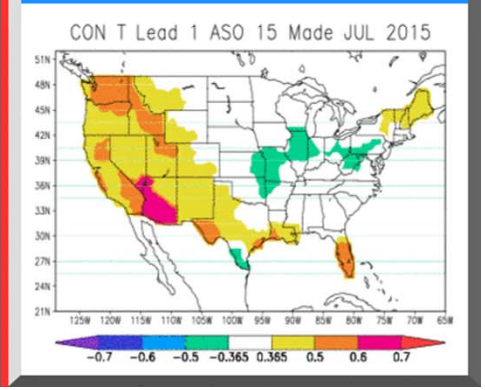
IRI



IMME

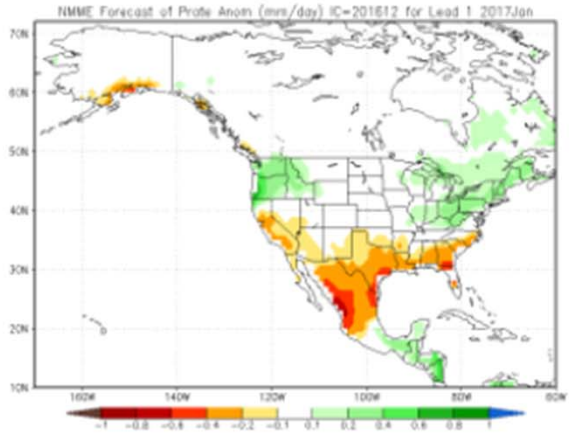


CONSOLIDATION

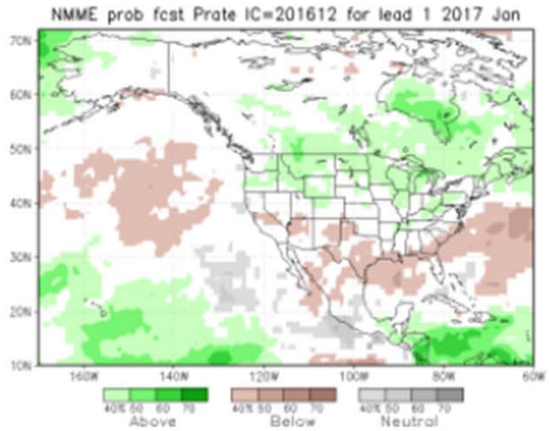


January 2017 NMME Forecasts: NMME Probabilistic Forecast Indicates Near Normal Precipitation for California

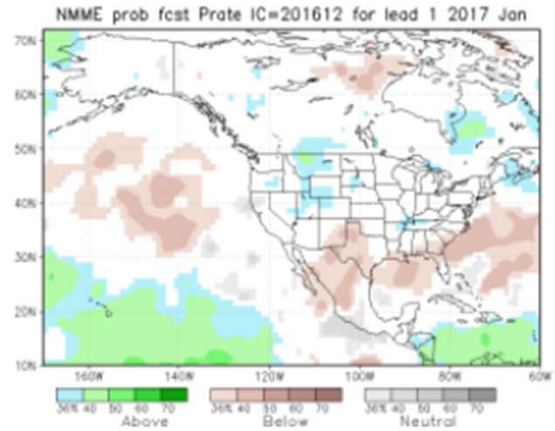
NMME



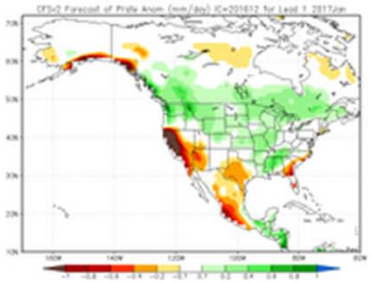
Prob fcst



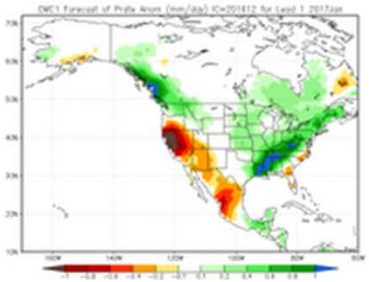
PAC calib. prob fcst



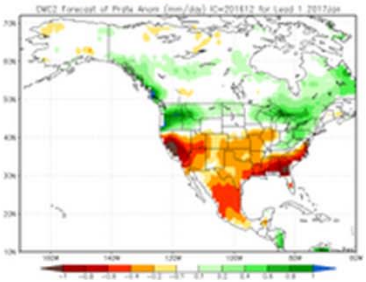
NCEP_CFSv2



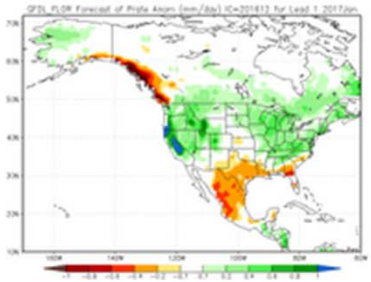
CMC1_CanCM3



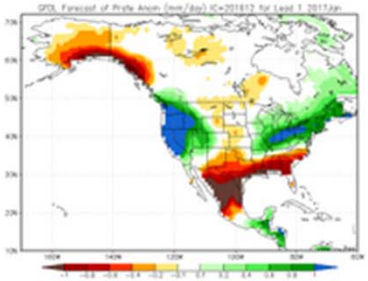
CMC2_CanCM4



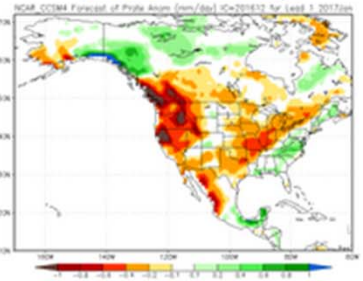
GFDL_FLOR



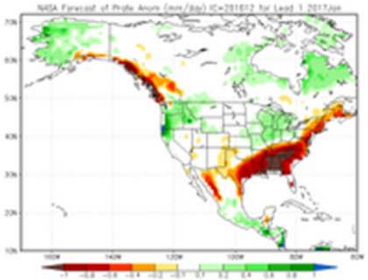
GFDL_CM2.1



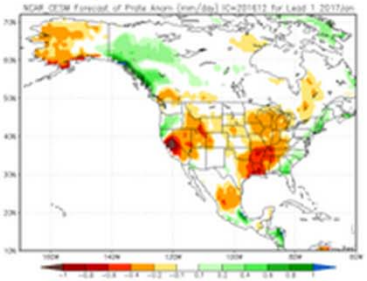
NCAR_CCSM4



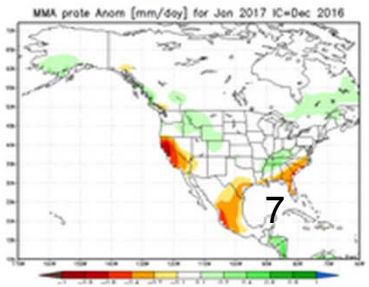
NASA_GEOS5



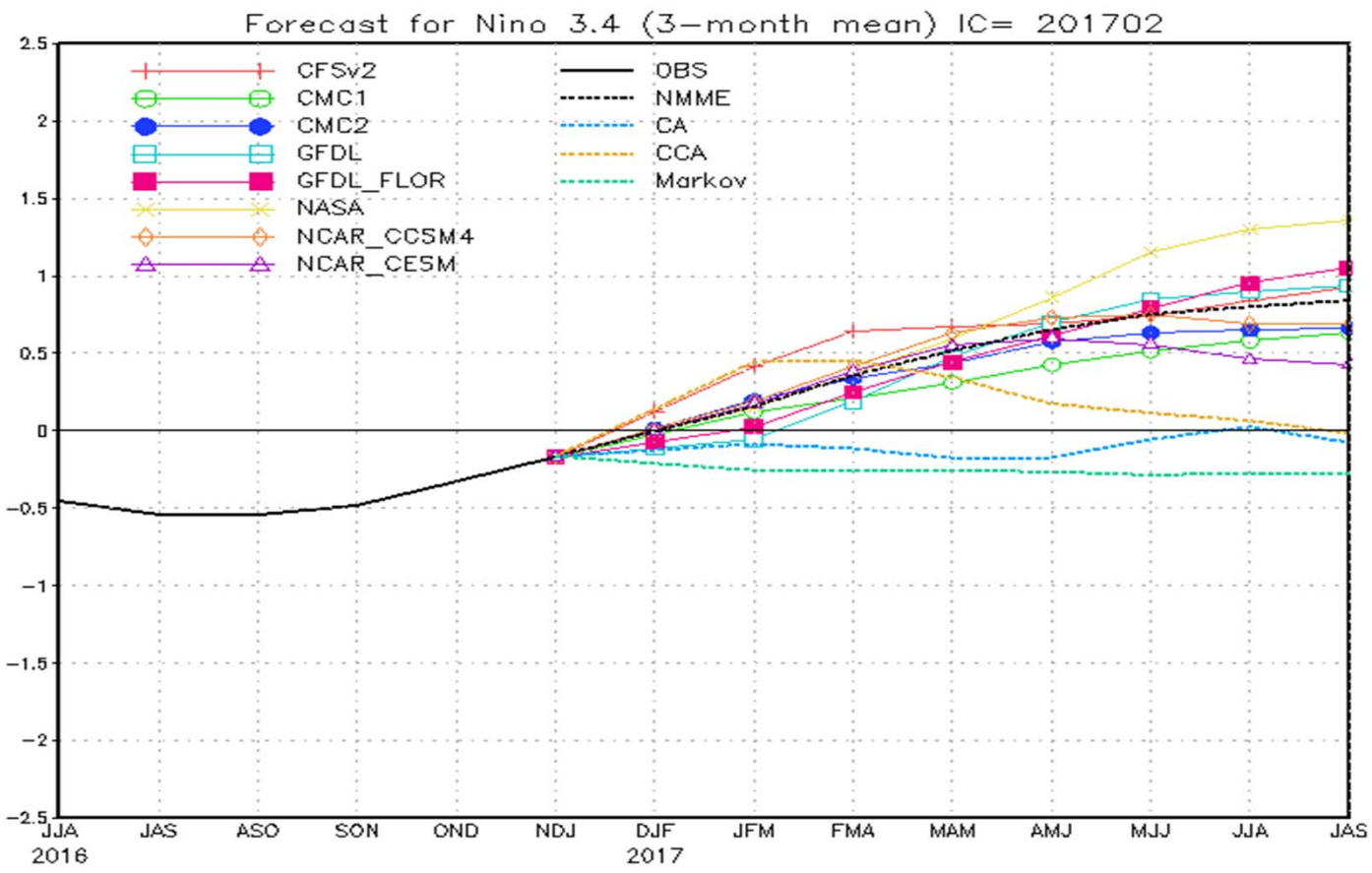
NCAR_CESM



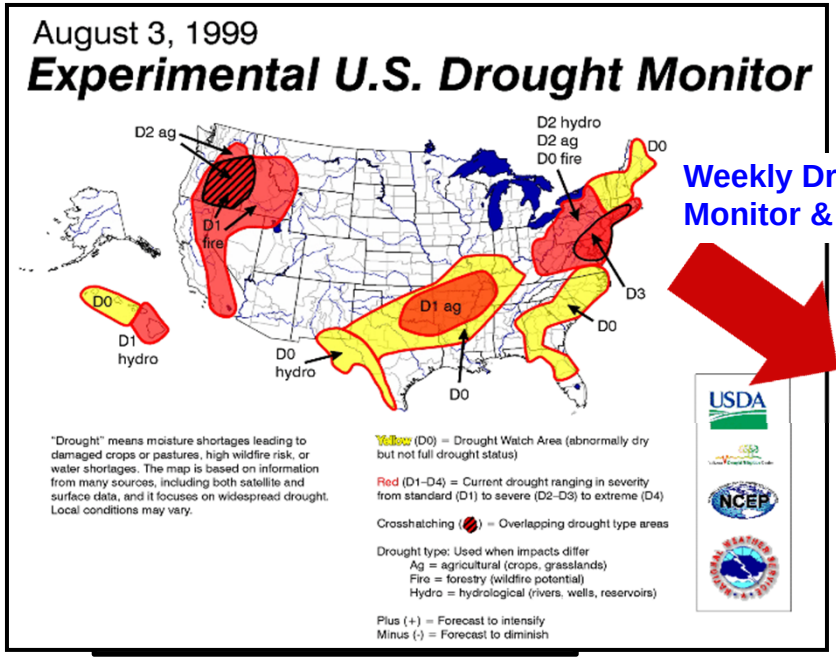
IMME



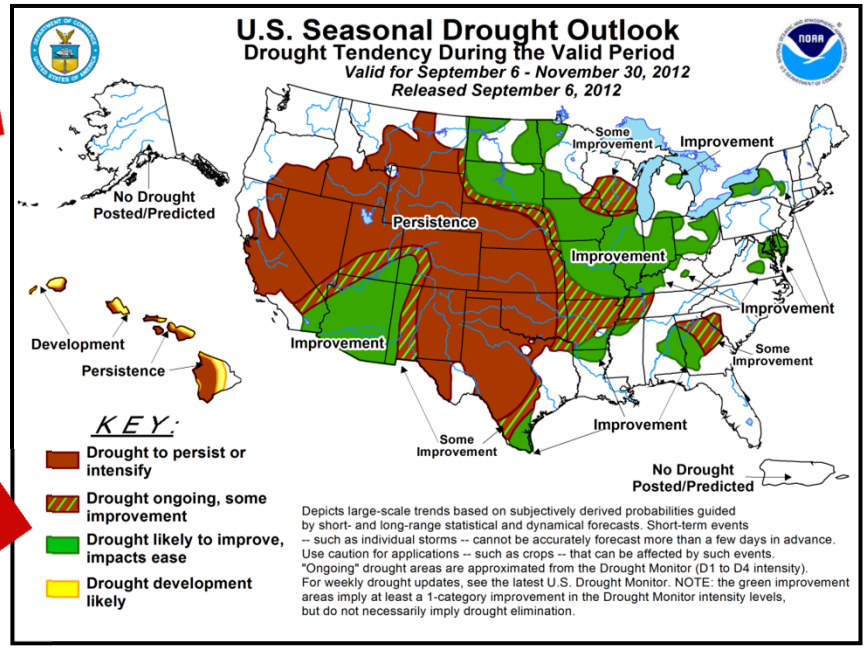
NMME SST Forecasts Combined with CPC Statistical Tools to Inform El-Nino Diagnostic Discussion



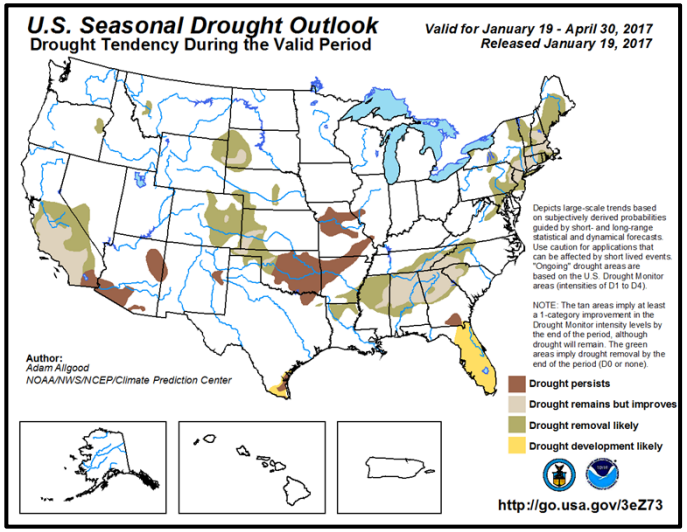
Evolution of the U.S. Drought Outlook

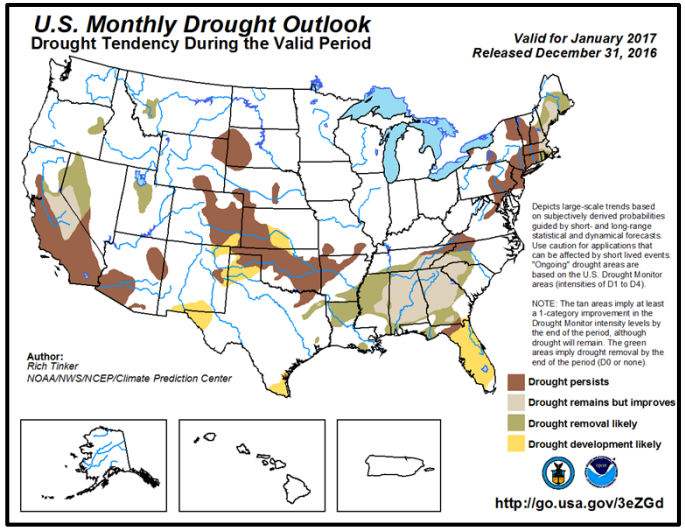


Weekly Drought Monitor & Outlook

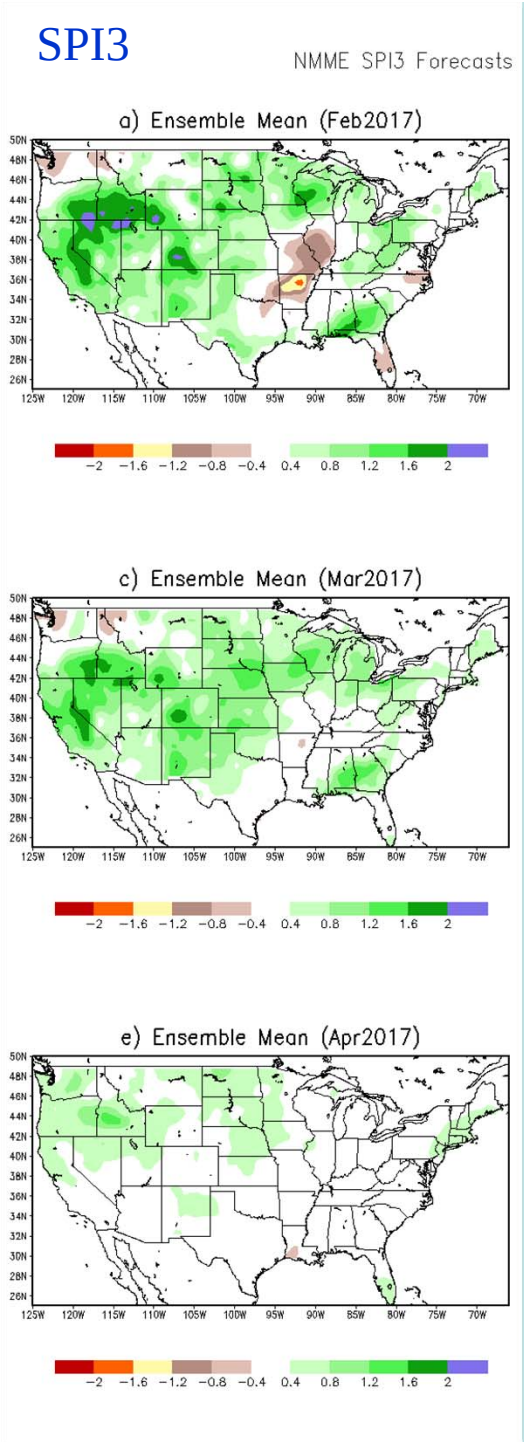


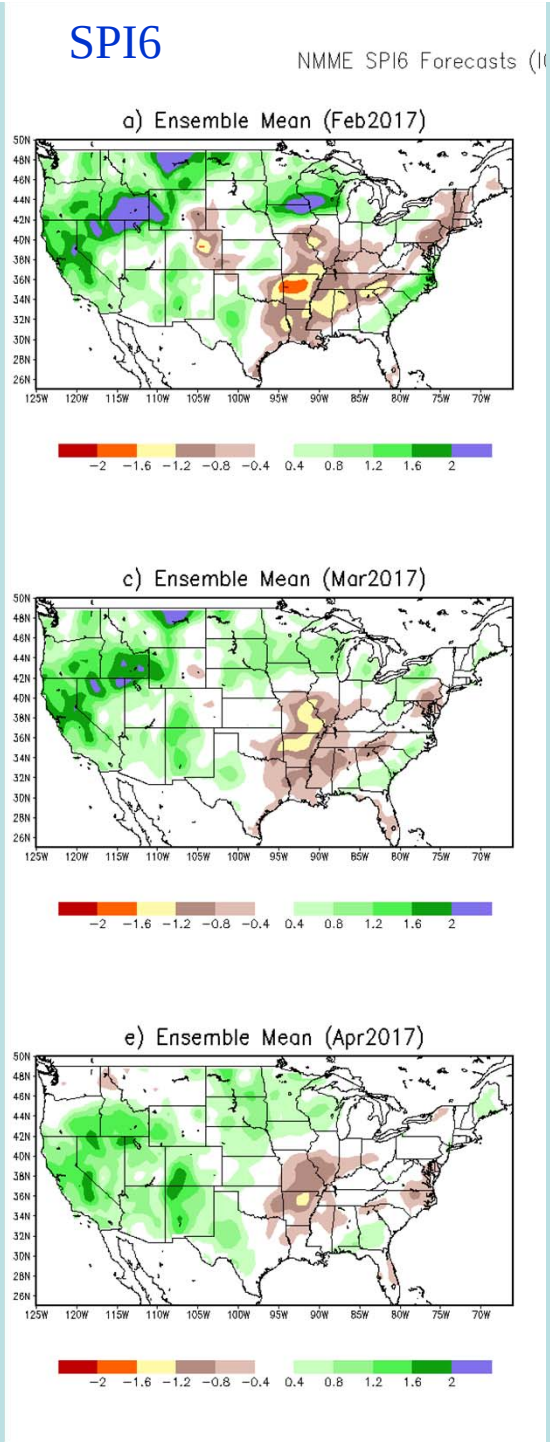
Seasonal Drought Outlooks (2/month; Initial & Update)





Seasonal and Monthly Drought Outlooks





SPI3 & SPI6

Forecasts from 6NMME Models

(uses obs. P up to past month(Jan), and forecast months' P from NMME models)

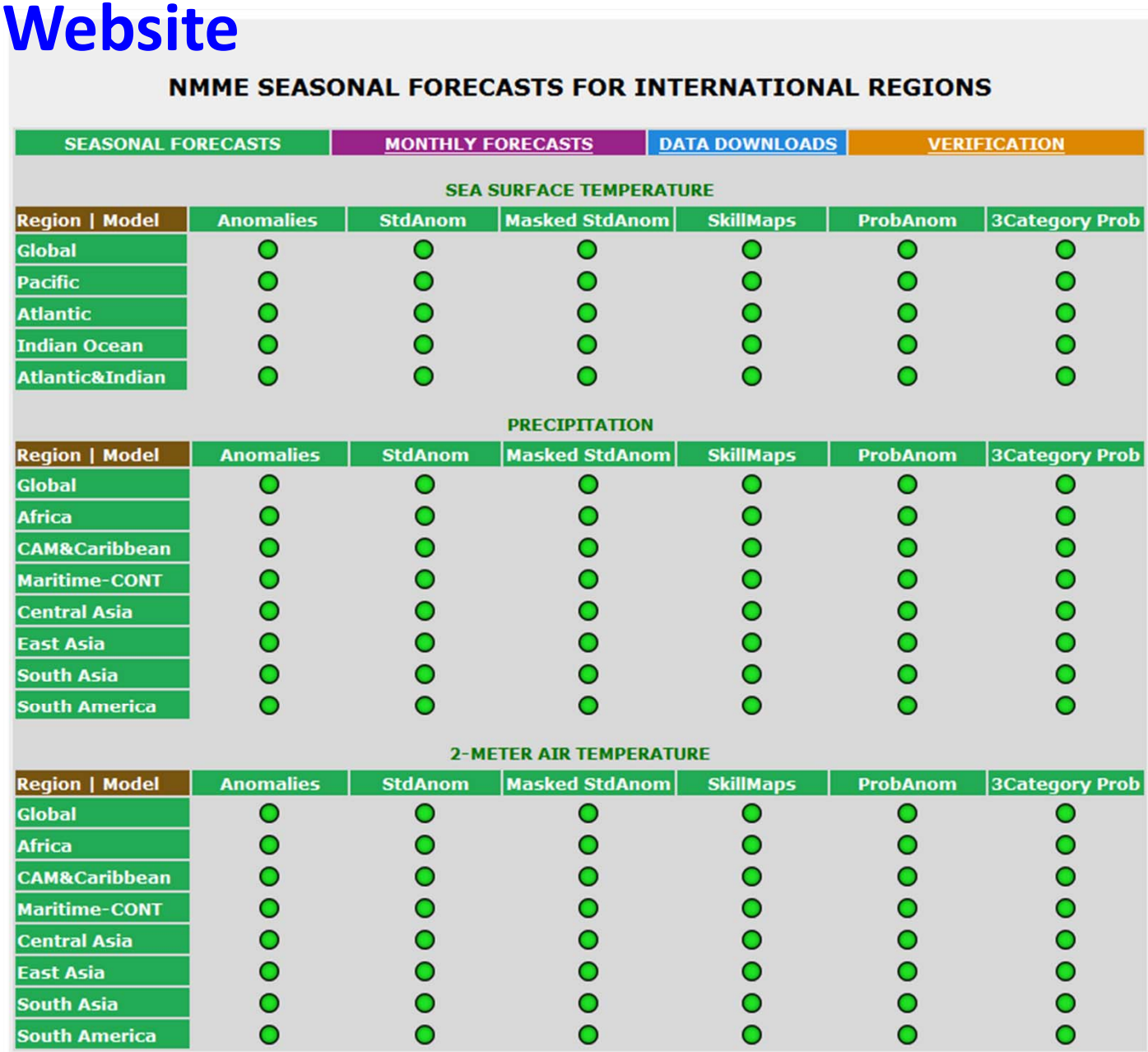
NMME Ensemble Mean (6 models)
SPI Forecasts for Feb/Mar/Apr.
Left Panels: SPI3
Right Panels: SPI6

- In general, SPI3 can be somewhat more trusted than SPI6, to the extent the NMME models have any skill at all in the 1-3 months
- <u>It is interesting that by March and April, the models do not have any negative SPI3 anywhere in US</u> ☺
- However, -ve SPI6 regions exist, through gradually with decreasing area extents in the southeast US.

International Desk Use of NMME

- Inform Famine Early Warning System Products
- Website of Products for Most of Globe Giving Deterministic and Probabilistic Forecast Products (not post-processed)

CPC International Desks NMME Website



NMME SEASONAL FORECASTS FOR INTERNATIONAL REGIONS

SEASONAL FORECASTS | MONTHLY FORECASTS | DATA DOWNLOADS | VERIFICATION

SEA SURFACE TEMPERATURE

Region | Model	Anomalies	StdAnom	Masked StdAnom	SkillMaps	ProbAnom	3Category Prob
Global	●	●	●	●	●	●
Pacific	●	●	●	●	●	●
Atlantic	●	●	●	●	●	●
Indian Ocean	●	●	●	●	●	●
Atlantic&Indian	●	●	●	●	●	●

PRECIPITATION

Region | Model	Anomalies	StdAnom	Masked StdAnom	SkillMaps	ProbAnom	3Category Prob
Global	●	●	●	●	●	●
Africa	●	●	●	●	●	●
CAM&Caribbean	●	●	●	●	●	●
Maritime-CONT	●	●	●	●	●	●
Central Asia	●	●	●	●	●	●
East Asia	●	●	●	●	●	●
South Asia	●	●	●	●	●	●
South America	●	●	●	●	●	●

2-METER AIR TEMPERATURE

Region | Model	Anomalies	StdAnom	Masked StdAnom	SkillMaps	ProbAnom	3Category Prob
Global	●	●	●	●	●	●
Africa	●	●	●	●	●	●
CAM&Caribbean	●	●	●	●	●	●
Maritime-CONT	●	●	●	●	●	●
Central Asia	●	●	●	●	●	●
East Asia	●	●	●	●	●	●
South Asia	●	●	●	●	●	●
South America	●	●	●	●	●	●

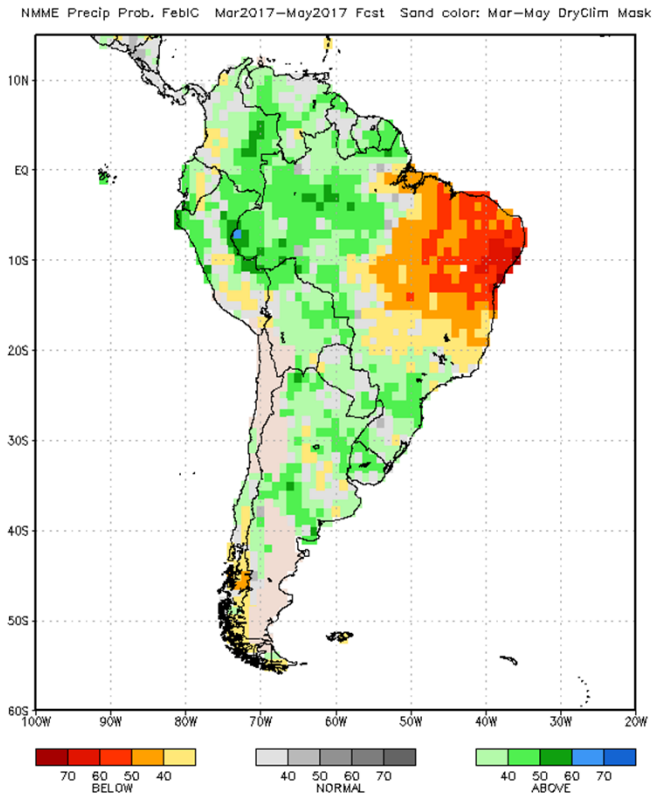
The page features real time regionalized monthly and seasonal forecasts from the NMME updated by the 10th of each month.

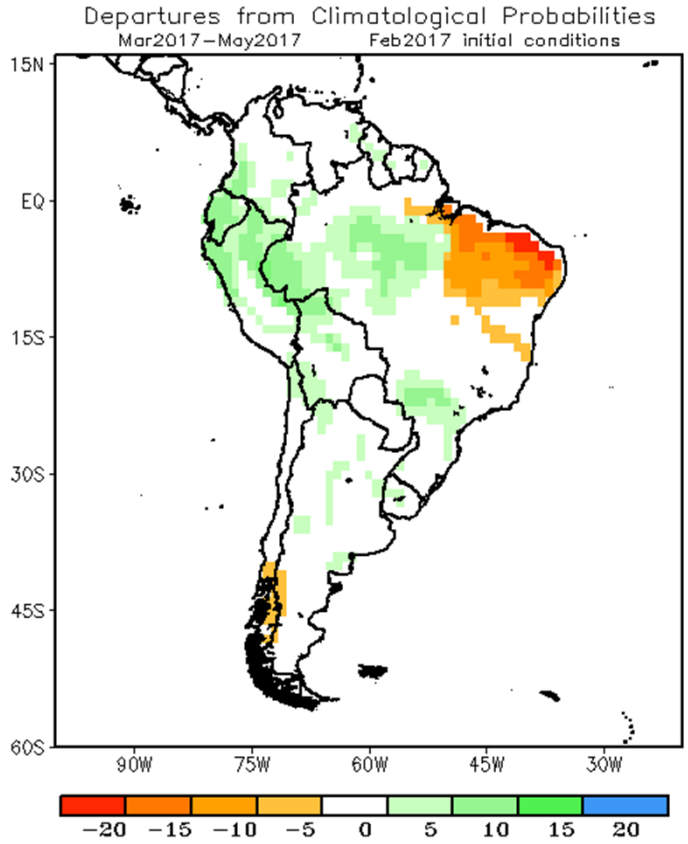
For each of the individual NMME models and the ensemble mean, the website displays forecasts up to 5 months lead time of SST, air temperature and precipitation in both deterministic and probabilistic forms as well as the associated skill map derived from the 1982-2010 NMME hindcasts . Forecast data in both binary and CPT form can also be made available.

Forecast verifications will be added.

Sample Products – Precipitation – Probabilistic

Seasonal Forecasts for South America, Mar-May 2017, Feb IC





Improving Utility of NMME for CPC Forecast Operations

- Calibrated forecasts using the Probability Anomaly Correlation (PAC)
- Explore use of unequal weights to maximize skill (ongoing evaluation)

Improving Utility of NMME To CPC Forecast Operations: Development and Implementation of Calibrated NMME Forecasts Using the Probability Anomaly Correlation (PAC) Method

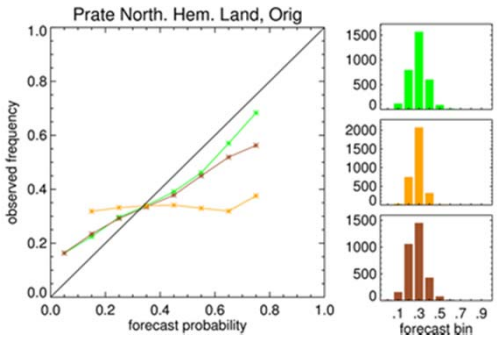
-Calibration results in:

*Dramatic increase in reliability of forecasts for SST, temperature, and precipitation

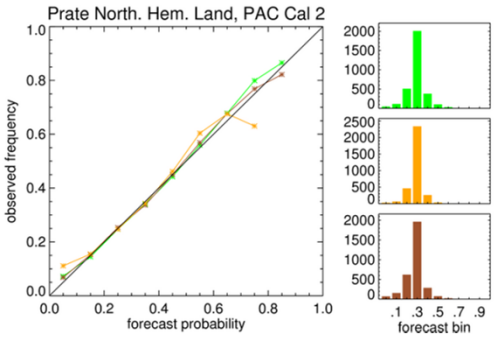
*Modest skill increase measured using Brier Skill Score

-Calibrated forecasts implemented operationally in July 2016 for forecaster use in developing monthly and seasonal temperature and precipitation outlooks

-R2O transition accomplished through Climate Testbed



Uncalibrated



Calibrated

Reliability curves for lead one precipitation forecasts for 1982-2010

Strategic Priority: Understanding why Models Didn't Perform Well in Predicting Winter Precipitation in the West for 2014-2017

Is there less predictability in the system then we previously believed?

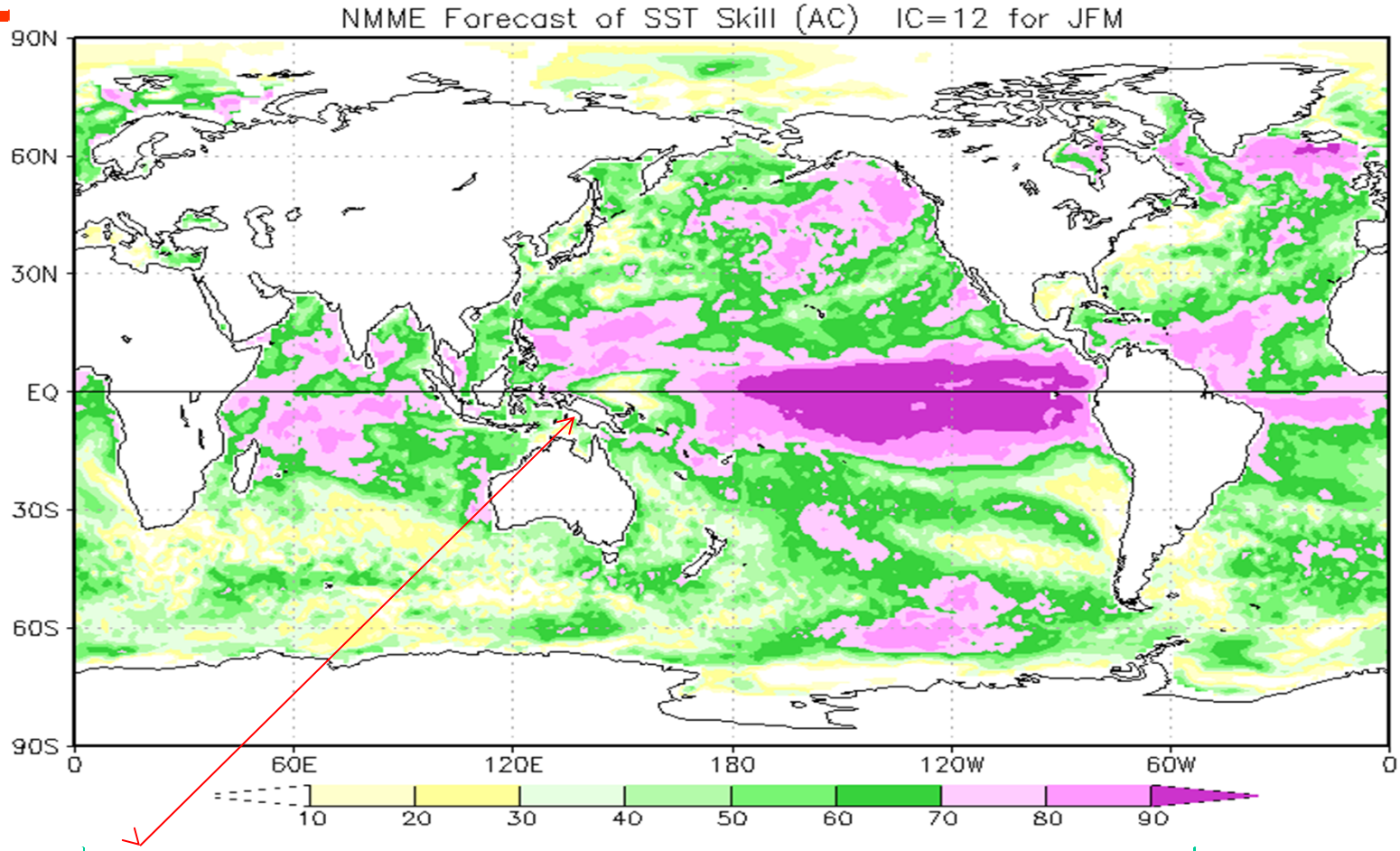
Do the current generation of models misrepresent or not represent at all key processes?

Was the forced signal overwhelmed by atmospheric transients?

This is a golden opportunity for the short-term climate forecasting community to explore these issues to see if this was predictable and, if so, why our tools fell short.

NB: Circa 1999 based on successful predictions for record 1997-98 El-Nino and 1999 La-Nina then CPC Director Ants Leetma declared that seasonal prediction problem was solved. Unfortunately, this proved to not be the case! **We need strategic investment in the most promising tools to push the subseasonal to skill envelope and there is plenty of room for improvement (DGD, 2015-2017).**

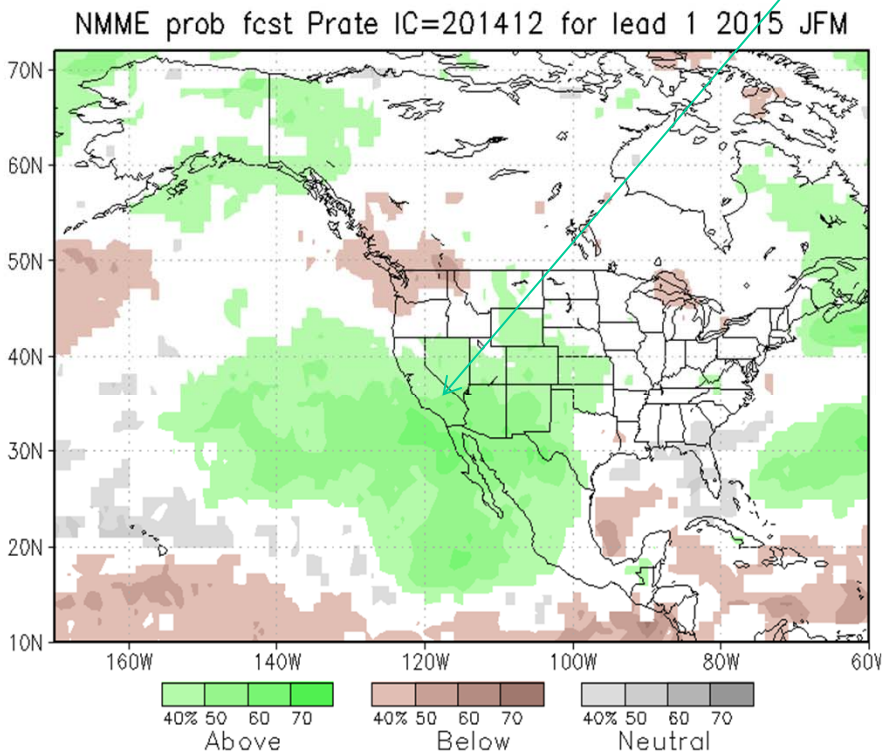
Retrospective Forecast Skill of Lead 1 NMME SST Forecast for JFM from NMME

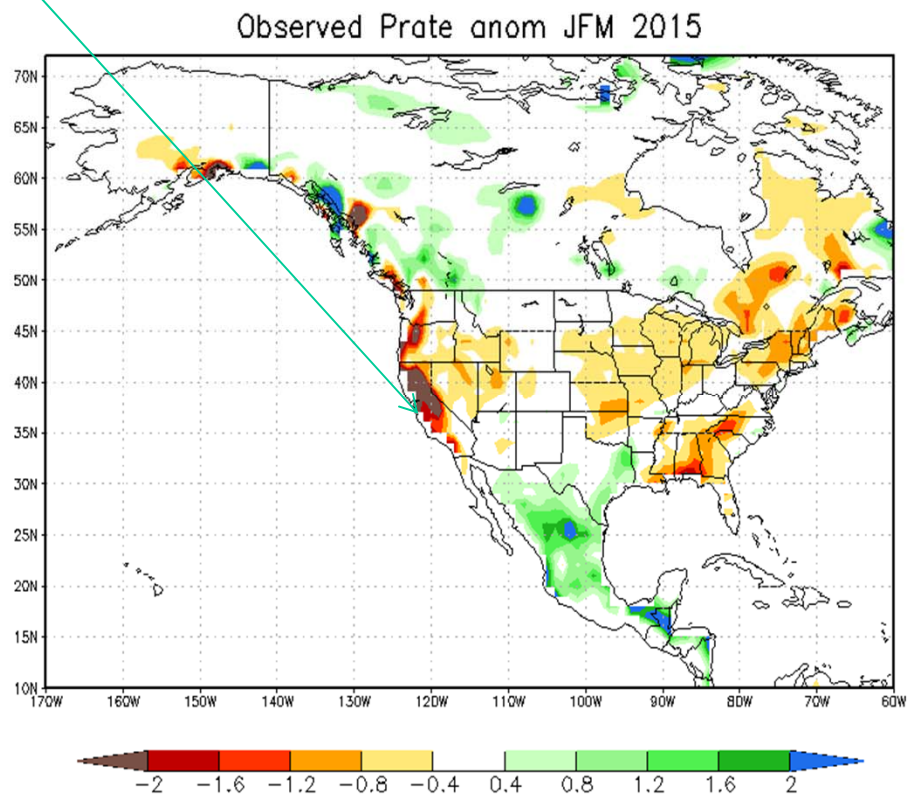


State of the Art MME Dynamical Forecast System has Low Skill in Predicting Near-Equatorial Western Pacific SST. How important is SST in this region in driving anomalies over the US?

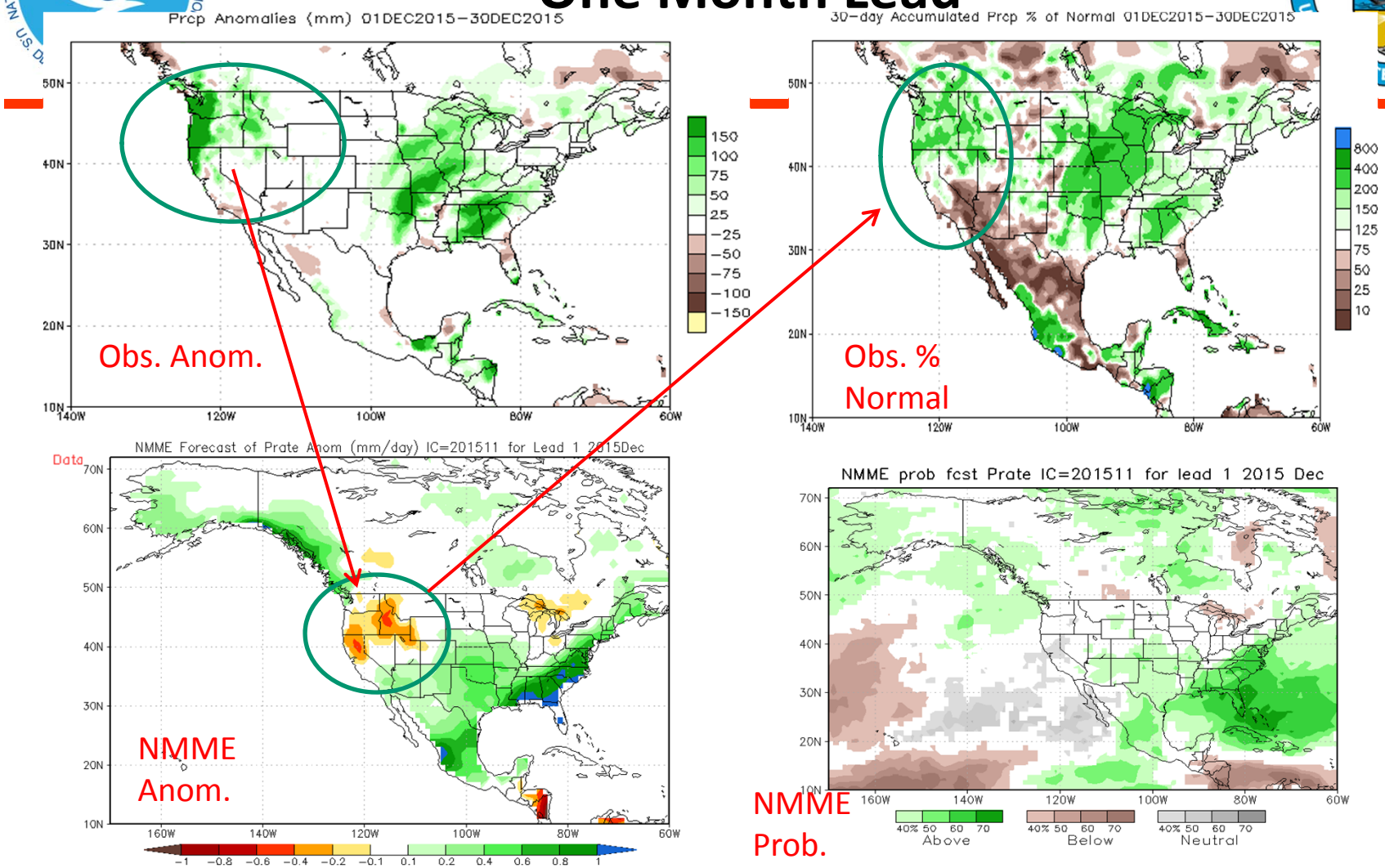
Lead 1 NMME Precipitation Forecast for JFM 2015

Associated precipitation forecast calls for modest probability of above normal precipitation, while record breaking drought was observed.



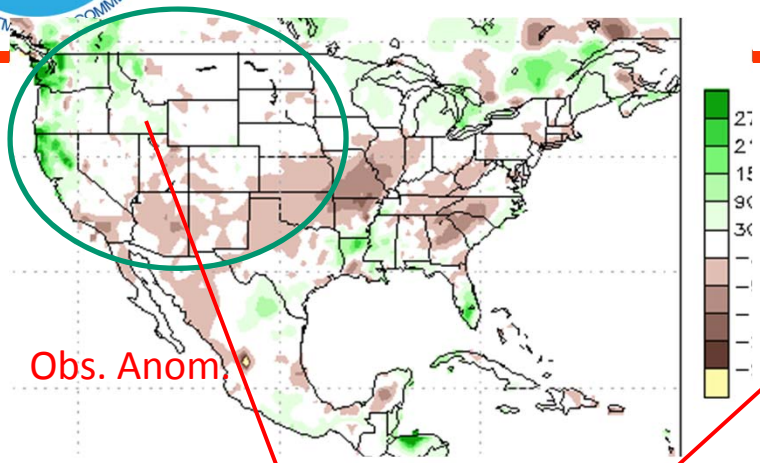


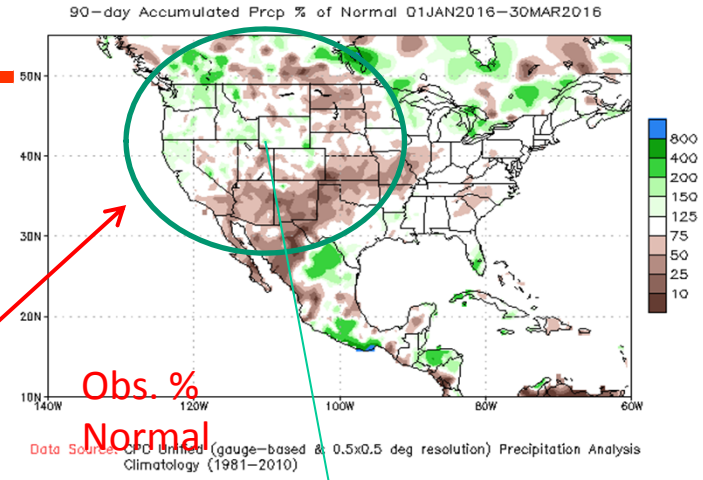
NMME Precipitation Forecast for December 2015 at One Month Lead

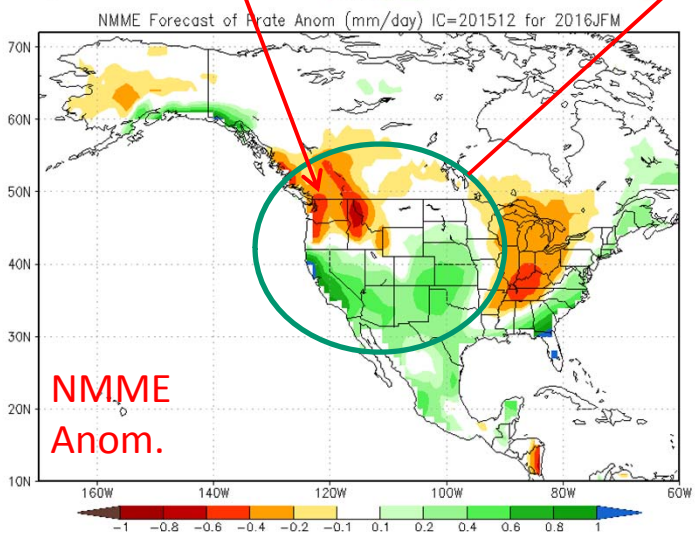


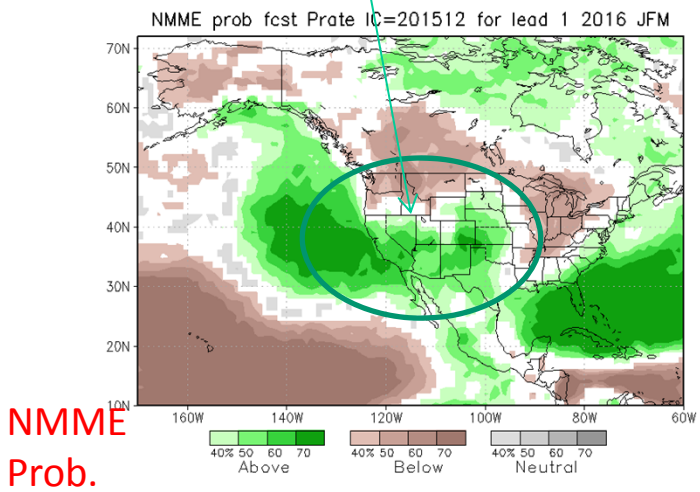
State of the art NMME misses major precipitation anomalies in Western US.

NMME Precipitation Forecast for JFM 2015-16
One Month Lead Despite Strong El-Nino



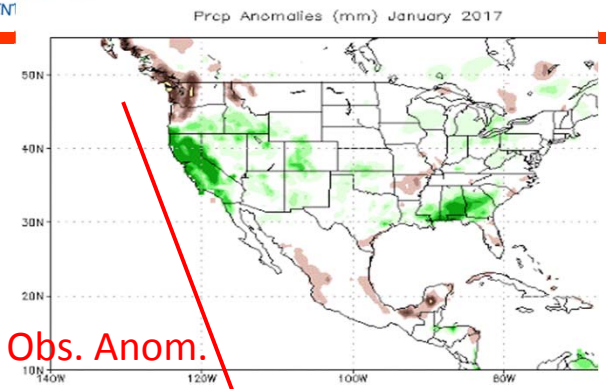


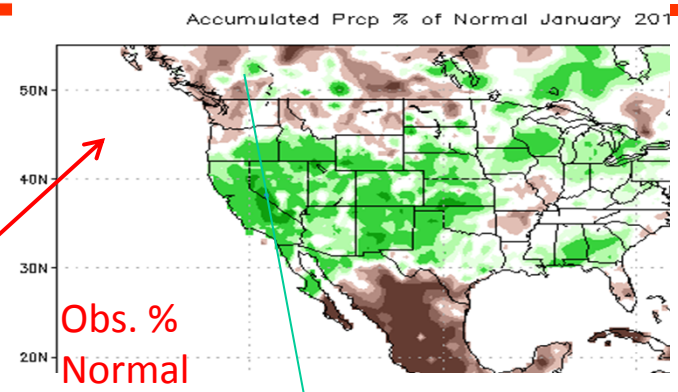


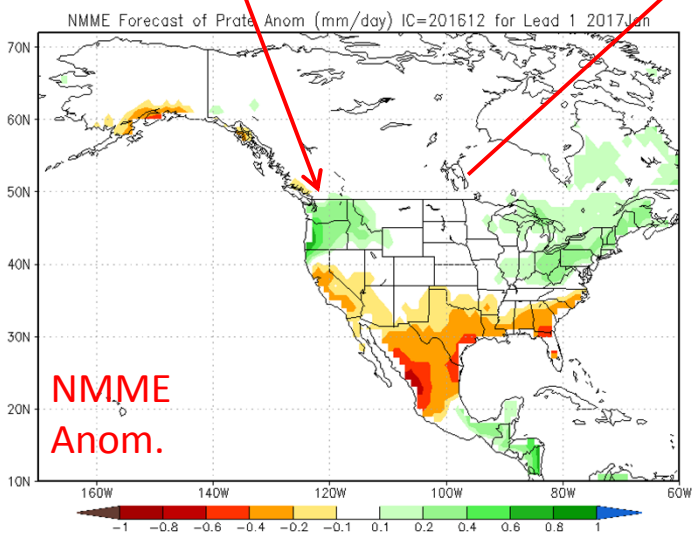


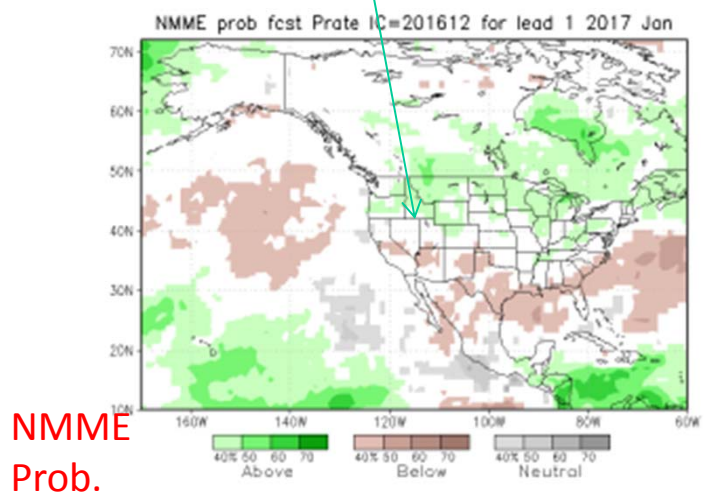
State of the art NMME misses major precipitation anomalies in Western/Central US.

NMME Precipitation Forecast for Jan. 2017
One Month Lead



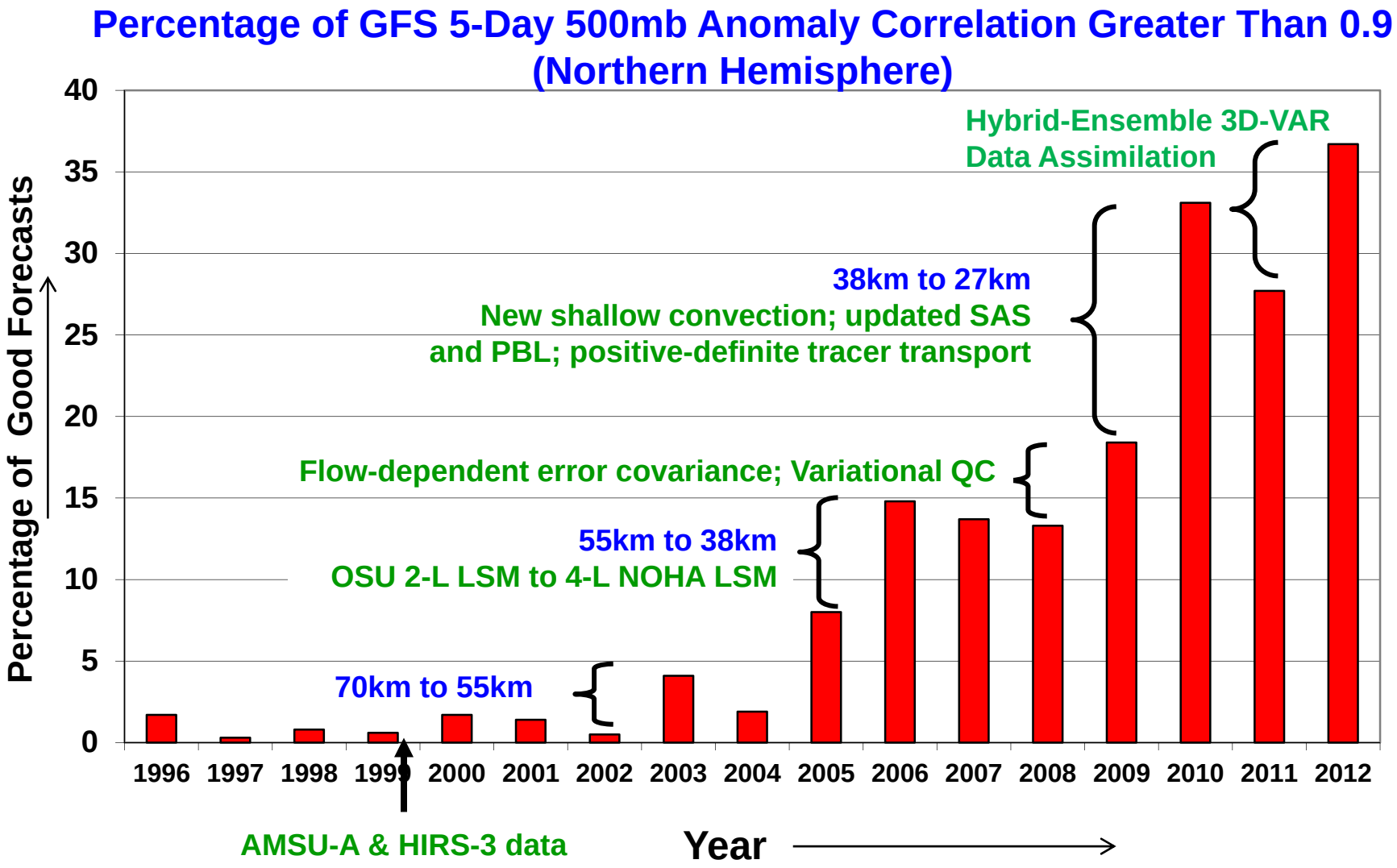






State of the art NMME misses major precipitation anomalies in Western US at One Month Lead

Strategy for Improving Monthly/Seasonal Forecasts

- Ultimately, monthly/seasonal climate forecasts are average of weather.
- Hypothesis: Need to represent weather systems with fidelity in order to get statistics correct, thus enabling more skillful monthly/skillful forecasts. How do we do that?
  - Increased resolution
  - Improved physics
  - Improved initialization (data assimilation)

GFS Skill Improvement Due to Resolution, Data Assimilation and Physics Upgrades